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Title An Appraisal of Future Economic Conditions Affecting the Pacific Coast Bartlett Pear Industry

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The pear-decline disorder has threatened to seriously reduce future Bartlett-pear production in many Pacific Coast areas. As a result, growers have established extensive new plantings in many areas. In addition, farmers in potential pear-producing areas, such as the Willamette Valley, have become increasingly interested in developing new pear orchards. Because the effects of pear-decline have diminished in recent years, future production increases from the large non-bearing acreages may result in substantially lower prices.

This study was undertaken to clarify the future economic situation of the Pacific Coast Bartlett-pear industry by predicting future price and production levels and developing a pattern of future regional production.

Long-run supply and demand equations were developed for the industry. The resulting demand equation for farm prices of all

Bartlett sales includes the following independent variables: (1) Pacific Coast Bartlett-pear production, (2) production in Michigan and New York, and (3) California cling-peach price, (4) canners' stocks, and (5) canned-pear exports. The supply equation includes the independent variables of lagged price and lagged production.

The supply and demand equations, along with projected values of the exogenous variables, were combined into a model to predict future average price and production levels. Alternative levels of the exogenous variables were projected and substituted into the model to determine several possible series of future predictions.

Each series of price predictions indicates that future prices will continue to increase for several years, and then decrease steadily until about 1972-1975 as expanding production from existing non-bearing acreage occurs. Steadily rising price levels from 1975 to 1985 are indicated in each case as a result of population expansion and growers adjustments to lower prices in the earlier years.

The highest series of predicted prices indicates a level of $83 - $84 per ton during the low-price period from 1972 to 1975; while the lowest price series shows $60 - $62 per ton during this period. The highest price series involves predictions which rise to $97 per ton by 1985; while the lowest series indicates a price of $77 per ton in this year.

Single-value estimates were made of farm production costs in major Pacific Coast areas and the Willamette Valley to determine the comparative cost position of these areas. Cost estimates indicate relatively low production costs in the Sacramento River, Hood River, and Lake-Mendocino areas. The areas of Central Washington, Santa Clara, Medford, and irrigated orchards in the Willamette Valley form an intermediate group in respect to comparative production costs; while the Sierra Foothills area and unirrigated orchards in the Willamette Valley exhibit high costs.

Changes in the regional production pattern were projected on the basis of (1) trends in bearing and non-bearing acreage, (2) comparative production costs in relation to expected future prices, and (3) relative supply elasticities in the various states. Substantial production increases are indicated for the Sacramento River, Lake-Mendocino, Central Washington, and Hood River areas. Thus, a gain in the future relative position of these areas is evident. Relatively stable production can be expected in the Medford area, which will result in a decline in the area's relative position. Indications point to future production decreases and a less important position for the Sierra Foothills and Santa Clara areas.

Comparison of relatively high costs per ton in the Willamette Valley to decreasing future prices shows unpromising prospects for future expansion of pear acreage in this area. However, because high costs per ton in the area result primarily from low average yields, possible increases in yields would greatly improve the area's comparative cost position. Increases in average yields of 25 percent (with cost conditions remaining constant in other production areas) will change the ranking of this area from a high-cost area to one of relatively low costs. This would enhance the economic prospects for future expansion of Bartlett-pear production in the Willamette Valley.

AN APPRAISAL OF FUTURE ECONOMIC CONDITIONS AFFECTING THE PACIFIC COAST BARTLETT PEAR INDUSTRY

by

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I. INTRODUCTION

Recent developments affecting the Pacific Coast pear industry have confronted growers, as well as processors and shippers, of this important crop with a high degree of uncertainty in regard to future economic conditions. Although a lack of complete knowledge regarding future conditions is a problem which is faced by firms in every industry, certain current conditions affecting the pear industry cause this problem to be one of particular importance to the industry at the present time.

One condition which has created uncertainty in this industry is the widespread presence of a tree disorder known as "pear-decline." The incidence of this disorder has reached serious proportions in certain Pacific Coast pear-producing areas, and has caused the removal of large acreages in some areas. A second, and related, condition which has added to future uncertainties is the existence of abnormally large acreages of new plantings. These new plantings have been induced, to a large extent, by prospects of severe production curtailment due to the effects of pear-decline. Rapid removal of extensive bearing acreages accompanied by large new plantings can lead to relatively rapid shifts in geographical areas of production -- a situation which further adds to future uncertainties of the industry. In addition, the threat of urbanization in certain production areas adds complexities to the ever-changing situation.

In an effort to place the industry and its related problems in perspective, a brief description of some important characteristics of the industry is presented below. A discussion of each condition which contributes to the uncertainty of the industry's future is also included in order to clarify these problematical situations.

The Industry

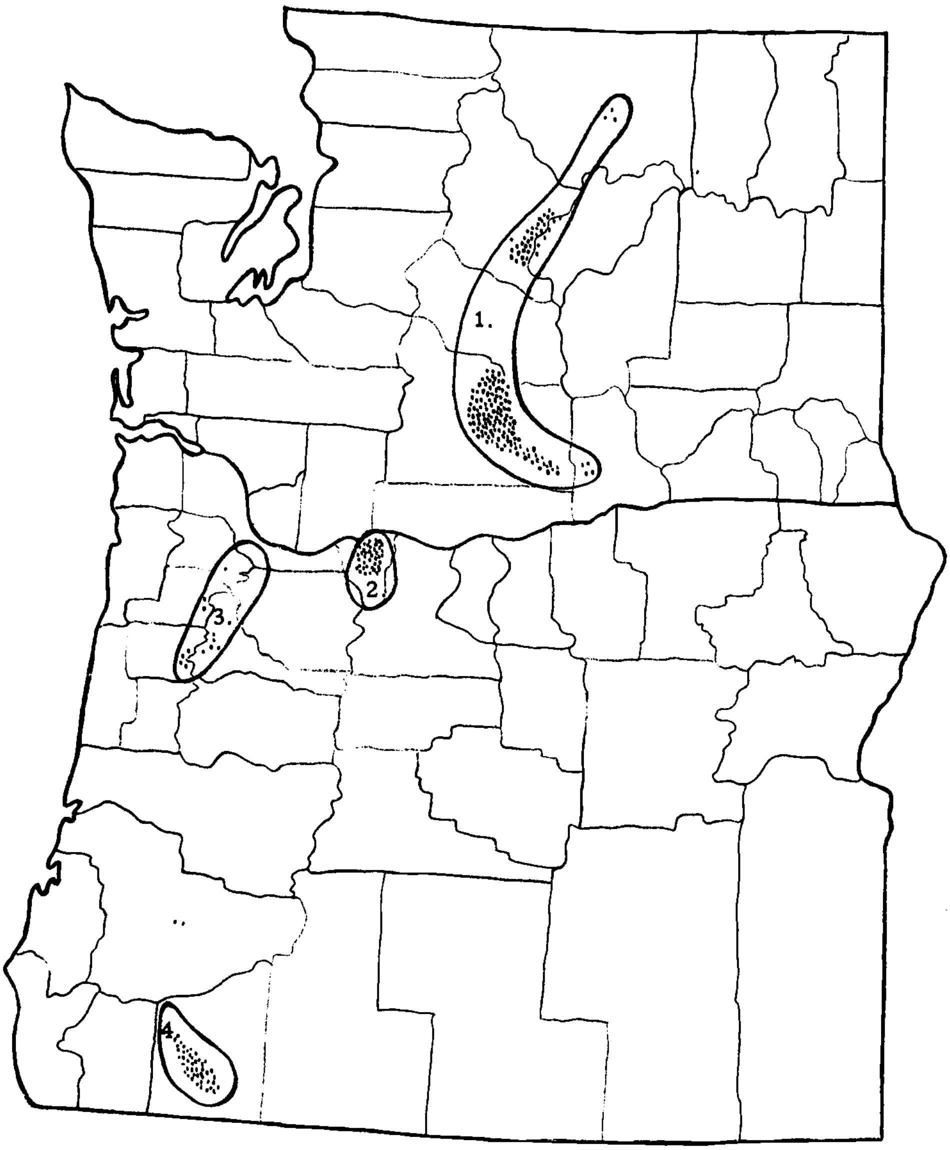
The pear-producing industry constitutes an important segment of the agricultural economies of the Pacific Coast states (Oregon, Washington, and California). During the five-year period from 1959 to 1963, pear production contributed an average annual value of $47,108,000 to the agricultural income of this three-state region (39, 40, 41). About 74 percent of this value is attributed to sales of the Bartlett variety. During this period, average value of the total pear crop by states was as follows: Oregon - $9,860,000; Washington - $9,436,000; and California - $27,812,000. Of these values, Bartlett pears accounted for approximately the following percentages: Oregon - 38 percent; Washington - 63 percent; and California - 91 percent. In certain concentrated areas of production, pears constitute a primary economic base for the local area.

Major production areas are found in each of the Pacific Coast states. In each of these states, however, pear production is concentrated in relatively few geographical areas of production (Figures 1 and 2).

Pear production in Oregon is centered primarily in two areas -- the Medford area in Jackson County and the Hood River Valley. The Willamette Valley of western Oregon constitutes a third area of production, although it has been of somewhat minor importance in the recent past. However, climate, available water supply, and a large acreage of suitable land in this area make it potentially a major production area if future economic conditions warrant such activity.

In Washington, pear production is concentrated in the irrigated valleys of central Washington, east of the Cascade Mountains. The Yakima Valley contains a large portion of the state's pear acreage; while the area near Wenatchee is also an important area of production.

California has several pear-producing areas of major importance. One production area -- the Sacramento River area -- is located primarily in the river-bottom lands of Sacramento and Solano Counties, with smaller acreages in other parts of the Central Valley. A second important area is centered in Lake and



1. Central Washington Area
2. Hood River Area
3. Willamette Valley Area
4. Medford Area

1 dot = 10,000 trees of all ages

Washington - 1961
Oregon ---- 1963

Figure 1. Washington and Oregon Bartlett-pear Production Areas.

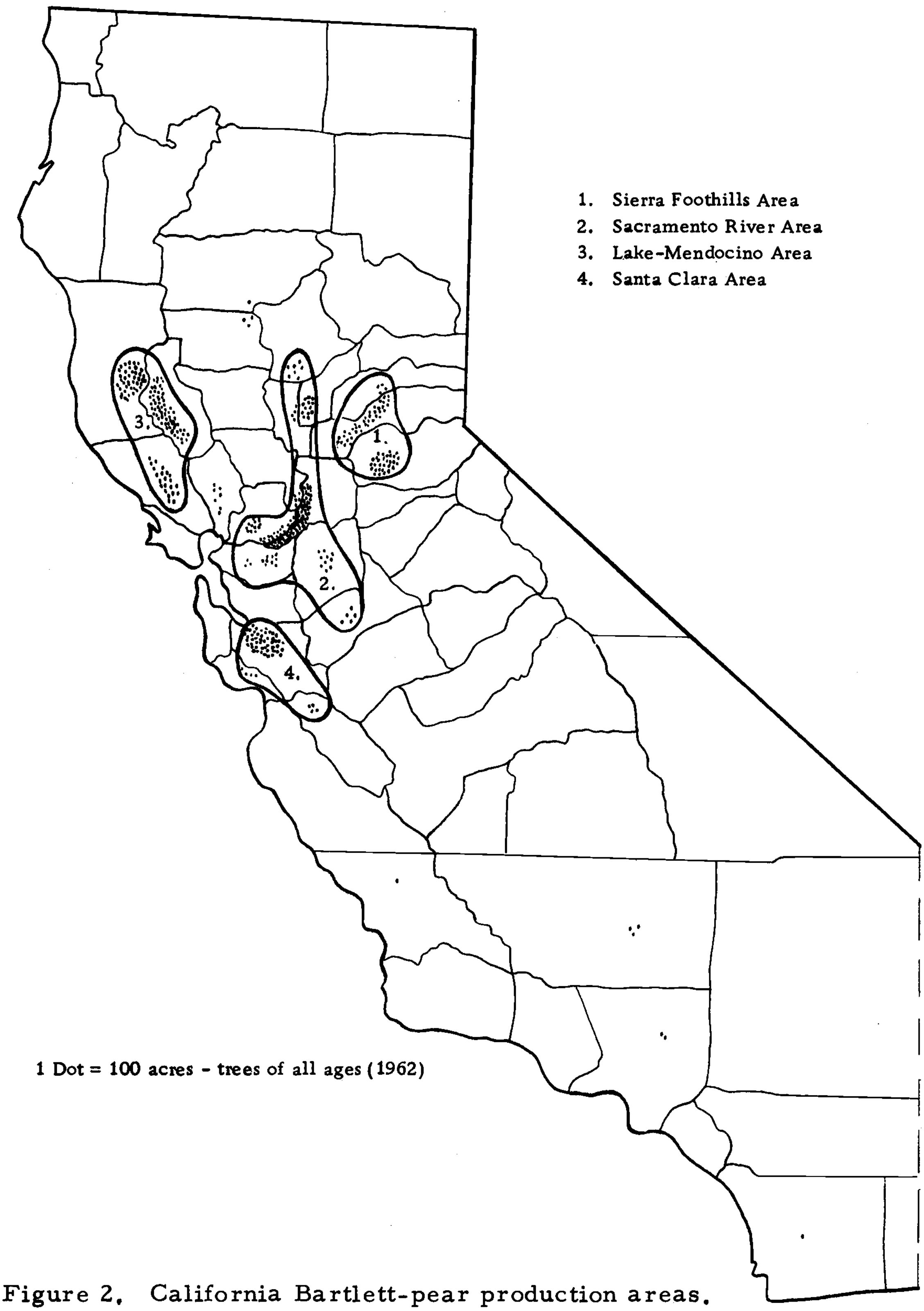


Figure 2. California Bartlett-pear production areas.

Mendocino Counties. The production area which is located in the Sierra Foothills area of Placer and Eldorado Counties has been one of important production, particularly before the advent of pear decline. A fourth major production area is centered in Santa Clara County. Although there are several other areas in California where relatively minor quantities are produced, the four areas listed above include the state's major concentrations of pear acreage.

Pears produced in the Pacific Coast states can be classified into two categories according to variety -- Bartletts and winter pears. Although these categories originate from botanical differences, the main economic basis for such a classification is due to differences in market utilization and marketing season.

While Bartlett pears can be utilized equally well for fresh market or canning, varieties which are classified as winter pears are marketed primarily as fresh fruit. Canned utilization of Bartletts includes use for canned halves, fruit cocktail, fruits for salad, and baby food. Bartlett pears are also suitable for utilization as dried pears. Market outlets for cull fruit of all varieties are provided by manufacturers of pear nectar and vodka. Table 1 shows ten-year average percentages of Pacific Coast Bartlett sales by method of utilization.

In the Santa Clara area of California, there is substantial production of the Hardy variety. This variety is used primarily

Table 1. Utilization of Pacific Coast Bartlett Pears, 1953-62.

	Fresh	Canned	Dried
	(Average Percent of Crop)		
Oregon	35	65	--
Washington	26	74	--
California	23	73	4
Pacific Coast	25	73	2

Source: (39, p. 80-83; 40, p. 18-19; 41, p. 16-17)

in the manufacture of fruit cocktail.

The harvest season for Bartletts, and hence the marketing season for fresh sales of this variety, begins earlier than that for winter pears. Harvest and fresh shipment of Bartletts in California begins in July; while fresh shipments of this variety from Oregon and Washington end in October or November. Although harvest of winter pears begins in September, most of the crop is usually placed in storage and held until Bartletts are no longer on the fresh market in large quantities. Thus, direct competition between these two types of pears is reduced to a minimum. Because winter pears have a relatively long storage life, the marketing season for these varieties extends through the winter months and into spring. This fact provides the basis for the designation "winter pears."

Pear production in California areas is composed almost entirely of Bartletts. The single notable exception to this situation is found in the Santa Clara area where a sizeable acreage of Hardy pears exists. In most pear-producing areas of the Northwest, on the other hand, production of both winter pears and Bartletts is common, and both types are commonly found on the same ranch.

In 1962, California production areas contained approximately 43,000 acres of Bartlett pears (all ages), 1,600 acres of Hardies, and 1,900 acres of winter pear varieties (2, p. 25). According to data from a 1963 tree survey in Oregon, there were 977,000 Bartlett trees of all ages and 869,000 winter pear trees of all ages in the state at that time (26). On an acreage basis, these tree numbers are approximately equal to 11,100 acres of Bartletts and 11,150 acres of winter pears. A 1961 tree survey in the state of Washington indicated the existence of approximately 1,711,000 Bartlett trees (all ages), and 476,000 trees (all ages) of winter pear varieties (51). These estimates are comparable to about 19,000 acres of Bartletts and 5,950 acres of winter pears.

In an economic analysis of the pear industry, due consideration should be given to the interrelationships between these two major types of pears because of (1) similarities of the two products; (2) the fact that both compete with one another in the fresh market, for at least a part of the season; and (3) the fact that many farms and marketing firms, particularly in the Northwest, produce and market both Bartletts and winter pears. On the other hand, differences in primary utilization of these two types provide a logical basis for separating the industry into two major segments -- Bartletts and winter pears -- for analytical purposes. This logic is supported by the fact that these two types of pears compete directly in only the fresh market -- and for only a brief period. The present study is devoted to an analysis of Bartlett pears; although consideration is given to the effects of winter pears upon the Bartlett segment of the industry.

Recent Developments and Their Relation to the Problem

The widespread occurrence of pear decline in certain production areas has become a major problem in recent years. Beginning about 1954, pear decline compelled growers to remove large acreages of pears in Central Washington. A portion of the bearing acreage in this state was removed from production entirely because of this disorder, while yields on a large additional acreage were reduced considerably. In more recent years, pear decline has, in a similar manner, seriously affected pear production capabilities in Medford and California production areas. For several years commencing in 1959, pear decline reached epidemic proportions in certain California production regions such as the Sierra Foothills area. Although the prevalence of the disorder has been reduced considerably, pear decline remains as a troublesome factor which affects the industry today.

During the first few years following the occurrence of pear decline, little was known regarding causes or remedies of this disorder except that it seemed to primarily affect trees on certain types of rootstock. As a consequence, during the late 1950's, and probably until about 1961, many industry representatives estimated that as much as 25 percent to 40 percent of bearing pear acreages in Pacific Coast states would succumb to the disorder. This would, of course, mean severe economic hardships for many individual growers and have important economic ramifications for communities in which pear production constitutes a primary source of income.

During these years, prospects of a marked drop in future production led to a considerable rise in expectations regarding future prices. As a result, large acreages of young Bartlett pears were planted in response to these prospects. The most extensive acreages of new plantings have occurred in the Yakima Valley of Washington and the Sacramento River and Lake-Mendocino areas of California; although substantial new plantings have been made in most other established production areas as well.

At the same time, landowners in some areas which have not, in the past, been major pear-producing areas have gained considerable interest in planting young acreages of Bartlett pears. Because of this, such areas as the Willamette Valley and portions of the

Central Valley of California, which have land and a climate which are suitable for Bartlett pear production, have gained a sizeable acreage of new plantings. These areas also have a potential for greater acreage expansion in the future. Prospects of high future prices for Bartlett pears, as well as relatively unfavorable profit conditions associated with some of the more traditional crops in these potential pear-producing areas, have provided special incentives for landowners in these areas to consider development of a pear enterprise.

Within the last two or three years, it has become increasingly evident that reductions in pear acreage due to pear decline will not reach the magnitudes which were indicated by earlier predictions. The large extent of recent plantings has also become increasingly evident. There are indications that these new plantings are of sufficient magnitude to provide productive capacity much in excess of that lost through removals from pear decline. These facts have led many industry members to fear that production levels will be sufficient when these new plantings come into bearing to lower prices considerably below the levels of recent years.

Although pear growers and managers of pear-marketing firms are keenly aware of the importance of future prices and production to their profit position, accurate estimates of these future unknowns are extremely difficult to obtain because of the complex and ever-changing set of factors which are involved in their determination.

A lack of knowledge regarding the competitive position of various established and potential production areas also presents a problem to industry managers in regard to decisions such as acreage expansion or contraction within a given area. At the present time, these problems are complicated and intensified by rapid changes and uncertainties which have arisen with the advent of pear decline and the accompanying expansion of new plantings.

Objectives of the Study

In light of the problems outlined above, the following objectives are formulated:

1. Predict future price and production levels by an analysis of the important factors which influence these variables.
2. Estimate costs of producing Bartlett pears in the major production areas.
3. Analyze future possibilities in respect to changes in the regional pattern of production.

Methods of Analysis

A brief outline of the methods of analysis which were used to achieve the stated objectives is presented below. A more detailed discussion of the various methodologies used will be presented in later sections of the text.

A demand (price-estimating) equation was developed which expresses the relationship between grower price for Pacific Coast Bartlett pears and various independent variables which have an important influence in determining price. Economic logic was used as the basis for hypothesizing the important variables which influence the price of Bartlett pears. Use was made of scatter diagrams and simple regression to test these tentative hypotheses. The least-squares method of linear multiple regression was used to estimate coefficients for a price-estimating equation and as a further test of the price-determination hypotheses.

Similar methods were used to develop a supply (quantity-estimating) equation. Thus, by the use of economic logic, scatter diagrams, and least-squares multiple regression it was possible to develop an equation to estimate production of Pacific Coast Bartlett pears.

These demand and supply equations, plus projected estimates of the various exogenous variables, were combined into a model which was used to predict future price and production levels. Several alternative projections of the exogenous variables were substituted into the model to determine the possible effects upon future price and production of these "reasonable" alternatives.

In estimating production costs for Bartlett pears in the various geographical areas, reliance was placed upon previously completed studies as much as possible. In certain areas, however, it was necessary to conduct original studies to obtain recent cost estimates. For this purpose, a group of representative growers from the area supplied basic information for cost estimates through a "group interview." The resulting cost estimates were then checked with local industry representatives and extension workers for accuracy.

Changes in the regional pattern of production were projected on the basis of (1) bearing and nonbearing acreage trends, (2) relative cost estimates in the various areas in relation to future price predictions, and (3) relative supply elasticities by area.

II. THE DEMAND RELATIONSHIP

In this chapter, development of the demand relationship for Pacific Coast Bartlett pears at the farm level will be discussed. Development of such a demand relationship involves the determination of important factors which influence prices received by growers. An analysis of price relationships for Bartlett pears at the farm level is complicated by the existence of important market outlets for both fresh and processed forms and a complex set of price-making factors in each of these major markets. For this reason, complete success in describing all factors which influence demand and price for this commodity is a goal which is unlikely to be attained. An attempt was made, however, to analyze and isolate the main factors which have had an important influence upon farm prices of Pacific Coast Bartlett pears in past years.

Theoretical Development of the Bartlett-Pear Market at the Farm Level

Principles of economic theory as well as a knowledge of the organization and operation of the specific market under consideration provide a basic framework of analysis and a guide for the determination of relevant variables in a demand relationship. For this reason, a theoretical outline of the market for this commodity is discussed below.

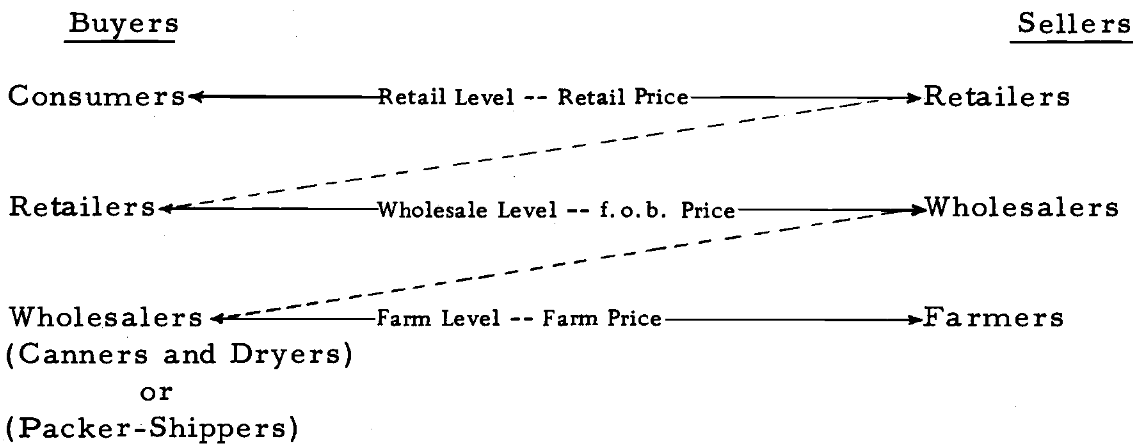
The overall market for Bartlett pears can be broken into two major component markets on the basis of utilization -- (1) the fresh market and (2) the processing market. In some ways the organization and operation of these two markets in respect to price-making forces are similar. On the other hand, the differences which exist between these two markets are sufficient to warrant a separate discussion of each.

Marketing Levels and a Derived Demand

Certain generalized marketing levels can be outlined for both the fresh and the processing markets. These markets can be divided into three main levels for the purpose of a theoretical discussion -- (1) retail level, (2) wholesale level, and (3) farm or producer level (Figure 3). Wholesalers in the processing market are primarily canners and dryers; while wholesalers in the fresh market are mainly packer-shippers.[1]

[1] It is recognized that there are often one or more handlers between the processor or packer-shipper and the retailer, and that more than three marketing levels, therefore, exist. For this reason, a generalized portrayal of three marketing levels is somewhat of an oversimplification. Nevertheless, with the growing importance of chain-store retailers, a large percentage of fresh sales by pear shippers are made directly to chain-store buyers (20, p. 97-100). A recent study also indicates that an increasing percentage of canned fruits and vegetables are sold by processors, or their agents, directly to chain-store retailers (32, p. 9-13). Therefore, although such a schematic portrayal of marketing levels is somewhat of an oversimplification, it gives an accurate representation of a major, and growing, portion of the market for this commodity.

Figure 3. Marketing Levels of Bartlett Pears[1]



In the present study, an analysis of Bartlett-pear prices at the <u>farm</u> level is a major objective. However, because demand for this product at the farm level is derived from demand conditions at the retail and wholesale levels, consideration must be given to the interrelationships between demand and price-making conditions at these different marketing levels. For example, demand for processing pears at the farm level is primarily provided by canners' demand for their raw product -- which is, in turn, dependent upon canners' expectations of retailers' future demand for canned pears. Retailer demand is, of course, derived from consumer demand at the retail level. Thus, it can be seen that demand conditions at the farm level are dependent upon demand conditions at other marketing levels,

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[1] The diagrammatic portrayal of marketing levels is adapted from a similar scheme outlined by Norman (24, p. 66).

and that certain factors which exert a direct effect upon price at another level may have an effect upon farm prices as well.

The Processing Market

On the basis of percentage of the crop utilized, the processing market is the most important outlet for Bartlett pears; and canning is the dominant processing use (Table 1).

Most canners buy pears on a cash basis at a price established immediately before or during the harvest season. These farm prices of Bartlett pears for processing are determined in an environment which is commonly characterized by a large number of relatively small producers and a relatively small number of processor-buyers. The processor-buyer side of the market at this level can be described as one of oligopsony (few buyers; each of whom consider the actions of other individual firms in their decisions regarding price and quantity of purchases). In the Northwest, there are only about 11 canning firms which purchase Bartlett pears for processing. A somewhat larger number of processor-buyers (approximately 18 canners) operate in California. However, pricing decisions of four or five very large firms have a disproportionate influence upon price offerings by canners in both areas. (Several of these large canning firms buy and process pears both in the Northwest and in California.) The processor side of the market also includes one or more grower-owned cooperatives in each of the Pacific Coast states.

The farmer-seller side of the market can be described as one which approaches conditions of pure competition. However, this situation has been considerably altered by the formation of producer bargaining associations in both California and the Northwest during the 1950's. These bargaining associations now control a substantial portion of the grower tonnage in each area for the purpose of bargaining prices for canning Bartlett pears. The existence of grower bargaining associations lends an element of monopoly to the price-making environment. On the other hand, a substantial grower tonnage of Bartlett pears, including those which are processed by co-operative canners, is still not committed to the bargaining associations for price negotiations. In addition, the fact that growers have opportunities to sell their Bartletts in the fresh market (for which no bargaining association exists) complicates the price-making situation and alters the grower associations' bargaining power.

Although existence of producer bargaining associations modifies the price-making situation from one approaching pure competition, both bargaining associations and processor buyers presumably base their bargaining activity upon an evaluation of "economic" factors such as size of crop, carryover, competing fruits, disposable income, and population.

On the processor-buyer side of the price-determining situation, it is assumed that firm managers use a profit-maximizing criteria of one form or another in their decisions regarding prices for cannery pears. To do this, canners must estimate future f. o. b. or wholesale prices at which they expect to sell the canned product. Expectations regarding future f. o. b. prices of canned pears are, in turn, based upon expected supply conditions of canned pears as well as expectations of conditions affecting consumer and retailer demand. Canners must also consider their processing costs. In this context, such factors as case yield, labor costs, other variable input costs, and fixed costs are important determinants of canners' demand for Bartlett pears at the farm level. These factors will be discussed in more detail in a later section.

Factors which influence farm prices of cannery Bartletts. The basic economic concept of a demand relationship embodies the notion that quantity sold is inversely related to price. Therefore, on the basis of economic logic, the quantity of pears which are available for canning would be expected to have an important influence upon price.

In addition to the quantity factor, a standard text on economic principles often outlines a generalized list of factors which affect demand, such as the following: (1) consumer tastes and preferences, (2) consumer income, (3) population, (4) prices of competing products, and (5) buyers' expectations regarding future prices. From this generalized list, one would expect to find several specific factors which have an important influence upon prices of a given commodity such as Bartlett pears.

Results of similar previous studies also provide a basis for tentative hypotheses regarding specific variables to be included. For example, results of an analysis by Pubols of farm prices of Pacific Coast cannery Bartletts indicated that 94 percent of the price variation was explained by the following variables: (1) total production of Pacific Coast Bartlett pears, (2) disposable personal income, (3) stocks of canned pears, and (4) production of Pacific Coast pears other than Bartlett (30). Similarly, an analysis by Schneider demonstrated that prices received by Washington and California growers for canning pears were influenced by the following factors: (1) production of Pacific Coast Bartlett pears, (2) canners' holdover, and (3) U.S. per capita disposable income (33, p. 99-109).

In a study of the f. o. b. price relationship for Pacific Coast canned pears, Hoos found that the following variables have an important influence upon price: (1) canners' commercial domestic movement of Pacific Coast canned pears (a measure of quantity of the product), (2) index of United States disposable personal income, and (3) an index of prices of competing canned fruits (the competing canned fruits include California cling peaches, California apricots, Pacific Coast freestone peaches, California fruit cocktail, and

Hawaiian pineapple). Statistical results of this study indicate that these three variables explain from 97 percent to 99 percent of the variation in f. o. b. prices of Pacific Coast canned pears (19, p. 22).

Although the Hoos study provides estimates of f. o. b. price of canned pears, these results may provide useful insights into the relevant variables which influence farm prices of Bartlett pears because of the derived nature of cannery demand. Similarly, results of previous studies concerning f. o. b. prices of other canned fruits may also suggest tentative hypotheses regarding specific variables to be included in the present analysis.

A study of f. o. b. prices of Midwestern canned tart cherries (25, p. 16-17) indicates that a measure of per capita supply of processed tart cherries and a trend variable have important influences upon price. (By expressing quantity supplied on a per capita basis, population was included as an implicit variable in this study.) F. o. b. prices of canned California cling peaches, Pacific Coast freestone peaches, and California apricots have also been analyzed by Hoos (19). The results indicate that the three factors of canners' movement, disposable income, and an index of competing canned fruit prices are important in the explanation of f. o. b. prices of these other fruits as well as for canned pears.

Studies of farm prices of other cannery fruits may also be useful in formulating tentative hypotheses for Bartlett-pear prices. In a study conducted by Oldenstadt and Pasour (29, p. 14-19) concerning farm prices of U.S. apples for processing, the following variables were found to have an important influence on price: (1) an estimate of the apple crop, (2) stocks of processed apples, (3) farm prices of fresh apples, and (4) a trend variable. In a similar analysis, statistical results obtained by Brandow suggest that farm prices of U.S. apples for canning are influenced to a large extent by: (1) production utilized for canning, (2) general food prices, (3) military purchases and exports of canned apples, and (4) carry-in stocks of canned apples (1, p. 10-16). Results of a study by French and Bressler (15, p. 1026-1028) indicate that: (1) per capita sales, (2) per capita disposable income, and (3) a time factor are important variables in their effect upon farm prices of California lemons sold for processing.

Demand model for cannery Bartletts. In light of (1) general economic principles, (2) specific knowledge of the canning-pear market, and (3) results of previous studies, the following generalized theory regarding farm prices of Bartlett pears for canning was formulated:

$$P_{BC} = f(Q_T, Q_C, Q_{MNY}, P, Y, I_{PCF}, S_{CP}, C, E_C, G, u_1 \ldots u_n)$$

where: P_{BC} = farm price of Pacific Coast Bartlett pears for canning

Q_T = total quantity of Bartlett pears produced in Pacific Coast states

Q_C = quantity of Pacific Coast Bartlett pears sold for canning

Q_{MNY} = quantity of pears produced in Michigan and New York

P = U. S. population

Y = U. S. disposable income

I_{PCF} = index of prices of competing canned fruits

S_{CP} = stocks of canned pears at beginning of the marketing year

C = processing costs for canning pears

E_C = exports of canned pears

G = the general price level

$u_1 \ldots u_n$ = other unspecified variables

It will be noted that this theoretical model includes several variables (Q_T, Q_C, Q_{MNY}, and S_{CP}) which are measures of quantities of Bartlett pears or closely competing pear products. Population, disposable income, and prices of competing fruits are included as variables which are commonly believed to affect consumer demand, and hence to influence farm price. Exports of canned pears are included because it is recognized that the domestic market is not the sole source of demand for this product. The unspecified variables ($u_1 \ldots u_n$) are those which lead to unexplained variations in price. A more detailed discussion of the rationale behind the inclusion of each variable is presented in a following section.

The Fresh Market

The fresh market for Bartlett pears normally absorbs about 25 percent of the Pacific Coast crop (Table 1). Pears for the fresh market are sometimes sold by farm producers to wholesale packer-shippers for a cash price at the time of delivery. In many production areas, however, a more common arrangement is that of fresh sales on a commission basis, or through cooperative organizations. In this case, growers are paid a return which is based on prices received by the packer-shipper for packed fruit, minus all costs for packing, grading, and shipping. Overall grower returns for fresh sales are thus determined, in part, by cash prices paid by packer-shippers and, in part, by grower returns from commission sales.

In the fresh market, the number of first-handlers (packer-shippers) is larger than is the case in the processing market and hence, a greater degree of competition is found on the buyer side of the fresh market. On the other hand, because of the relative importance of commission sales in the fresh market, the number of first-handler buyers is less likely to have an effect upon price determination in this market than in the processing market.

Demand conditions for fresh Bartletts, as well as for processing pears, at the farm level are derived from demand conditions at marketing levels which are nearer the final consumers. However, because fresh marketings involve a higher percentage of commission sales, and because marketing costs for fresh pears usually represent a smaller percentage of retail price, demand conditions for farm sales of fresh Bartletts can be expected to be more closely associated with changes in consumer demand than is the case in the processing market. Therefore, the effects of certain demand conditions, such as population, disposable income, and prices of competing fruits, may be substantially different in the two markets.

Hypotheses regarding the relevant variables in a demand relationship for fresh Bartlett pears are suggested by results of previous studies of fresh pear prices. A study by Pubols (30) of the factors which influence farm prices of fresh Pacific Coast Bartlett pears indicates that (1) production of Pacific Coast Bartletts, (2) disposable personal income, (3) stocks of canned pears, and (4) production of Pacific Coast pears other than Bartlett were important factors in determining prices.[1]

[1]The impact of canned stocks upon farm prices of fresh Bartletts is probably exerted through the effect on cannery prices. Prices for cannery pears affect producers' decisions to sell in the canning or fresh market, and hence, influence the quantity of fresh sales. The quantity sold in the fresh market, in turn, influences the price of fresh Bartletts. These indirect effects upon price exemplify the complex interrelationships which exist between the fresh and processing markets for Bartlett pears.

Sindelar found in a study of winter-pear prices that a large percentage of annual variations in f.o.b. price at the shipping point level were explained by the following factors: (1) domestic supplies of winter pears, (2) consumer income, (3) fresh sales of Eastern apples, (4) shipments of Washington Delicious apples, and (5) fresh sales of California Bartlett pears (35). Because winter pears and fresh Bartlett pears are similar products, factors which have an important effect upon winter pear prices may also be important determinants of price for fresh Bartlett sales.

On the basis of theoretical considerations and results of previous studies, the following theory is formulated regarding the determination of farm prices of Pacific Coast fresh Bartlett pears:

$$P_{BF} = g(Q_T, Q_F, Q_{MNY}, Q_{WP}, I_{PFF}, P, Y, E_F, G, u_m \ldots u_q)$$

where: P_{BF} = annual-average grower returns for fresh sales of Pacific Coast Bartlett pears

Q_T = total production of Pacific Coast Bartlett pears

Q_F = quantity of Pacific Coast Bartlett pears sold fresh

Q_{MNY} = quantity of pears produced in Michigan and New York

Q_{WP} = quantity of winter pears produced in Pacific Coast states

I_{PFF} = an index of prices of competing fresh fruits

P = U.S. population

Y = U.S. disposable income

E_F = exports of fresh pears

G = the general price level

$u_m \ldots u_q$ = other unspecified variables

The variable which expresses quantity of Bartletts which are sold fresh (Q_F) is essentially the difference between total production (Q_T) and that sold for canning (Q_C); although relatively minor quantities are also utilized for drying and other uses. An index of prices of competing fresh fruits (I_{PFF}) involves a different group of fruits than those included in the index of prices of competing canned fruits (I_{PCF}). Alternatively, indices of quantities of competing fruits may be used in the models for either the fresh market or processing market because of the importance of production in determining prices of competing fruits.

Unspecified variables, which account for the unexplained variation in fresh prices, probably include a different set of variables than those which account for the unexplained variation in cannery prices. However, some of the same unspecified variables may be included in both groups.

Factors Which Influence Grower Returns from All Sales

One of the major objectives of this study was to analyze and predict future levels of grower returns from all sales of Pacific Coast Bartlett pears. Therefore, it is necessary to develop a theoretical description of demand conditions in the total market (all sales) of Bartlett pears.

Grower returns from all sales are, of course, determined by price conditions in both the processing market and the fresh market for Bartletts. Consequently, a theoretical description of price determination in the overall market for Bartlett pears would be expected to include variables which are important only in the fresh market, variables which are important only in the processing market, and variables which are important in both of these markets.

Several previous studies of farm prices of fruits which can be marketed fresh or for processing suggest possible independent variables to be included in the overall analysis. In an analysis of grower returns for all sales of all Pacific Coast pears (including both Bartletts and winter pears), Pubols found that the following variables explained 91 percent of price variations during the 1942-54 period: (1) total production of Pacific Coast pears, (2) disposable personal income, (3) stocks of canned pears, June 1, and (4) production of pears other than Pacific Coast (30). Results of a study by French of U.S. farm price of apples (all sales) indicated that 94 percent of the variations in these prices were explained by: (1) U.S. total production of apples sold in the United States, (2) index of per capita disposable income, and (3) U.S. total per capita consumption of oranges, pears, and bananas (14, p. 8).

Demand model for all Bartlett sales. The theoretical demand relationship outlined for the fresh market and for the processing market were combined into a model of the total market (all sales) for Bartlett pears. For this purpose, the following demand equation was formulated for grower returns from all Bartlett sales:

$$P_{BAS} = h(Q_T, Q_{MNY}, Q_{WP}, I_{QFF}, I_{QCF}, S_{CP}, C, P, Y, E, G, u_1 \ldots u_q)$$

where: P_{BAS} = grower returns for Pacific Coast Bartlett pears -- all sales

Q_T = total production of Pacific Coast Bartlett pears

Q_{MNY} = quantity of pears produced in Michigan and New York

Q_{WP} = quantity of winter pears produced in Pacific Coast states

I_{QFF} = an index of quantities of competing fresh fruits

I_{QCF} = an index of quantities of competing fruits for canning

S_{CP} = stocks of canned pears at beginning of year

C = processing costs for canning pears

P = U. S. population

Y = U. S. disposable income

E = moving average of exports of all pears in period t-1

G = the general price level

$u_1 \ldots u_q$ = other unspecified variables

Rationale of the variables included. A discussion of the logic behind the inclusion of each of the variables in the above equation and the manner in which price is influenced by each is presented in this section.

1. Total production of Pacific Coast Bartlett pears (Q_T). The economic notion of a demand (price-quantity) relationship strongly suggests that some measure of quantity or production of Bartlett pears is of major importance in determining grower prices. The relationship between price and quantity is expected to be an inverse one; that is, the sign of the coefficient for this variable in the estimating equation is expected to be negative.

2. Quantity of pears produced in Michigan and New York (Q_{MNY}). This variable is included as a quantity measure of a product which competes closely with Pacific Coast Bartlett pears (and is, in fact, indistinguishable to many consumers in either the canned or fresh form from Pacific Coast Bartletts). It is included as a separate variable, however, because of the geographical differences in the production areas. An inverse relationship between this quantity variable and price is hypothesized. Therefore, a negative coefficient for this variable in the estimating equation is expected.

3. Quantity of winter pears produced in Pacific Coast states (Q_{WP}). Winter pears would logically be expected to be an important competing fruit in the fresh market because of the similarity in the two products. Although winter pears are only one of many competing fresh fruits, it was felt that this fruit was important enough in its effect upon Bartlett pear price to include it as a separate variable in order to isolate and quantify its effect.

The main direct effect of winter pears would be expected to be felt at the retail level through the effect of winter pear prices on consumption and retail prices of fresh Bartletts. However, the price of winter pears is probably influenced in turn by the price of fresh Bartletts -- the independent variable in the present analysis. Therefore, the price of winter pears is not a true independent or exogenous variable. In addition, price of winter pears is probably influenced by some of the same variables which influence the price of Bartletts -- such as other competing fruits, population, and disposable income. Thus, one might expect multi-colinearity between these variables and the price of winter pears.

Both of these problems can be avoided, to a large extent, by the use of total production of winter pears as a measure of the effect of winter pears on prices of Bartletts. The quantity produced of winter pears is determined to a large extent by exogenous weather conditions, bearing acreage, and pre-harvest cultural practices.

Thus, a measure of quantity of winter pears more nearly meets the qualifications of an independent or exogenous variable than does a measure of winter-pear price.

Increases in the production of winter pears would be expected to lower winter-pear prices and hence the price of Bartletts. For this reason, a negative coefficient for this variable is expected in the estimating equation.

4. Index of quantities of competing fresh fruits (I_{QFF}). Other competing fresh fruits can be expected to exert an influence upon prices of Bartlett pears in a manner similar to that of winter pears. Important competing fresh fruits probably include such fruits as apples, peaches, grapes, bananas, and oranges. An index of quantities of competing fruits rather than a price index was included in the demand equation for the reasons which were outlined in the above discussion concerning winter pears. Similarly, the coefficient for this variable would be expected to be negative.

5. Index of quantities of competing fruits for canning (I_{QCF}). Canned pears must compete at the retail level with many other canned fruits, such as cling peaches, freestone peaches, fruit cocktail, apricots, apple sauce, pineapple, sweet cherries, and purple plums. An idea of the relative importance of each of these competing canned fruits may be gained from examination of the average size of pack (actual cases) of each during the 1958-62 period:

(1) cling peaches - 25 million cases, (2) freestone peaches - 8.6 million cases, (3) fruit cocktail - 17.7 million cases, (4) apricots - 5.3 million cases, (5) apple sauce - 18.7 million cases, (6) pineapple - 20.4 million cases, (7) sweet cherries - 1.4 million cases, (8) purple plums - 1.6 million cases, and (9) fruit salad - 1.1 million cases (22).[1] In terms of volume, price competition, and trade acceptance, cling peaches are probably the most important of these competing canned fruits.

The main direct effect of competing canned fruits is probably exerted through retail price levels. Retail prices of competing fruits influence the retail price of canned pears, which is, in turn, reflected through the marketing channels to farm prices. Prices of competing fruits, however, are not true independent variables for reasons similar to those discussed in the section on winter pears. Therefore, an index of quantities of competing canned fruits was again used instead of a price index.

The number of cases of canned product may seem to be the most appropriate measure of quantities of competing canning fruits which affect pear prices. However, canners must make their decisions regarding farm prices for cannery pears before the pack of

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[1] By comparison, the canned pear pack averaged 11.1 million cases during this same period.

most competing fruits is complete. Therefore, prices for cannery pears are probably based on estimates of farm production of competing fruits which will be sold for canning. The index used for this independent variable, therefore, is based upon farm sales of competing fruits for canning.

Increases in quantities of competing fruits for canning would be expected to result in lower prices for Bartlett pears. A negative sign for the coefficient of this variable is, therefore, anticipated.

6. Stocks of canned pears (S_{CP}). Stocks of canned pears which are carried over from the previous year's pack would be expected to influence prices of cannery Bartlett pears in a negative manner. If canners' stocks are larger than normal at the beginning of the marketing year, they will tend to pay a lower price for the new crop of pears than if carry-over stocks are relatively small. This pricing reaction to a large carryover on the part of canners is engendered by the fact that lower retail and f. o. b. prices will be necessary to move the resulting large total supply of canned pears, if other factors remain constant. A negative sign for the coefficient of this variable would be expected in view of the inverse relationship which is hypothesized.

7. Processing costs for canning pears (C). It is assumed that prices which canners pay for cannery pears are influenced by net profits which are obtainable from processing this product. These

profits are influenced by costs associated with processing and marketing the product as well as by the f. o. b. prices which can be realized from the canned pears. Because canners' costs influence profits, these costs can be expected to influence canners' demands for the raw product and, hence, the farm prices of cannery pears.

In addition to prices of the raw product, processing costs are influenced by prices of variable inputs such as labor, materials, and utilities. The technology used and quality of the raw product also influence the case yield of a ton of pears and, hence, the cost per case of canned product.

The amount of fixed costs, such as are associated with building and machinery investments, must also be considered in determining costs of canning. Fixed costs per case of canned product are influenced by the number of cases canned in a season with a given set of plant resources. For this reason, canners attempt to utilize their plant capacity as fully as possible throughout the processing season. Relatively large plant capacities on the part of the canning industry will tend to strengthen demand for cannery pears.

Accurate estimates of canners overall costs are difficult to obtain without a thorough survey of the pear-canning industry. This difficulty is posed by the fact that published sources of canning costs are virtually nonexistent. Although it is recognized that canning costs have an influence upon prices of cannery pears, sufficient resources were not available to undertake a survey of canners' costs in connection with this study. As a result, accurate data regarding detailed costs of pear canners were not available; and alternative measures of this variable were sought. In general, however, increases in canning costs, with other factors remaining constant, would be expected to lower processor demand and price of cannery pears; while decreases in canning costs per case would increase processor demand and thus tend to raise farm prices of cannery Bartlett pears. Therefore, a negative relationship between canning costs and pear prices would be expected.

8. United States population (P). The number of persons and, hence, the number of potential customers in the economy is expected to affect the demand for a product such as Bartlett pears in a positive manner. Assuming that consumer tastes and preferences do not change, an increase in population would increase demand and raise pear prices. The coefficient for this variable is, thus, expected to be positive.

9. United States disposable income (Y). Increases in disposable income in the economy would be expected to raise prices of Bartlett pears. Because canned and fresh fruits are relatively unessential food items, the income-elasticity for these fruits would

be expected to be relatively high in relation to some other foods. Pubols results, in fact, indicate that a one percent increase in disposable income was associated with an increase in farm price of 2.9 percent for fresh Bartletts and 4.0 percent for cannery Bartletts during the 1942-54 period (30). A positive coefficient is expected for the disposable income variable in the demand equation.

10. Exports of pears (E). Because a portion of the crop is sold in foreign markets, export demand factors have an influence upon price levels of Bartlett pears. Although factors in importing countries such as population, disposable income, consumer tastes, and prices of competing products undoubtedly influence consumer demand for imported pears, one of the most important factors in determining effective demand for U.S. pears in these countries is the degree of trade restrictions such as tariffs, quotas, license requirements, etc. which are imposed by the importing (and potential importing) nations. These trade restrictions are determined by political considerations and by economic planning decisions of the various foreign governments. Because trade restrictions are based on decisions which are essentially political in nature, estimating patterns of change in these restrictions on an economic basis is, to a large extent, futile.

Nevertheless, exports are of sufficient importance in the total market for Bartlett pears that their consideration in an analysis of demand conditions is advisable for purposes of completeness.[1] Therefore, export sales are included in the demand model. An increase in export sales would, of course, be expected to increase total demand for pears and hence raise the price level.

On the other hand, quantity of exports would logically be expected to be influenced by pear prices in the United States. Therefore, quantity of exports within a given year would not be a strictly independent variable in the determination of pear prices in that year -- but rather one which is simultaneously determined. For this reason, exports during a period immediately preceding the time period in question were used as a measure of the export variable. One reason for the use of a lagged measure of exports is that buyer-seller relationships are established as a result of previous transactions, and that the parties involved strive to maintain these trade relationships in so far as possible (10, p. 2). Another reason is that the degree of trade restrictions would be expected to be similar from one year to the next; and therefore, exports in immediately previous periods would give a fairly accurate estimate of export

[1] Canned pear exports averaged 23,500 T. (fresh basis) per year for the five-year period 1958-62 (36), which was an average of about seven percent of all sales for canning. A large portion of these canned pear exports were in the form of fruit cocktail. During this same period exports of fresh Bartletts averaged 13,600 tons per year, or about 12 percent of fresh Bartlett sales.

demand in the current year. To account for fluctuations in export levels due to annual variations in size of the crop, a moving average of annual export levels during two previous years was used. Such a measure of export levels is determined independently of prices in the current year.

Increases in average export levels in previous years would be expected to be associated with expanded buyer-seller relationships and to indicate reductions in effective trade barriers. Therefore, such increases in previous exports would be expected to indicate continued high levels of exports and tend to raise pear prices. A positive relationship and coefficient are, thus, indicated.

11. The general price level (G). Prices received by farmers for Bartlett pears would be expected to rise and fall with fluctuations in the general price level and to move in the same direction as prices in general. Changes in the general price level, of course, measure the degree of inflation which is present in the economy. This factor may be included explicitly as a separate variable in the demand equation or it may be incorporated in an implicit manner by expressing price variables in terms of constant dollars.

12. Other unspecified variables ($u_1 \ldots u_q$). Unspecified variables in the model include all variables which account for the unexplained variation in grower price of Bartlett pears. Variables in this category are unspecified in the analysis because: (1) accurate

measurement is impossible due to a lack of data, or (2) the average influence of each variable is believed to be insufficient to warrant their inclusion.

Changes in consumer tastes are presumably included in this category of unspecified variables. Although consumer tastes are one of the basic determinants of demand, measurement of such tastes is extremely difficult. For this reason, such a variable is not specified in the demand equation.

Factors which may be classified as changes in the "psychological outlook" of processors and other buyers which are not explained by changes in the specified variables may also be included in the unspecified group. Such factors are usually difficult to measure or do not follow a discernable pattern in respect to observed changes.

Statistical Results

Hypotheses regarding the relevant variables to be included in the demand equation were tested by the use of least-squares multiple regression analyses. Through the use of the least-squares method of estimation, the square of the unexplained residual term (u) is minimized. The least-squares method involves the following assumptions regarding the residual term (u):

1. The u term for each equation is a random variable.
2. The average, or expected, value of u is equal to zero.

3. The u's have a constant variance -- σ^2.

4. The u for one set of observations is not correlated with the u for any other set of observations; that is, the u's are independent of one another.

5. The u is not correlated with any independent variable in the equation.

Based upon the theoretical formulation of the variables in the equation, it appears that none of these assumptions are violated in the demand model.

Selection of the Time Period

Series of data for most of the independent variables in the demand equation were available on an annual basis from 1925 until the present time. Data for the war years (1941-46) were omitted from the analysis because of government price controls and other abnormal conditions during and immediately after World War II.

The data were divided into two time-series (1925-41 and 1947-62) in order to explore the possibility that effects of various demand factors on Bartlett-pear prices have changed noticeably from the pre-war to the post-war period. Results of preliminary step-wise regression analyses indicated that substantial changes have occurred between these two periods in the relative importance of various independent variables as well as in the magnitude of the effects of each upon pear prices. (A summary of these results are presented in Appendix B-2.) Therefore, the most recent time period was selected for further analysis because of the greater likelihood that market conditions in the more recent past will reflect conditions in the future. Annual data from this time period provide a total of 16 observations for the independent and dependent variables in the demand analysis.

Modifications of the Demand Equation

Certain modifications in the general demand equation presented in the foregoing sections seemed desirable.

Population was included as an implicit variable rather than as a specific variable by expressing all quantity variables on a per capita basis. Thus, the quantity variables Q_T, Q_{MNY}, Q_{WP}, I_{QFF}, and I_{QCF} were all expressed on the basis of tons per 1,000 persons of U. S. population, while S_{CP} was expressed on the basis of cases per 1,000 persons.

The general price level was also included in an implicit manner by expressing price variables on a basis of constant dollars. This was accomplished by adjusting such price variables as disposable income (Y) and grower returns for Bartlett pears (P_{BAS}) for changes in the Department of Labor Consumer Price Index (1957-59 = 100) (48, p. 260). Both population and the general price level (as measured by the Consumer Price Index) were incorporated into the other variables in order to increase the degrees of freedom. The degrees of freedom were relatively low because only 16 observations were available in the post-war period and because of the relatively large number of independent variables used.

Because accurate data were unavailable regarding processing costs for canning pears, an attempt was made to include an alternative measure of canners' profits. One alternative measure which was tried for this purpose was that of season average f.o.b. price of canned pears during the previous marketing season (f.o.b. price in year t-1). Another alternative which was used as a measure of profit in a previous period is that of gross profit per case, i.e., f.o.b. price (per case) minus raw product cost per case.[1]

It is hypothesized that a relatively high profit per case in one period will tend to lead canners to pay high farm prices for cannery pears in the next period. A positive sign on the partial regression coefficient would, therefore, be expected.

Although Bartlett pears are exported in both the fresh and the

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[1]Raw-product cost per case was found by dividing the average farm price for cannery Bartletts (per ton) by the average case yield per ton of raw product. Raw-product cost per case reflects changes in canning costs which are due to technological changes that affect case yield. Thus, the effects of increased case yield, and the resulting lower canning costs per case, from recent improvements in peeling techniques presumably will be reflected in this measure.

canned form, data regarding exports of fresh pears were not available by variety for the entire period of the analysis. For this reason, it was impossible to determine quantities of fresh Bartlett exports. Exports of canned pears, on the other hand, can be assumed to be primarily Bartletts. Because of the nature of available export data, exports of canned pears were used as the measure of Bartlett-pear exports.

With these modifications, the demand equation which was estimated by the least-squares stepwise regression procedure has the following form:

$$\hat{Y}_1 = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9$$

where: $\hat{Y}_1$ = average annual grower returns per ton of Pacific Coast Bartlett pears -- all sales, expressed in real terms (1957-59 dollars)

X_1 = total farm production of Pacific Coast Bartlett pears in tons per 1,000 persons of U.S. population

X_2 = total production of pears in Michigan and New York in tons per 1,000 persons

X_3 = total production of pears other than Bartlett in Pacific Coast states in tons per 1,000 persons

X_4 = index of quantities of competing fresh fruits, adjusted for population changes

X_5 = index of quantities of competing fruits for canning, adjusted for population changes

X_6 = canners' stocks of canned pears -- beginning of year - cases per 1,000 persons

X_7 = measure of canners' profit in period t-1, expressed in real term (1957-59 dollars)

X_8 = U. S. disposable income per capita, expressed in real terms (1957-59 dollars)

X_9 = two-year moving average of exports of canned pears in period t-1 (tons)

Results of Regression Analyses

Stepwise regression procedures were used to evaluate the effect of each of the independent variables upon price and to provide an estimating equation for the dependent price variable (Y_1). Various alternative measures were tested for several of the independent variables. From the various alternative measures and combinations of the variables analyzed, the most satisfactory price-estimating equation was selected on the basis of statistical properties and the accuracy of price estimates resulting from such an equation. The following price-estimating equation, which is based on data for the period 1947-62[1], was selected:

[1] This price-estimating equation was brought up to date by the use of data for the period from 1948 to 1963. The results are presented in Appendix B-7. along with comparisons of estimated and actual prices for this period.

$$\hat{Y}_1 = -1.16675 - 43.47234\,X_1 - 77.60454\,X_2 + .98502\,X_5 - 46.52603\,X_6$$
$$\qquad (-5.95756)^{***}\quad (-2.29239)^{**}\quad (-5.39076)^{***}\quad (-5.31243)^{***}$$

$$+ .00196\,X_9$$
$$(1.94492)^{*}$$ [1]

$R^2 = .945$ [2]

Standard Error Y.X = 10.35559

where: $\hat{Y}_1$ = first difference average annual grower returns per ton for Pacific Coast Bartlett pears -- all sales, expressed in real terms (1957-59 dollars)

X_1 = first difference total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

X_5 = first difference average annual grower returns of California cling peaches for canning, expressed in real terms (1957-59 dollars)

X_6 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases -- 24 No. 2½ basis per 1,000 persons)

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[1] Figures in parenthesis are t-ratios of the regression coefficients. The t-ratio of the coefficient for X_1, X_5, and X_6 are each significant at the one percent level (***) while that for X_2 is significant at the five percent level (**) and that for X_9 is significant at the ten percent level (*).

[2] The term R^2 is the coefficient of multiple determination. In this case an R^2 value of .945 means that the five independent variables explain 94.5 percent of the variation in year-to-year change (first difference) in average annual grower returns per ton for Pacific Coast Bartlett pears -- all sales.

X_9 = first difference two-year moving average of canned exports in period t-1 (tons)

It will be observed that the dependent and independent variables in the estimating equation are expressed in terms of first differences which measure year-to-year change in the respective variables. First differences are used in preference to actual data when a high serial correlation exists between successive unexplained residuals of an estimating equation (12, p. 30). Although inspection of the unexplained residuals suggested the existence of serial correlation, a Durban-Watson test for serial correlation of the residuals (9) proved inclusive at the five percent level of significance. However, a preliminary regression analysis in which the variables were expressed as first differences yielded an estimating equation with a substantially higher R^2 value (R^2 = .908) than was obtained with the use of actual data (R^2 = .745) (Appendix B-3). Therefore, an equation in which the variables were expressed as first differences was accepted.

It will be noted that the price-estimating equation includes grower price of California cling peaches (X_2) as a measure of the effects of competing canning fruits. Several quantity indices of competing canning fruits were analyzed as alternative measures of this variable before grower price of cling peaches was accepted as the most satisfactory measure. The following quantity measures of competing canning fruits were analyzed: (1) an index of canning sales of

California cling peaches, Pacific Coast freestone peaches, California apricots, and Pacific Coast canning prunes (each expressed on a per capita basis), (2) a similar index including California cling peaches, Pacific Coast freestone peaches, and California apricots; and (3) quantity of Pacific Coast cannery peaches (cling and freestone) in tons per 1,000 persons.

Statistical results of stepwise regression analyses show a positive sign on the partial regression coefficient for each of these quantity measures (Appendix B-4). A positive relationship is not in agreement with the economic logic presented in a previous section (pages 33-35)[1]. Therefore, these measures of competing canning fruits were rejected.

Because California cling peaches are the single most important competing cannery fruit, grower price of cling peaches was used as an alternative measure of this variable. Satisfactory statistical results were obtained with the use of this price measure; and it was, therefore, included in the demand equation for Bartlett pears.

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[1]A possible explanation of this positive relationship between quantities of competing canning fruits is that cling peaches (the competing fruit of greatest importance) and Bartlett pears are both important ingredients of fruit cocktail. A large cling peach crop usually gives rise to a large pack of fruit cocktail and may, therefore, raise demand for the complementary ingredient of cannery Bartlett pears.

Variables Which were Excluded from the Demand Equation

The following variables were not included in the final estimating equation: (1) total production of Pacific Coast pears other than Bartlett (Q_{WP}), (2) a measure of quantities of competing fresh fruits (I_{QFF}), (3) a measure of canners' costs or profit in period t-1 (C_{t-1}), and (4) U. S. disposable income per capita (Y).

The variable Q_{WP} was excluded because regression analyses indicated: (1) the partial regression coefficient exhibited a sign which was inconsistent with economic logic. (2) The t-ratio for the partial regression coefficient was not significantly different from zero. (3) Inclusion of the variable did not materially raise the R^2 value of the estimating equation (Appendix B-1). The variables Y and C_{t-1} were also excluded because the results indicated one or more of the above conditions in each case (Appendix B-1).

Several alternative indices of quantities of competing fresh fruits were evaluated. These alternative indices included: (1) an index of fresh sales of U. S. apples, U. S. peaches, and California nectarines, plums, grapes, and oranges per 1,000 persons of U. S. population, (2) an index of fresh sales of U. S. apples, U. S. peaches, and California nectarines, plums, and grapes per 1,000 persons, and (3) an index of fresh sales of U. S. apples, U. S. peaches, and California grapes weighted by average grower price per ton for each fruit and expressed in tons per 1,000 persons. In addition, the amount of fresh sales of U. S. apples in tons per 1,000 persons was included as an alternative quantity measure of competing fresh fruits.

On the basis of economic logic, a quantity measure of competing fruits would be expected to have a negative sign on the partial regression coefficient. Results of regression analyses, however, showed a positive sign for each of the alternative fresh fruit indices (Appendix B-5). In addition, the t-ratio of the partial regression coefficient for the price-weighted index was not significantly different from zero (Appendix B-1). Although the measure of fresh sales of U. S. apples exhibited a negative sign, the t-ratio was not significantly different from zero (Appendix B-5). For these reasons, the variable which expresses a quantity measure of competing fresh fruits was excluded from the final demand equation.

The alternative measures of canners' costs or profit in period t-1 were discussed in a previous section (page 44). Three alternatives measures of this variable were analyzed: (1) season average f. o. b. price per case of canned pears (24 No. $2\frac{1}{2}$ basis) in year t-1, expressed in real terms (1957-59 dollars), (2) gross profit per case (f. o. b. price minus raw product cost per case) in year t-1, expressed in real terms, and (3) three-year average of gross profit per case for previous three years (period t-1), expressed in real terms.

Statistical results of a regression analysis using the first alternative (f. o. b. price in year t-1) showed a negative sign for the partial regression coefficient, which is not in agreement with the logic developed in a previous section.[1] The t-ratio of the partial regression coefficient was also generally not significantly different from zero at the five percent level (Appendices B-2 and B-4). Similarly, statistical results which were obtained with the other alternative measures (gross profit per case in year t-1 and three-year average gross profit per case in period t-1) indicate negative coefficients for which the t-ratios were generally not significantly different from zero (Appendices B-1 and B-6). On the basis of these statistical results, none of the measures of canner profit in a previous

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[1] One possible explanation of the negative coefficient for this variable may be attributed to trade practices on the part of retailers. That is, short supply of available canned pears which is normally accompanied by high prices, reduces the volume of canned pears which retailers can handle during that year, and hence, encourages them to reduce shelf space and promotional activities devoted to canned pears. These practices tend to be continued over time. Therefore, if a larger quantity of canned pears becomes available in a later year, a large decrease in price will be necessary to encourage retailers to once again increase their shelf space and promotional activities to the original level.

Effects of these retailer actions upon pear prices may be strengthened by changes in consumer buying habits. That is, consumers who are originally discouraged from buying pears by relatively high prices in the previous period may continue to purchase substitute products through the force of habit, even after prices of canned pears fall to their original levels.

Because of these changes in consumer buying habits and retailer trade practices, a large increase in price in one period may, in itself, lead to lower prices in a later period.

period were deemed satisfactory. This variable was, therefore, excluded from the demand equation.

Economic Interpretation and Implications of the Price-estimating Equation

The economic interpretation of the resulting equation can be summarized as follows:

1. An increase in total farm production of Pacific Coast Bartlett pears of 0.1 ton per 1,000 persons of United States population, considered by itself, will result in a decrease in annual average grower returns for all sales of Pacific Coast Bartlett pears of $4.35 per ton, in real terms.

2. An increase in production of all pears in Michigan and New York of 0.1 ton per 1,000 persons of United States population, considered by itself, will result in a decrease in annual average grower returns for all sales of Pacific Coast Bartlett pears of $7.76 per ton, in real terms.

3. An increase in annual average grower returns for California cling peaches for canning of one dollar per ton, expressed in real terms, will result in an increase in annual average grower returns for all sales of Pacific Coast Bartlett pears of $.99 per ton, in real terms, if the other variables remain constant.

4. An increase in canners' stocks of canned pears at the

beginning of the year (June 1) of 100 cases (24 No. $2\frac{1}{2}$ basis) per 1,000 persons of U. S. population, considered by itself, will result in a decrease in annual average grower returns for all sales of Pacific Coast Bartlett pears of $4.65 per ton, in real terms.

5. An increase in the two-year average of canned pear exports in period t-1 of 1,000 tons, considered by itself, will result in an increase in annual average grower returns for all sales of Pacific Coast Bartlett pears of $1.96 per ton, in real terms.

Results of the step-wise regression analyses indicate that Pacific Coast production of Bartletts is the single most important factor in determining farm price of Bartlett pears, and that this variable alone explains about 57 percent of the variation in grower price (Appendix B-1). Therefore, changes in production because of changes in bearing acreage or average yields per acre will have an important influence upon price.

The fact that the five independent variables -- Pacific Coast production, production in Michigan and New York, California cling-peach price, canners' stocks, and canned-pear exports -- explain approximately 95 percent of the variation in farm price of Bartlett pears indicates that the resulting equation may provide a useful mathematical tool for predicting future price levels. It should also be noted that the factors of population and the general price level are implicitly included in the demand equation.

Comparison of Estimated Prices with Actual Prices

The demand equation can be used to estimate real prices for Pacific Coast Bartlett pears (all sales) at the farm level. An indication of the accuracy of these estimates can be gained from a comparison of estimated and actual prices within a given period. Estimated real farm prices during the period from 1947 to 1962 are presented in Table 2 along with actual prices for purposes of comparison. A graphic comparison of these actual and estimated prices is presented in Figure 4.

Prices in Table 2 show that during the sixteen-year period from 1947 to 1962 the average absolute difference between actual and estimated price was $6.90 per ton or about nine percent.

Price-estimating Equation for Cannery Bartlett Pears

A demand or price equation was also estimated for Pacific Coast Bartlett pears sold for canning. This analysis included those independent variables which were hypothesized to be important factors in the determination of farm prices for cannery Bartlett pears. Because canning sales are a major component of all sales of Bartlett pears, some of the same independent variables were included in both analyses.

The demand equation for cannery Bartlett pears which was

Table 2. Actual and estimated real farm prices for all sales of Pacific Coast Bartlett pears, 1947-62.

Year	Actual Price (Dollars per Ton)	Estimated Price (Dollars per Ton)	Difference (Dollars per Ton)	Percent Difference
1947	$ 96.97	$110.01	-13.04	13.44
1948	131.90	142.14	-10.24	7.76
1949	38.67	44.00	- 5.33	13.78
1950	98.91	98.23	0.68	0.69
1951	108.41	107.59	0.82	0.76
1952	54.95	58.66	-3.71	6.75
1953	72.85	65.95	6.90	9.47
1954	80.74	77.55	3.19	3.95
1955	77.58	88.74	-11.16	14.39
1956	83.67	74.47	9.20	11.00
1957	65.64	50.69	14.95	22.78
1958	80.07	77.66	6.41	8.01
1959	65.72	77.42	-11.70	17.80
1960	83.07	80.95	2.12	2.55
1961	88.80	80.09	8.71	9.81
1962	65.31	63.00	2.31	3.54

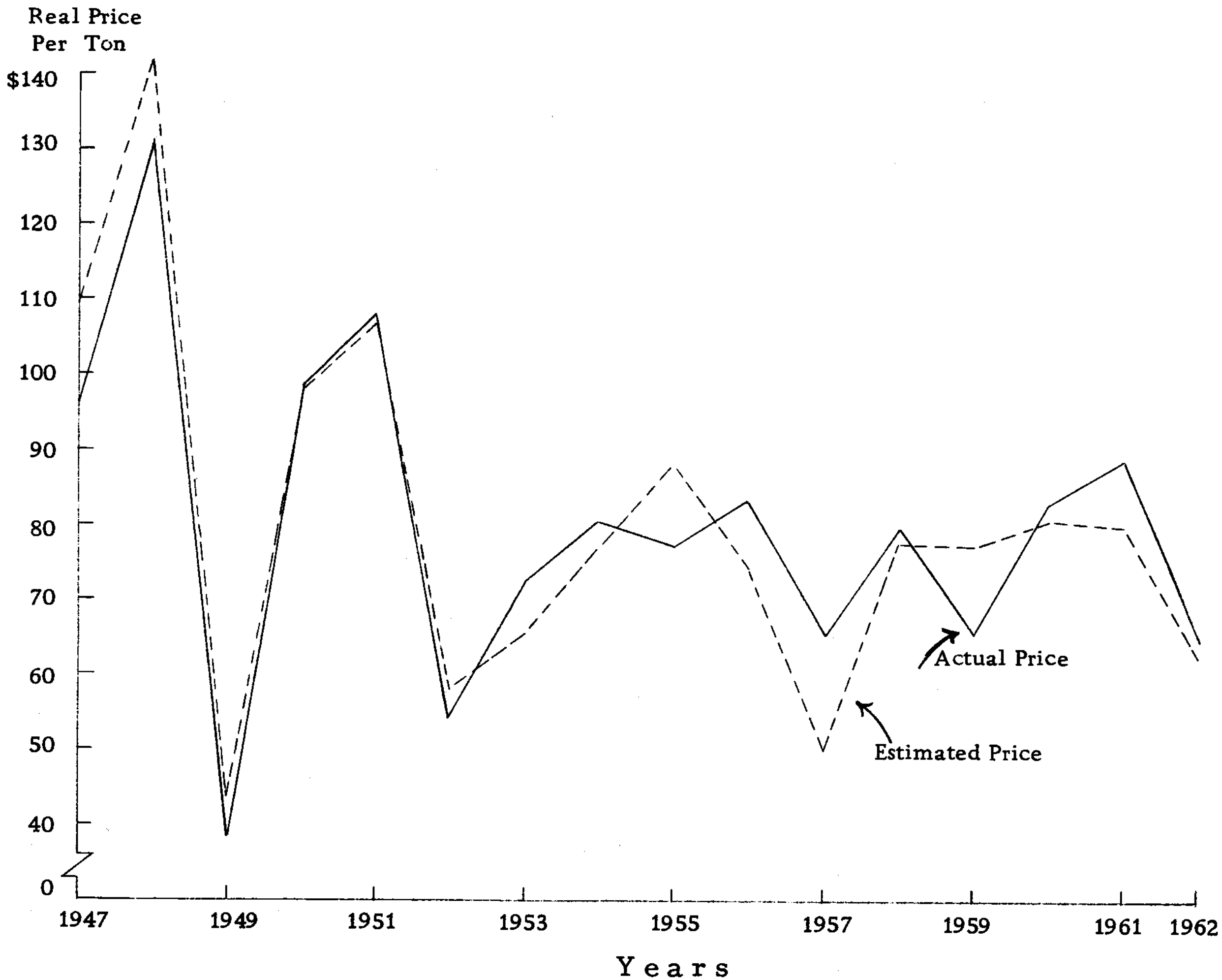

Figure 4. Actual and estimated real farm prices for all sales of Pacific Coast Bartlett pears, 1947 - 1962.

estimated by the stepwise least-squares regression procedure has the following form:

$$\hat{Y}_2 = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7$$

where: $\hat{Y}_2$ = annual average grower returns per ton of Pacific Coast Bartlett pears sold for canning, expressed in real terms (1957-59 dollars)

X_1 = total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = total production of pears in Michigan and New York (tons per 1,000 persons)

X_3 = index of quantities of competing fruits for canning; or alternatively, farm price of California cling peaches for canning, expressed in real terms (1957-59 dollars)

X_4 = canners' stocks of canned pears at the beginning of year (June 1) (1,000 cases -- 24 No. 2½ basis -- per 1,000 persons)

X_5 = measure of canners' costs or profit in period t-1, expressed in real terms (1957-59 dollars)

X_6 = U. S. disposable income per capita, expressed in real terms (1957-59 dollars)

X_7 = two-year moving average of exports of canned pears in period t-1 (tons)

The rationale behind the inclusion of each of these independent variables is similar to that presented in the previous discussion of the demand equation for all Bartlett sales.

Results of regression analyses. Alternative measures of several of the independent variables were tested. From the various measures and combinations of the variables which were analyzed, the following price-estimating equation for fresh sales was selected.[1]

$$\hat{Y}_2 = -1.64879 \underset{(-5.37270)^{***}}{-47.44792\, X_1} \underset{(-1.72446)}{-70.65333\, X_2} \underset{(5.01309)^{***}}{+1.10861\, X_3} \underset{(-4.47013)^{***}}{-47.38091\, X_4}$$

$$\underset{(1.87649)^{*}}{+.00229\, X_7}$$

$R^2 = .931$

Standard Error Y.X - 12.53300

where: $\hat{Y}_2$ = first difference average annual grower returns per ton of Pacific Coast Bartlett pears sold for canning, expressed in real terms (1957-59 dollars)

X_1 = first difference total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

X_3 = first difference average annual grower returns from California cling peaches for canning, expressed in real terms (1957-59 dollars)

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[1] This equation is based on data for the 1947-62 period.

X_4 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. $2\frac{1}{2}$ basis - per 1,000 persons)

X_7 = first difference two-year average canned pear exports in period t-1 (tons)

As was the case for all sales of Bartlett pears, a price-estimating equation with the variables expressed in terms of first differences provided the most satisfactory results (Appendix B-4). It will be noted that the independent variables in the equation for cannery Bartlett pears are the same as those included in the price-estimating equation for all Bartlett sales. These independent variables explain 93 percent of the annual variation in farm price for cannery Bartlett pears.

The independent variable X_5 (measure of canners' costs or profits in period t-1) was excluded from the final price-estimating equation. Statistical results obtained with alternative measures of this variable (1. - f.o.b. price per case in year t-1, and 2. - gross profit per case in year t-1) indicate in each case a negative sign for the partial regression coefficient and a t-ratio which is not significantly different from zero (Appendices B-9 and B-4). A negative sign is not in agreement with the economic logic which was developed previously. For these reasons, this variable was excluded from the price-estimating equation.

The independent variable X_6 (U.S. disposable income per capita) was also excluded because the t-ratio for the partial regression coefficient was not significantly different from zero (Appendices B-2, B-4, and B-9).

Economic Interpretation of the Price-estimating Equation for Cannery Bartletts

The economic interpretation of the resulting equation can be summarized as follows:

1. An increase in total farm production of Pacific Coast Bartlett pears of 0.1 ton per 1,000 persons, considered by itself, will result in decrease in annual average grower returns for Pacific Coast cannery Bartlett pears of $4.74 per ton, in real terms.

2. An increase in production of all pears in Michigan and New York of 0.1 ton per 1,000 persons, considered by itself, will result in a decrease in annual average grower returns for Pacific Coast cannery Bartlett pears of $7.07 per ton, in real terms.

3. An increase in annual average grower returns for California cling peaches for canning of one dollar per ton, expressed in real terms, will result in an increase in annual average grower returns for Pacific Coast cannery Bartlett pears of $1.11 per ton in real terms, if the other variables remain constant.

4. An increase in canners' stocks of canned pears at the

beginning of the year (June 1) of 100 cases (24 No. $2\frac{1}{2}$ basis per 1,000 persons), considered by itself, will result in a decrease in annual average grower returns for Pacific Coast cannery Bartlett pears of $4.74 per ton, in real terms.

5. An increase in the two-year average of canned pear exports in period t-1 of 1,000 tons, considered by itself, will result in an increase in annual average grower returns for Pacific Coast cannery Bartlett pears of $2.29 per ton, in real terms.

Comparison of Estimated Prices with Actual Prices of Cannery Bartletts

Real farm prices of Pacific Coast cannery Bartlett pears were estimated with the price equation for the 16 years during the period 1947-62. These estimated prices are presented in Table 3, along with actual prices during the same period for purposes of comparison. A graphic comparison of these actual and estimated prices is presented in Figure 5.

The prices in Table 3 show that during the period from 1947 to 1962 the average absolute difference between actual and estimated price was $8.60 per ton or about 12 percent.

Price-estimating Equation for Fresh Bartlett Pears

An attempt was also made to develop a demand or price

Table 3. Actual and estimated real farm prices for Pacific Coast cannery Bartlett pears, 1947-62.

Year	Actual Price (Dollars per Ton)	Estimated Price (Dollars per ton)	Difference (Dollars per Ton)	Percent Difference
1947	$ 95.12	$112.46	-17.34	18.22
1948	137.23	143.79	- 6.56	4.78
1949	37.35	42.17	- 4.82	12.90
1950	97.26	100.85	- 3.59	3.69
1951	109.06	107.61	1.45	1.33
1952	49.73	56.16	- 6.43	12.93
1953	68.45	61.12	7.33	10.71
1954	76.60	70.43	6.17	8.05
1955	74.17	89.17	-15.00	20.22
1956	82.68	71.47	11.21	13.56
1957	61.53	46.34	15.19	24.69
1958	80.64	70.97	9.67	11.99
1959	60.49	75.61	-15.12	25.00
1960	77.69	76.19	1.50	1.93
1961	87.14	76.22	10.92	12.53
1962	65.37	59.84	5.53	8.46

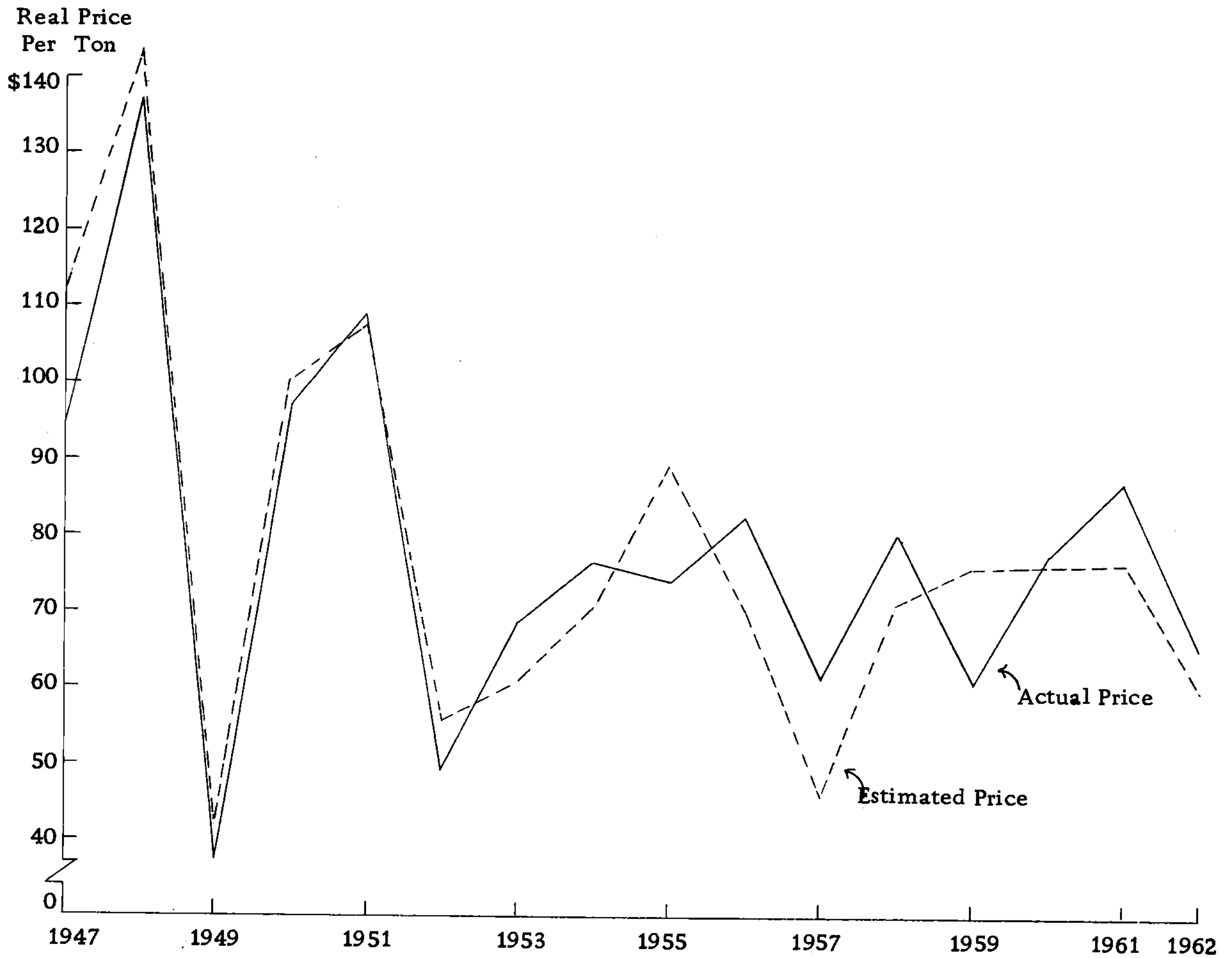

Figure 5. Actual and estimated real farm prices for Pacific Coast cannery Bartlett pears, 1947 - 1962.

equation for fresh sales of Pacific Coast Bartlett pears. A theoretical development of the demand relationship for fresh Bartlett pears is discussed in a previous section (page 25). Some of the factors which are hypothesized to be important in the determination of fresh Bartlett prices are the same as those which are included in the price analyses of all sales and of cannery sales.

The demand equation for fresh Bartlett pears which was estimated by the least-squares regression procedure has the following form:

$$\hat{Y}_3 = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

where: $\hat{Y}_3$ = annual average grower returns per ton of Pacific Coast Bartlett pears sold fresh, expressed in real terms (1957-59 dollars)

X_1 = total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = total production of pears in Michigan and New York (tons per 1,000 persons)

X_3 = total fresh sales of winter pears (pears other than Bartlett and Hardy) in Pacific Coast states (tons per 1,000 persons)

X_4 = index of quantities of competing fresh fruits (based on tons per 1,000 persons)

X_5 = U. S. disposable income per capita, expressed in real terms (1957-59 dollars)

It should be noted that population and the general price level are again included in an implicit manner by expressing quantity variables on the basis of 1,000 persons and deflating price variables through the use of constant (1957-59) dollars. Exports of fresh Bartlett pears were not included in the equation, because data on fresh-pear exports were not available by variety for the whole period of the analysis. The quantity of Pacific Coast Bartlett pears sold fresh was not included in the equation because it is determined simultaneously with the price and is, therefore, not an exogenous variable.

Statistical results obtained from regression analyses of fresh Bartlett prices did not prove satisfactory for the following reasons: (1) The independent variables explained a relatively small percentage of annual variations in price ($R^2 = .513$). (2) The signs of one or more of the partial regression coefficients are not in agreement with economic logic. (3) T-ratios for several of the partial regression coefficients are not significantly different from zero (Appendix B-10).

Results of a similar regression analysis of fresh Bartletts, which includes farm price of cannery Bartlett pears as an independent variable, indicate that this variable, taken by itself, explains 88 percent of the annual variation in grower returns from fresh sales (Appendix B-10). This indicates a high correlation between grower returns in the two markets -- fresh and canning.

Because of the high correlation between farm prices of fresh and cannery Bartletts and because of the unsatisfactory statistical results obtained with price analyses of the fresh market, an investigation of fresh Bartlett prices was not pursued further. This decision was strengthened by the fact that the major objective of the price-analysis portion of the study was to obtain a price-estimating equation for all sales of Bartlett pears, while determination of price-estimating equations for the cannery and fresh segments of the market were objectives of secondary importance.

III. THE SUPPLY RELATIONSHIP

A long-run supply function for Pacific Coast Bartlett pears was developed to facilitate prediction of future production levels. Supply relationships were also developed for each of the individual Pacific Coast states of Oregon, Washington, and California.

Annual production levels are characterized by wide fluctuations because of variations in weather conditions. Average production during a period of several years, however, is more stable and is determined largely by management decisions regarding extent of bearing acreage and levels of variable inputs used. Supply relationships developed in this study are intended to describe changes in average or "normal" production over a period of several years. For this reason production levels are expressed as moving averages during a period of four to six years.

Historical Production and Acreage Changes

Total production in the three Pacific Coast states (expressed as a six-year moving average) increased at a steady, rapid rate from the early 1920's until shortly after World War II, with a slight pause during the early 1930's (Figure 6). Production increases during this period can be attributed to (1) an expansion of bearing acreage in each state until the early 1930's (Figure 7) and (2) increases

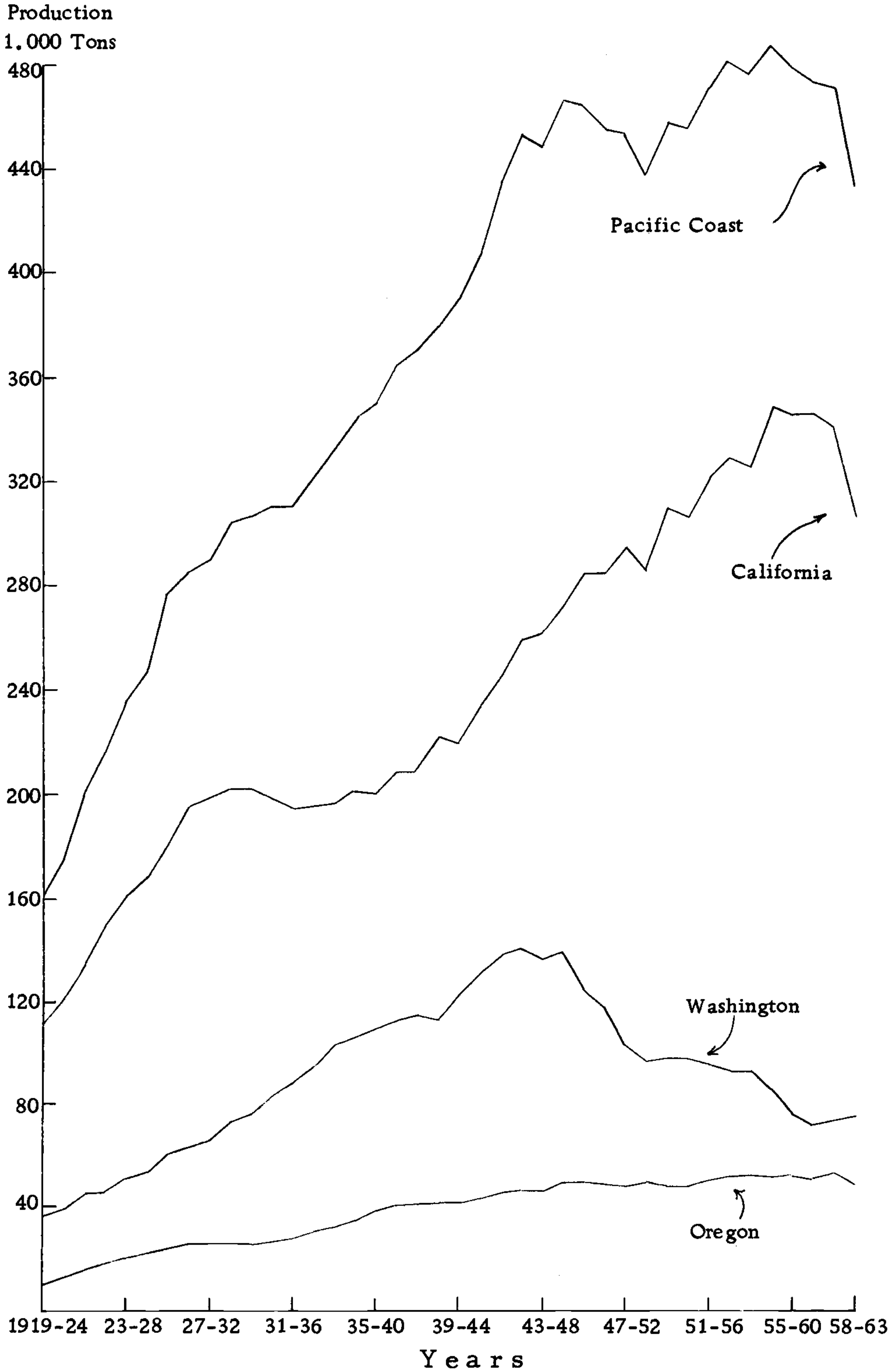

Figure 6. Six-year moving average of Bartlett pear production -- Pacific Coast, 1924 - 1963.

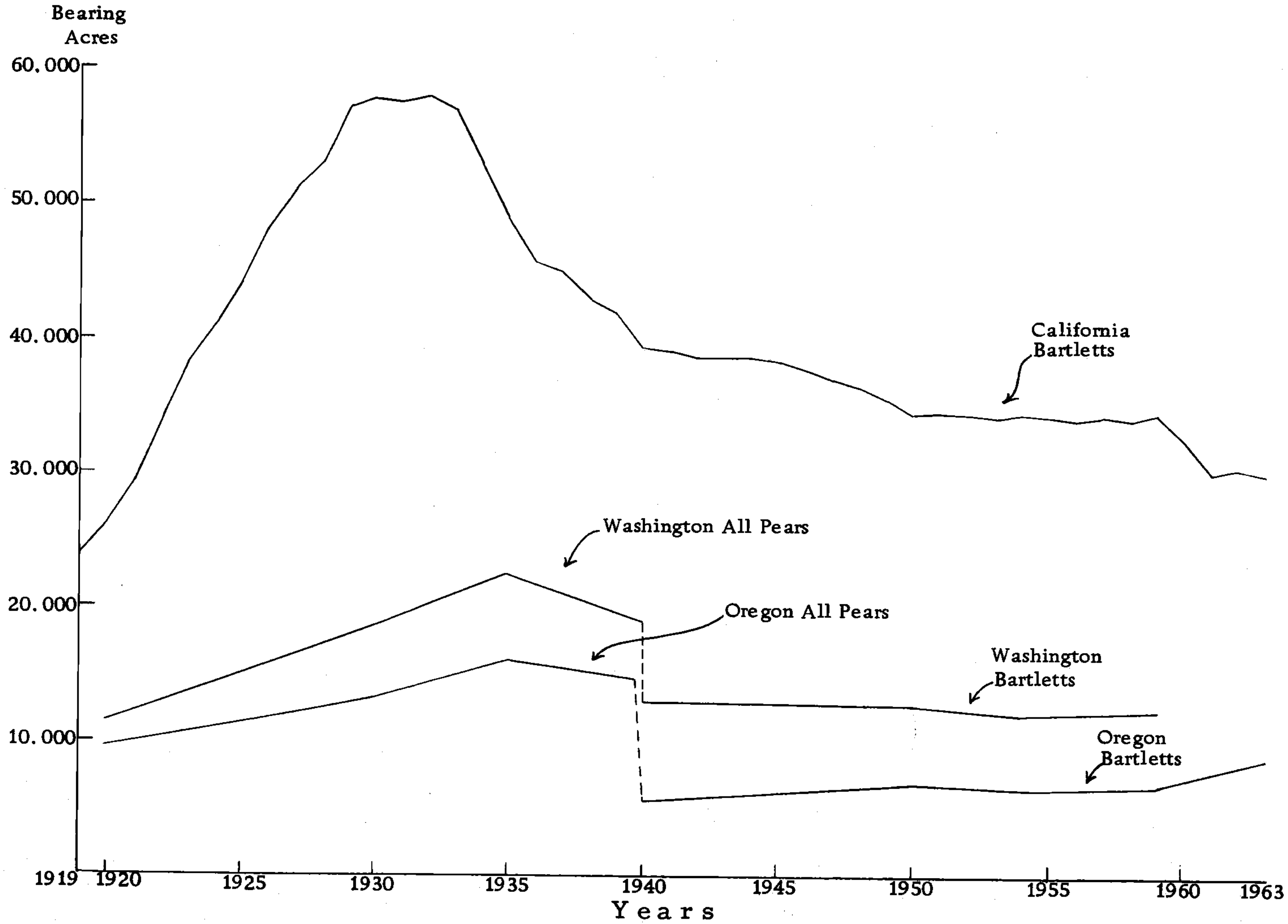

Figure 7. Bearing pear acreage -- Pacific Coast, 1919-1963.

in yields per acre, particularly in California, which were sufficient to more than offset reductions in bearing acreage in the latter part of the period.

Pacific Coast production levels remained relatively constant from the late 1940's until 1963.[1] During this period, bearing acreage in all three states was relatively stable; while rising yields in California tended to offset yield decreases in Washington.

Production of Bartlett pears in California increased at a relatively rapid rate during the decade from the early 1920's to the early 1930's and during the period between 1940 and 1960. However, during the deflationary years of the 1930's, production in this state leveled off and declined slightly. Production has decreased somewhat during the last several years due to the effects of pear decline. In general, the periods of increasing production in this state have accompanied, or immediately followed, periods of relatively high price levels; while the period of somewhat decreasing production in the 1930's was during a period of low farm prices.

Increases in California production during the 1920's can be ascribed to a steadily expanding bearing acreage during this period

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[1] Extremely adverse weather conditions during the 1963 bloom season in California and Oregon led to a very short crop, and thus, to a substantially lower average production for these states, as well as for the Pacific Coast, in the six-year period ending with this year.

(Figure 7). On the other hand, increased production during the war and postwar years was obtained from a slowing decreasing bearing acreage. Thus, the prolonged rise in production since about 1940 is attributable entirely to increasing yields.

A steady increase in Washington Bartlett-pear production from the early 1920's until just after World War II (Figure 6) was due largely to increases in bearing acreage which continued until 1940.[1] Although bearing acreage in this state decreased from 1940 to 1945, average production continued to increase during this period. Since World War II, however, production in Washington has exhibited a steady downward trend; while bearing acreage has remained relatively constant. Reduced yields associated with production decreases in this period were undoubtedly due, in part, to the inroads of pear decline during the 1950's.

Moderate increases in bearing acreages in Oregon occurred until 1940, and were accompanied by a slow, steady rise in production of Bartlett pears which continued until the late 1940's. Since

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[1] Accurate estimates of Bartlett-pear acreage in Washington and Oregon are hampered by the fact that census data on pear tree numbers (which is the sole source of information reported on a continuing basis) were not reported by variety before 1940. However, if it is assumed that the variety composition of bearing acreage in these states did not change substantially over time, census figures which indicate changes in acreage of all pears will give an indication of changes in Bartlett acreages as well.

that time, a relatively stable bearing acreage has been accompanied by similarly stable levels of average production in the state.

Model No. 1

Theoretical Development

Economic theory provides a basic framework of analysis in the development of a supply relationship and suggests specific hypotheses regarding the relevant variables to be included. A common hypothesis is that producers' decisions regarding quantity supplied are influenced, to a large extent, by expected net returns from alternative uses of their resources. Economic logic suggests that quantity supplied of a given product will increase, if producers as a whole expect net returns from that alternative to rise in relation to net returns from other enterprises. Such a rise in net returns may result from increases in price or decreases in costs of the enterprise in question -- if other conditions remain unchanged. A positive relationship between expected price and quantity supplied is, thus, postulated.

Accurate producer expectations of future profit conditions must take account of expected costs as well as future prices. In their formation of cost expectations, producers weigh the importance of such factors as input prices and the state of technology. Price expectations of a commodity such as pears, which are produced under conditions approaching pure competition, are influenced by producers' expectations of such factors as total production, population, and other demand-influencing variables.

In addition to expectations regarding prices and costs of the commodity in question (in this case -- Bartlett pears), producers' supply decisions are affected by their expectations of future profits from alternative uses of their resources such as land and management. In this context, owners of arable land weigh profit possibilities of suitable alternative crops, as well as expected returns from nonagricultural uses of land.

Although supply-response decisions depend upon producers' expectations of future profit conditions, these expectations are formed with a lack of complete knowledge regarding the future. Thus, these expectations are of a speculative nature in every instance; even though producer decision-makers probably vary widely in the degree of sophistication employed in the formation of these expectations. For these reasons, a common hypothesis is that producers base their future profit expectations, to a large extent, upon present or past profit conditions which are, by and large, known quantities.

In addition to the apparent realism of this hypothesis, it has a practical advantage in that it facilitates quantification of future profit expectations. Profit expectations, themselves, are elusive quantities which do not lend themselves to accurate measurement. On the other hand, if profit expectations are based upon present and/ or past conditions, an expression of these known conditions can provide measurable indications of these expectations. For this reason quantified analyses of supply relationships usually include certain past price or cost factors as indicators of future profit expectations.

Within the framework of these general notions regarding supply relationships, an attempt was made to develop a more specific supply (or quantity-estimating) equation for Pacific Coast Bartlett pears.

The supply response of a commodity such as pears is influenced by the long-run nature of the production process for tree-fruit crops. A period of several years is required to raise newly-planted trees to a bearing stage; and full production is not reached for several more years. Thus, decisions to expand bearing acreage result in production increases only after a considerable number of years. Once bearing age is reached, however, production from the established orchards normally continues for many years.

In contrast to the long time-period involved in production responses to new plantings, removals of bearing acreage have an impact upon production in the following season. However, because of the lengthy time period and the large investment required to raise a bearing orchard, pear growers are reluctant to remove bearing acreages in response to relatively small changes in profit expectations.

In addition to variations in bearing acreage, changes in average yields also provide an important source of supply response. Although variations in weather have a marked effect upon annual yield fluctuations, some changes in average yields over a longer period are a result of overt actions on the part of growers in response to economic incentives. Variations in the level of input use such as fertilizer and irrigation water fall into this category -- as does adoption of certain production technologies.

An analysis of supply relationships for a tree-fruit commodity such as Bartlett pears includes the determination of factors which influence the amount of bearing acreage as well as factors which affect average yields. Specific hypotheses regarding the variables to be included are suggested by previous studies of supply relationships for similar tree-fruit commodities, as well as by economic theory.

An analysis of the supply relationship for U. S. and Michigan apples by French (14, p. 13-17) indicates that apple production in year t was influenced to a large extent ($R^2 = .72$) by the ratio of apple prices to an index of prices paid by farmers in each of the years t-10 to t-14.

In a similar study of the supply relationship of Michigan tart cherries, Dennis (8, p. 7-13) attempted to estimate production by estimating non-bearing and bearing acreage responses. He found that the number of non-bearing trees in year t was largely influenced by a variable which expresses the ratio of an index of farm price of tart cherries to an index of farm prices of other fruits in each of the years t-8 to t-2. The quantity of cherries supplied in a given period was estimated from the number of non-bearing trees in the preceding time-period through the use of a set of simplified assumptions regarding: (1) years needed for non-bearing trees to reach bearing condition, (2) amount and age of tree removals, and (3) yields per bearing acre.

In an analysis of the supply response for California lemons, French and Bressler (15, p. 1022-1026) predicted bearing acreage by estimating both new plantings and tree removals. Production was then predicted on the basis of average yields. Their results indicate that new plantings in year t were explained to a large extent by a variable expressing a five-year average of net returns per acre during the years t-1 to t-5, expressed in 1959-60 dollars. Removals were expressed as merely a constant average percentage of bearing acreage which was expected to be removed because of old age, disease, or other causes. However, before this measure of removals was accepted, an attempt was made to estimate removals more precisely through the use of such exogenous variables as (1) profit per acre in the preceding period and (2) proportion of bearing trees over a certain age.

Although these latter two studies indicate the possibility of estimating future production based on predictions of bearing acreage, a lack of accurate acreage data in Oregon and Washington led to the decision to estimate production changes directly, without the intermediate step involving amounts of bearing acreage.

Based upon theoretical considerations and the results of previous studies, a single equation expectation model was hypothesized to describe the supply relationship for Bartlett pears. Model No. 1 includes: (1) measures of expected future profits from Bartlett pears, and (2) expected profits from alternative enterprises. Algebraically, this model can be expressed as follows:

$$Q_T = \beta_o + \beta_1 \pi^*_{BP} + \beta_2 \pi^*_{AE} + u$$

where: Q_T is total farm production of Bartlett pears, π^*_{BP} is expected profits from producing Bartlett pears, and π^*_{AE} is expected profits from alternative enterprises.

Because expectations of future profits cannot be readily measured directly, expressions of past prices and costs were used as indicators of future profit expectations for both Bartlett pears and for alternative enterprises. By expressing profit expectations (π^*) in terms of past prices and costs, the following estimating form of this model was hypothesized:

$$Q_t = \beta_o + \beta_1 \left(\frac{P_{BP}}{I_{PPF}}\right)_{t-x} + \beta_2 \left(\frac{P_{BP}}{I_{PPF}}\right)_{t-y} + \beta_3 \left(\frac{I_{PAE}}{I_{PPF}}\right)_{t-x} + \beta_4 \left(\frac{I_{PAE}}{I_{PPF}}\right)_{t-y} + u_t$$

where: Q_t is quantity supplied of Bartlett pears in period t; P_{BP} is farm price of Bartlett pears -- all sales; I_{PPF} is an index of prices paid by farmers for production items including interest, wages, and taxes; and I_{PAE} is an index of farm prices of alternative fruit enterprises. In this case, the index of prices paid by farmers was included as a measure of producers' costs for both Bartlett pears and for alternative fruit enterprises.

Two alternative measures of the dependent quantity variable (Q_t) were hypothesized -- (1) farm production of Bartlett pears and (2) farm production adjusted for average yield trend. The second alternative measure was designed to show supply responses from changes in bearing acreage separately from the response due to changes in long-run average yields. Use of the unadjusted quantity as the dependent variable will show the combined response from changes in both bearing acreage and average yields.

It will be noted that the ratios of farm price of Bartlett pears (P_{BP}) to the cost index (I_{PPF}) in each of two different time periods (t-x and t-y) were included as separate variables in the above equation. In this case, the period t-x is intended to include several years in the immediate past, and to reflect price and cost conditions which influence removal decisions. Period t-y is intended to include several years in the more distant past and to reflect profit conditions affecting decisions to make new plantings. Because several years are required for newly-planted trees to reach a mature bearing age, the time interval for t-y must be relatively long. On the other hand, because production changes from orchard removals occur during the next season, a relatively short interval is appropriate for t-x. This logic regarding the time interval applies to both Bartlett pears and to the alternative enterprises which were considered.

The ratio of Bartlett-pear price (P_{BP}) to the index of prices paid by farmers (I_{PPF}) is intended to give a measure of profits from producing Bartlett pears. It would be expected that an increase in prices received (P_{BP}), with other factors remaining constant, would result in increased profits, and hence, provide an incentive for producers to expand output. Thus, positive coefficients for the variables which express this ratio $\left[\left(\frac{P_{BP}}{I_{PPF}}\right)_{t-x} \text{ and } \left(\frac{P_{BP}}{I_{PPF}}\right)_{t-y}\right]$ would be expected. On the other hand, an increase in costs as expressed by the index of prices paid by farmers (I_{PPF}), taken by itself, would result in decreased profits, and thus would be expected to be followed by a decrease in quantity supplied in period t.

A rise in the index of prices received for alternative enterprises (I_{PAE}), taken by itself, would result in increased profits for these enterprises and, hence, result in a decrease in the <u>relative</u> profitability of Bartlett pears. Thus, a decrease in quantity supplied of Bartlett pears would be expected to result from such a change. A negative coefficient is, therefore, indicated for the variables which express the ratio of the index of prices received for alternative enterprises to the index of prices paid by farmers $\left[\left(\frac{I_{PAE}}{I_{PPF}}\right)_{t-x}\right.$ and $\left.\left(\frac{I_{PAE}}{I_{PPE}}\right)_{t-y}\right]$.

Data on Bartlett-pear production and farm prices were available for the three Pacific Coast states from 1919 to 1962 -- a period of 44 years. Although some technological changes have occurred within this period which affect the supply relationship of pears, the basic biological process of pear-production has remained essentially unchanged throughout the period. Therefore, the entire period for which data were available was used in the analysis. However, the number of observations was considerably reduced with Model No. 1 because two of the independent variables were lagged by a period of 14 years.

Statistical Results

Model No. 1 was used to estimate quantity supplied of Bartlett pears in California for the period from 1933 to 1963. Both of the alternative measures of the dependent variable (quantity supplied) were analyzed with this model. The statistical results obtained in each case were not satisfactory.

In the analysis in which the dependent quantity variable was unadjusted for average yield trend, a relatively small R^2 value was obtained (R^2 = .30). Moreover, each of the signs for the partial regression coefficients were not in agreement with economic logic; and only one of the t-ratios of the four partial regression coefficients was significantly different from zero (Appendix B-11).

In the analysis in which adjusted production was used as the dependent quantity variable, an even smaller R^2 value was obtained (R^2 = .18). In addition, the t-ratios for two of the partial regression coefficients were not significantly different from zero (Appendix B-11). Because of the unsatisfactory statistical properties, the results obtained with this model were not accepted and further analysis of the model was not pursued.

Model No. 2

Theoretical Development

An alternative model, which takes the form of the distributed-lags model developed by Nerlove (23), was hypothesized to describe the supply relationship for Bartlett pears. The model involves the hypothesis that quantity supplied in period t is a function of expected "normal" price for that period (P_t^*). The estimating equation for quantity supplied, however, makes use of past quantities for indicators of expected price. Thus, the independent variables in the estimating equation of this model are also lagged variables.

In this distributed-lags model, the estimating equation for quantity supplied takes the following form:

$$Q_t = \beta_o + \beta_1 P_{t-1} + \beta_2 Q_{t-1} + u_t$$

where Q_t is quantity supplied in period t, P_{t-1} is price of the product in period t-1, Q_{t-1} is quantity supplied in period t-1, and u_t is the unexplained residual or error term. The variable Q_{t-1}, which is the dependent variable lagged by one year, is intended to represent the cumulative effect of factors affecting production decisions in previous periods. It is further hypothesized that the primary factor which influences producers to alter production decisions from those of the previous period is price in the previous period (P_{t-1}).

The coefficients for this equation can be estimated by least-squares regression. However, it is recognized that the least-squares procedure will give somewhat biased estimates of the coefficients because of the inclusion of the lagged quantity variable as an independent variable. That is, use of a lagged value of the dependent variable as one of the independent variables in a single-equation model will result in biased estimates; because the assumption that u_t is not correlated with any of the independent variables is violated (49, p. 52-61).

In this model, an increase in price during period t-1 suggests a rise in expectations of future price. Therefore, such an increase in price would be expected to be associated with a larger quantity supplied in period t. A positive sign would, thus, be expected for this independent variable.

An increase in quantity supplied in period t-1 is hypothesized to indicate a rise in producers' expectations based upon all past conditions other than price in period t-1. Hence, a positive relationship is also suggested for this independent variable.

Although Nerlove's distributed-lags hypothesis was developed and tested with data for annual crops such as corn, wheat, and cotton, this hypothesis seemed to merit a test of application for use with a perennial crop such as pears.

Statistical Results

The estimating equation for the distributed-lags model was tested by the use of least-squares multiple-regression procedures. An estimating equation for quantity supplied was developed for Bartlett pears in each individual state of Oregon, Washington, and California as well as for the Pacific Coast area as a whole with the use of this model.

Statistical results obtained with the distributed-lags model were more satisfactory than those obtained with use of Model No. 1.

The following quantity-estimating (supply) equation for the Pacific Coast as a whole was, therefore, accepted as the most satisfactory estimating equation:

$$\hat{Y}_4 = 10.50162 + \underset{(1.66054)}{.16641}\ X_1 + \underset{(45.63785)^{***}}{.95249}\ X_2$$

$R^2 = .983$

Standard Error Y.X = 13.38324

where: $\hat{Y}_4$ = four-year moving average of all sales of Pacific Coast Bartlett pears in period t (1,000 tons)

X_1 = four-year moving average grower returns in dollars per ton for Pacific Coast Bartlett pears -- all sales in period t-1; divided by index of prices paid by farmers for production items, including interest, wages, and taxes, in period t-1

X_2 = four-year moving average of all sales of Pacific Coast Bartlett pears in period t-1 (1,000 tons).

The variables in this equation were expressed as four-year moving averages in an attempt to minimize the fluctuations in production due to annual variations in weather. The use of four-year averages reduces the number of observations by three. This fact, plus the use of independent variables which are lagged by one year, reduces the number of observations from 44 to 40 for this analysis. However, this is still a relatively large number of observations for an analysis using time-series data which is expressed on an annual basis.

The R^2 value of .983 indicates that the independent variables account for about 98 percent of the variation in production of Pacific

Coast Bartlett pears during the period from 1919 to 1962. The partial regression coefficients for both independent variables in the above equation are positive; which is in agreement with the theory outlined in the previous section.

Economic interpretation of the supply equation. Economic interpretation of this supply or quantity-estimating equation can be summarized as follows:

1. An increase in the four-year moving average of grower returns from all sales of Pacific Coast Bartlett pears, divided by the index of prices paid by farmers for production items, of one dollar per ton in period t-1, taken by itself, is associated with an increase in the four-year moving average of all sales of Pacific Coast Bartlett pears in period t of 166.41 tons.

2. An increase in the four-year moving average of all sales of Pacific Coast Bartlett pears in period t-1 of 1,000 tons, taken by itself, is associated with an increase in the four-year moving average of all sales of Pacific Coast Bartlett pears in period t of 952.49 tons.

Coefficients of supply elasticity were computed for short-run elasticity (by using the regression coefficient for price in period t-1, i.e. P_{t-1}) and for long-run elasticity (by using the coefficient for long-run "normal" or expected price, i.e. P_t^*) (23). The computed coefficient of short-run supply elasticity is .039; while the coefficient of long-run supply elasticity is .819. These coefficients indicate an inelastic supply response under both long-run and short-run conditions; although the long-run response is more elastic than that in the short-run. Such elasticities of supply are not unexpected on a theoretical grounds for a commodity such as Bartlett pears. That is, one would expect a rather inelastic supply response for a tree-fruit commodity, and would also expect that the long-run supply response would be greater than that in the short-run.

In connection with the distributed-lags model, Nerlove has developed a statistical quantity (T) which indicates average number of years which are required for the occurrence of a certain predetermined percentage of adjustment in quantity supplied resulting from a price change (23, p. 187-193). The length of this time period (T) can be estimated with the following formula: $1 - (\hat{\beta}_2)^T = 1 - e$, where $\hat{\beta}_2$ is the partial regression coefficient of the lagged quantity variable (Q_{t-1}) in the estimating equation; and e is an arbitrarily small number, the size of which depends upon the predetermined percentage of adjustments in quantity supplied. Thus, in order to estimate the number of years which are required for 95 percent of the effect of a price change to be reflected in quantity supplied, e would take the value of .05. The value of T can, then, be estimated by substituting the value of the partial regression coefficient $\hat{\beta}_2$ into the above formula.

In the case of the quantity-estimating equation for Pacific Coast Bartlett pears, this time period T is about 61 years for 95 percent of the production adjustment to a price change and about 19 years for 75 percent of the adjustment. These relatively long time periods which are required for production adjustments are in agreement with the relatively inelastic values of the computed supply-elasticity coefficients.

Comparison of actual and estimated quantities supplied. The supply equation which was developed on the basis of the distributed-lags model was used to estimate four-year average quantities of Pacific Coast Bartlett pears supplied during the period from 1919 to 1962. These estimates are presented in Table 4, along with actual quantities supplied for purposes of comparison. Figure 8 shows a graphic comparison of these actual and estimated quantities. For the entire period, the average absolute difference between actual and estimated quantities supplied is about 11,000 tons, or an average difference of three percent.

Supply equations for individual states. The distributed-lags model was also used to develop quantity-estimating equations for each of the individual states of Oregon, Washington, and California. The resulting equations which were estimated by the use of least-squares regression procedures are as follows:

Table 4. Comparison of actual and estimated four-year moving average of all sales of Pacific Coast Bartlett pears, 1920-62.

Period	Actual all sales (Four-year Average -- 1,000 Tons)	Estimated all sales (Four-year Average -- 1,000 Tons)	Difference	Percent Difference
1920-1923	157.85	168.82	-10.97	6.94
1921-1924	167.07	177.96	-10.89	6.52
1922-1925	193.60	186.75	6.85	3.54
1923-1926	214.82	211.22	3.60	1.68
1924-1927	221.14	230.49	- 9.35	4.23
1925-1928	252.47	237.09	15.38	6.09
1926-1929	260.06	264.81	- 4.75	1.83
1927-1930	270.42	273.55	- 3.13	1.16
1928-1931	282.55	282.63	- .08	.03
1929-1932	268.67	292.60	-23.93	8.91
1930-1933	268.94	277.62	- 8.68	3.23
1931-1934	266.51	274.56	- 8.05	3.02
1932-1935	270.14	273.73	- 3.59	1.33
1933-1936	295.89	277.05	18.84	6.37
1934-1937	312.00	302.68	9.32	2.99
1935-1938	318.76	318.22	.54	.17
1936-1939	337.03	322.72	14.31	4.25
1937-1940	332.84	340.45	- 7.61	2.29
1938-1941	344.64	336.59	8.05	2.34
1939-1942	354.32	349.21	5.11	1.44
1940-1943	364.64	362.40	2.24	.61
1941-1944	386.85	375.30	11.55	2.99
1942-1945	410.70	399.17	11.53	2.81
1943-1946	433.97	422.96	11.01	2.54
1944-1947	462.85	444.95	17.90	3.87
1945-1948	448.14	470.50	-22.36	4.99
1946-1949	444.55	456.32	-11.77	2.65
1947-1950	428.77	449.63	-20.86	4.87
1948-1951	417.55	433.32	-15.77	3.78
1949-1952	444.22	422.92	21.30	4.79
1950-1953	431.19	445.32	-14.13	3.28
1951-1954	447.58	434.33	13.25	2.96
1952-1955	458.41	449.38	9.03	1.97
1953-1956	467.81	458.73	9.08	1.94
1954-1957	490.76	469.04	21.72	4.43
1955-1958	479.42	490.69	-11.27	2.35
1956-1959	479.96	479.93	.03	.01
1957-1960	459.38	479.96	-20.58	4.48
1958-1961	444.85	460.35	-15.50	3.48
1959-1962	460.09	447.45	12.64	2.75

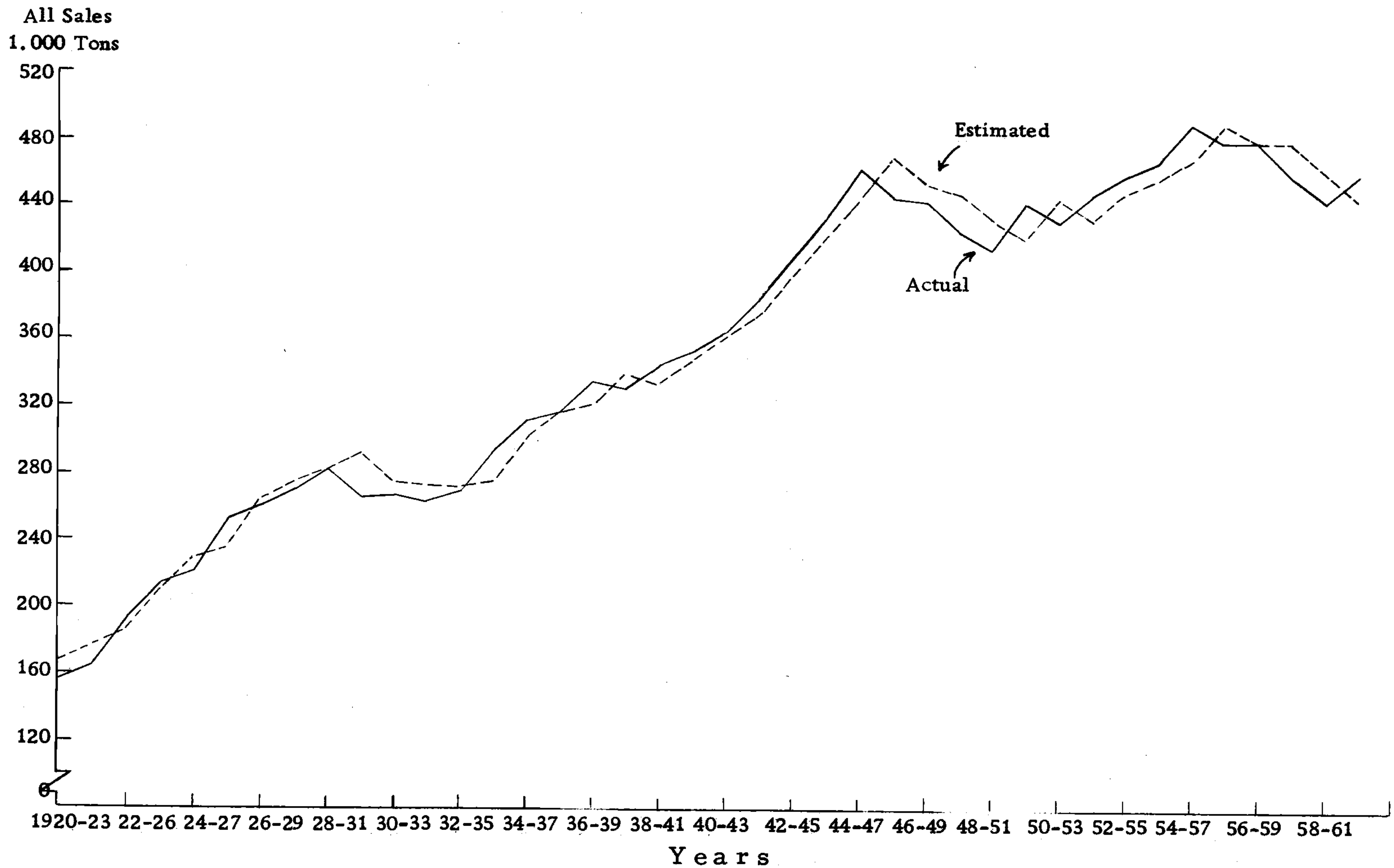

Figure 8. Comparison of actual and estimated four-year moving average of all sales of Pacific Coast Bartlett pears, 1920 - 1962.

(1) Oregon: $\hat{Y}_5 = 1.32077 + .01164\ X_{11} + .96413\ X_{21}$

$(.83706) \qquad (36.73132)^{***}$

$R^2 = .973$

Standard Error Y.X = 2.19223

(2) Washington: $\hat{Y}_6 = 7.17390 + .00087\ X_{12} + .92529\ X_{22}$

$(.01493) \qquad (21.00596)^{***}$

$R^2 = .930$

Standard Error Y.X - 7.54742

(3) California: $\hat{Y}_7 = -4.07349 + .15942\ X_{13} + .98322\ X_{23}$

$(2.02991)^{**} \qquad (41.79209)^{***}$

$R^2 = .979$

Standard Error Y.X = 10.46666

where: $\hat{Y}_5$, $\hat{Y}_6$, and $\hat{Y}_7$ = four-year moving averages of all sales of Bartlett pears in period t in the respective states (1,000 tons)

X_{11}, X_{12}, and X_{13} = four-year moving averages grower of returns in dollars per ton from all sales of Bartlett pears in period t-1 in the respective states; divided by index of prices paid by farmers for production items, including interest, wages, and taxes, in period t-1

X_{21}, X_{22}, and X_{23} = four-year moving averages of all sales of Bartlett pears in period t-1 in the respective states (1,000 tons).

In each case, the independent variables explain a high percentage of the variation in the dependent variable. This is shown by the high R^2 values which were obtained in each case.

Coefficients of supply elasticity were computed for each state. The following short-run elasticity coefficients (using P_{t-1}) were computed: (1) California -- .06, (2) Oregon -- .03, and (3) Washington -- .001. Long-run supply elasticity coefficients (using P_t^*) were found to have the following values: (1) California -- 3.51, (2) Oregon -- .75, and (3) Washington -- .01. These elasticity coefficients indicate that both short-run and long-run supply responses to price changes are relatively elastic in California and highly inelastic in Washington; while Oregon assumes an intermediate position in this respect.[1] In each case, the supply response under long-run conditions is more elastic than that under short-run conditions.

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[1] The following values of T were computed for each state: (1) California, T = 175 years for 95 percent of the adjustment in production and 54 years for 75 percent of the adjustment; (2) Oregon, T = 82 years for 95 percent of the adjustment production and 25 years for 75 percent of the adjustment; (3) Washington, T = 38 years for 95 percent of the adjustment and 12 years for 75 percent of the adjustment. The relative elasticities suggested by these T values are in direct contrast to the computed elasticity coefficients for these states. However, insufficient evidence is available to provide an explanation for this apparent contradiction.

These relatively long time periods, which are indicated by the value of T in each state, are not unexpected in view of (1) the length of time required to raise a mature bearing orchard, (2) the reluctance on the part of owners to sacrifice their large investment embodied in a bearing orchard through removal at a relatively young age, and (3) a relatively long average bearing life for Bartlett pears in the Pacific Coast states.

A relatively high coefficient of supply elasticity in California is related to the fact that California production increased steadily during periods of generally rising prices, i.e., during the 1920's until about 1932 and during the years of World War II and immediately following (Figure 6). In addition, production in California decreased somewhat during the 1930's when prices were at a low level and remained relatively constant during the relatively stable price period of the late 1950's and early 1960's. Thus, in most of the periods for which production and price data are available, supply response in California has been a relatively elastic one.

The highly inelastic coefficient of supply elasticity in Washington is conditioned by the fact that production in this state increased steadily and at a fairly rapid rate, during the low-price period of the 1930's (Figure 6). Also, production in this state decreased rather markedly during the 1950's, which was a period of relatively high, stable prices. Thus, although Washington Bartlett pear production increased with rising prices in the 1920's and during World War II, these responses are partially offset by a negative response or lack of response during certain periods.

Production response to changes in price was more moderate in Oregon than in either Washington or California. However, production increased in this state during periods of rising prices in the 1920's and 1940's and remained relatively stable during the period of price stability in the 1950's. Although supply response was moderate in Oregon, no negative responses were exhibited over an extended period as was the case in Washington. This, then, provides a plausible explanation for a coefficient of supply elasticity in Oregon which is greater than that computed for Washington but less than that for California.

<u>Statistical results with alternative measures of the variables.</u> Because the unsatisfactory results obtained with Model No. 1 did not provide a clear indication of the superiority of either measure of the dependent quantity variable, both of these alternative measures were treated with the distributed-lags model.

Statistical results which were obtained with quantity-supplied-adjusted-for-yield-trend as the dependent variable were not unsatisfactory. However, in each case the resulting R^2 values were lower ($R^2 = .897$ for the Pacific Coast, $R^2 = .811$ for California, $R^2 = .911$ for Oregon, and $R^2 = .917$ for Washington) than those obtained with unadjusted-quantity as the dependent variable (Appendix B-12). Therefore, the adjusted alternative measure of the dependent variable was not accepted on the basis of the inferior statistical results.

The distributed-lags model was also used in an attempt to develop an estimating equation for new plantings and tree removals of Bartlett pears. Such an equation would facilitate predictions of bearing acreage if accurage data were available on an annual basis regarding acreages by age groups.

With the use of this model to develop an estimating equation for new plantings of pear trees, the hypothesis is that producers decisions regarding new plantings are based upon their expectations of future prices. It is further hypothesized that producers' expectations of future prices can be approximated by prices received in period t-1 and by acres of new plantings in period t-1. In this case, acres of new plantings in period t-1 are presumed to reflect the cumulative effect of all factors affecting planting decisions in previous periods; while changes in price expectations are conditioned by prices received in period t-1.

Higher prices in period t-1 would be expected to raise producer's expectations regarding future prices and result in larger acreages of new plantings in period t. Therefore, a positive sign would be expected for the partial regression coefficient of the lagged-price variable in the estimating equation. Larger acreages of new plantings in period t-1 are presumed to reflect higher expected future prices, and thus, in themselves, to suggest increases in new plantings in period t. A positive sign for the partial regression coefficient of the lagged-quantity variable would, therefore, also be expected.

Similar hypotheses are involved with use of the distributed-lags model to develop an estimating equation for acreage removed in a given period. One difference, however, is that an increase in price in period t-1 would be expected to result in a decrease in acres removed. Thus, in this equation a negative sign is expected for the lagged-price variable. A positive sign is expected for the lagged-quantity variable; because greater removals in period t-1 presumably reflect a decrease in price expectations based upon all previous factors. It is expected that these factors will continue to have a similar influence upon removal decisions in period t.

Although the statistical results proved promising with the use of California data (Appendix B-12), comparable data regarding acreages or tree numbers on an annual basis were not available for Oregon and Washington. Because of the lack of necessary data, this alternative analysis of new plantings and removals was not pursued further.

IV. FUTURE PREDICTIONS OF PRICE AND PRODUCTION

The Model

The supply and demand equations were combined into a model which was used to predict future price and production levels. The model thus formed can be summarized as follows:

Supply equation -- $Y_4 = 10.50162 + .16641\ X_1 + .95249\ X_2$

Demand equation -- $Y_1 = -1.16675 - 43.47234\ X_3 - 77.60454\ X_4 + .98502\ X_5 - 46.52603\ X_6 + .00196\ X_7$

where: Y_4 = four-year moving average of all sales of Pacific Coast Bartlett pears in period t (1,000 tons) (Y_4 can be adjusted to the same basis as X_3 in the demand equation.)

Y_1 = first difference grower returns in dollars per ton for Pacific Coast Bartlett pears -- all sales, expressed in real terms (Y_1 in period t, adjusted to a four-year moving average of absolute dollars per ton, = X_1 in period t+ 1)

X_1 = four-year moving average of grower returns in dollars per ton for Pacific Coast Bartlett pears -- all sales in period t-1, expressed in real terms

X_2 = four-year moving average of all sales of Pacific Coast Bartlett pears in period t-1 (1,000 tons)

X_3 = first difference production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_4 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

X_5 = first difference grower returns for California cling peaches for canning, expressed in real terms

X_6 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases per 1,000 persons)

X_7 = first difference two-year average canned pear exports in period t-1 (tons)

In this model the variables of (1) pear-production in Michigan and New York, (2) farm price of California cling peaches, (3) canners' stocks of canned pears, and (4) canned-pear exports are completely exogenous to the model, as is the implicit variable of population. Therefore, separate projections of these variables were made and introduced into the model to facilitate future predictions of price and production.

With the exception of the first year, the model relies upon self-generated values of price and production for future predictions. Because both independent variables in the supply equation are lagged variables, production for the first future year (t) can be predicted with known price and production data for the current year (t-1).

The predicted production for year t, divided by projected population and expressed as a first difference, can then be combined with projected values of the other independent variables in the demand equation to predict price in year t. In the next iteration of the model, predicted price in year t (expressed as a four-year average of the absolute level) is used to predict production year t + 1.[1] These steps are repeated through successive iterations of the model in order to provide a series of future price and production predictions.

Comparison of Model Predictions to Actual Values

In order to check the accuracy or predictive ability of the model, prices and production levels were predicted during the period from 1947 to 1962. These predictions are presented in Table 5 along with actual values for purposes of comparison. The average absolute difference between predicted and actual production was 31, 800 tons, an average error of approximately seven percent.

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[1] Both predicted price (Y_1) in the demand equation and lagged price (X_1) in the supply equation are expressed in real terms, because each is adjusted on the basis of a general price index. However, Y_1 makes use of the Department of Labor Consumer Price Index; while X_1 is based on the Department of Agriculture's Index of Prices Paid by Farmers (48, p. 261 and 292). On the other hand, these two price indices tend to move together, and have been within one percentage point of one another during the last two years (1962 and 1963). Therefore, for the purpose of future predictions, it was assumed that both indices will change at the same rate. For this reason, and because the two indices start at the same level, an adjustment in the two price variables (Y_1 and X_1) was not needed from one iteration to the next for the different indices.

Table 5. Actual and predicted quantity supplied and farm prices of Pacific Coast Bartlett pears, 1947-62.

Year	Actual Quantity (Four-year Average -- 1,000 Tons)	Predicted Quantity (Four-year Average -- 1,000 Tons)	Difference (Tons)	Percent Difference	Actual Prices (Four-year Average --Dollars)	Predicted Prices (Four-year Average -- Dollars)	Difference (Dollars)	Percent Difference
1944-47	462.85	444.95	17.90	3.87	119.72	129.50	- 9.78	8.17
1945-48	448.14	455.01	- 6.87	1.53	120.11	129.06	- 8.95	7.45
1946-49	444.55	464.30	-19.75	4.44	99.25	115.20	-15.95	16.07
1947-50	428.77	470.99	-42.22	9.85	91.61	108.71	-17.10	18.67
1948-51	417.55	476.26	-58.71	14.06	94.47	109.56	-15.09	15.97
1949-52	444.22	481.20	-36.98	8.32	75.23	98.60	-23.37	31.06
1950-53	431.19	484.19	-53.00	12.29	83.78	98.74	-14.96	17.86
1951-54	447.58	487.10	-39.52	8.83	79.24	96.31	-17.07	21.54
1952-55	458.41	489.66	-31.25	6.82	71.53	91.79	-20.26	28.32
1953-56	467.81	491.76	-23.95	5.12	78.71	98.72	-20.01	25.42
1954-57	490.76	495.16	- 4.40	0.90	76.91	99.09	-22.18	28.84
1955-58	479.42	498.55	-19.13	3.99	76.74	90.49	-13.75	17.92
1956-59	479.96	500.42	-20.46	4.26	73.77	82.12	- 8.35	11.32
1957-60	459.38	500.83	-41.45	9.02	72.87	73.78	- 0.91	1.25
1958-61	444.85	499.84	-54.99	12.36	78.66	74.91	3.75	4.77
1959-62	460.09	499.07	-38.98	8.47	74.97	74.43	0.54	0.72

Predicted prices were, on the average, different from the corresponding actual prices by $13.25 per ton -- or an average of about 16 percent.

Comparison of predicted and actual production and prices during the 1947-62 period indicates that the model's predictions during this period were biased. That is, predicted prices and production tended to be greater than the actual values.

There are several possible sources of bias in the model. Combination of the supply equation and the demand equation, each of which were estimated independently and which include separate errors of estimation, into an iterative model provides a distinct opportunity for bias to arise. This is possible because in a given year the errors of estimation in each equation may be in the same direction and thus may fortify one another when the two equations are combined into a single model. These errors of the independently-estimated supply and demand equations may compensate on another -- but only by coincidence. The probability that such errors will exactly compensate each other, and thus result in no bias in the model,is extremely small.

The use of a lagged endogenous variable in the supply equation results in biased estimates of the coefficients in this equation,[1] and

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[1]See page 83.

thus provides a second source of bias in the model. In addition, because the coefficient for this lagged-quantity variable in the supply equation is .95, or nearly one, a large portion of the errors in predicted production are carried over to subsequent predictions through the iterative process.

Although predictions of the model for the 1947-62 period suggest the possibility of bias in the model, these results do not give positive proof of the existence, direction, or magnitude of bias in predictions for other time periods. Furthermore, although the possibility of biased results detracts from the predictive ability of the model, it is felt that the relatively small bias which is suggested does not destroy the usefulness of the model for future predictions.

Adjustments in the Model

Because of the indicated possibility of biased predictions from the model, an attempt was made to introduce an adjustment in order to minimize the possible bias. One source of bias outlined above arises from use of the lagged dependent variable as an independent variable in the supply equation, and the tendency for a large portion of the errors in predicted production to be carried over into succeeding predictions. In an attempt to counteract these tendencies, an adjustment was made in the following manner: (1) The model was used to make future predictions beginning with the last year for which complete data was available (1962). (2) Predicted production in 1962 was then compared to actual production in that year and adjusted to correspond to the actual production. (3) An adjustment was also made for the known error in predicted price for 1962. (4) Predicted production for 1963 was then adjusted by a quantity equal to .95249 (the coefficient for lagged production in the supply equation) times the net error in predicted production in 1962. This was done because this amount of error would otherwise be carried over to the 1963 predictions through the lagged-quantity variable. (5) In each succeeding year, an adjustment in predicted production equal to .95249 times the adjustment in the preceding year was made. That is, the adjustment in a given year was equal to $.95249^{t-1}(u_{1962})$; in this case, the following values are assigned to t: 1962 = 0, 1963 = 1, ..., 1985 = 23. (These adjustments were not cumulative. That is, the total adjustment for each year decreased during successive years of the projection period.) By means of the above adjustment, the tendency of the model to carry errors in predicted production over to succeeding predictions was reduced to a minimum.

In addition to the adjustment outlined above, a second adjustment was made in respect to future production predictions. The need for such an adjustment can be explained in the following manner: The supply equation makes use of production in the previous period (Q_{t-1}) to predict production in period t. However, at the present time, there are abnormally large acreages of non-bearing Bartlett pears which have not yet contributed to past production. As a consequence, future production increases from these abnormally large non-bearing acreages would not be reflected in the independent variable of lagged production in the supply equation. The resulting predictions would, thus, tend to underestimate future production levels. Therefore, an adjustment was made in future production predictions to allow for the abnormal amount of existing non-bearing acreage.

Predictions of future production which were generated by the model were adjusted upward according to increases in future production which are indicated by existing non-bearing acreages. In 1963, non-bearing acreage amounted to 42 percent of bearing acreage in California (2, p. 17) and was equal to approximately 45 percent of bearing acreage in Oregon (26). Non-bearing acreage in Washington in 1961 was equal to approximately 85 percent of the state's bearing acreage. These existing non-bearing percentages were compared to the following estimates of percentages which are needed to maintain a constant bearing acreage in each state: (1) California -- 17 percent, (2) Oregon -- 25 percent, and (3) Washington -- 25 percent.[1]

[1]These estimates of required percentages of non-bearing acreage are based upon: (1) an examination of past changes in bearing acreage in relation to percentages of non-bearing acreage. and (2) estimates of average years of bearing and non-bearing life. For a more detailed description of the procedure involved. see footnote on page 171.

Comparison of existing percentages to the required percentages indicated that existing bearing acreage will expand in future years by the following percentages: (1) California -- 25 percent, (2) Oregon -- 20 percent, and (3) Washington -- 60 percent. With average yields comparable to those obtained in recent years, similar percentage increases in production levels can be expected within the next ten years.[1] These indicated increases in future production were weighted by average production levels in each state. The resulting weighted average indicates a 30 percent increase in future production for the Pacific Coast as a whole.

It was assumed that the full 30 percent increase in average production will be attained by the year 1972, and that production will increase by a constant percentage each year until that time. Therefore, production predictions generated by the model for the years between 1963 and 1972 were adjusted upward on the basis of an increasing production trend of three percent per year as a result of abnormal amounts of existing non-bearing acreage.

The effects of these adjustments upon predicted future price and production levels are presented in a later section.

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[1] These estimates of future production increases lie within the range of projections which were outlined by a recent industry study-group (50). Estimated production increases in California also are in agreement with projected production levels suggested in a recent analysis by Gingerich of future conditions in California (16).

Alternative Predictions of the Exogenous Variables

For the purpose of predicting future price and production levels, various alternative values of the exogenous variables were projected and used in the model. In this manner the effects upon future prices of alternative levels of (1) pear production in Michigan and New York, (2) California cling-peach prices, (3) canned-pear exports, (4) and population were analyzed.[1] A brief discussion of the formulation of these alternative projections of the exogenous variables is presented below.

Pear production in Michigan and New York. Census data on bearing and non-bearing tree numbers were used as a basis for projecting future production trends in these competing states. Data from the most recent census (1959) indicate that non-bearing acreage in the two states was equal to about 37 percent of bearing acreage at that time (47). It was assumed that non-bearing acreage equal to about 27 percent is necessary to maintain a constant bearing acreage in these states.[2] Therefore, the existing percentage of non-bearing acreage will allow future increases in bearing acreage of about ten percent.

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[1] The other exogenous variable (average canners' stocks per 1,000 persons) was assumed to remain constant during future periods.

[2] This percentage corresponds to an average tree life of eight non-bearing years and thirty bearing years.

Additional new plantings have also been made in these two states since 1959, although data are not available regarding the exact magnitude of these plantings. However, these recent plantings of non-bearing trees would suggest a greater increase in future bearing acreage than that indicated by the 1959 census data. In addition, production in these states will probably increase more than proportionally with increases in bearing acreage, because of improvements in production techniques, management, and other yield-increasing factors. Based on these considerations, alternative increases in production of 10 percent, 20 percent, and 30 percent were projected for these two states by the year 1972.[1]

Farm price of California cling peaches. Future cling-peach prices were predicted on the basis of projected peach production, disposable income, and other price-influencing factors. Production projections were based upon data regarding existing bearing and non-bearing acreage. Data for 1963 indicate the presence of 60,300 bearing acres and 16,600 non-bearing acres of cling peaches in California (5). This non-bearing acreage is equal to approximately 27 percent of the bearing acreage.

Examination of historical acreage data indicates that non-bearing acreage equal to between 17 percent and 23 percent of

[1] For projected average production in tons, see Appendix Table A-7.

bearing acreage is needed to maintain a constant bearing acreage.[1] If the median value of 20 percent is used, existing non-bearing acreage indicates an increase in future bearing acreage of approximately seven percent. This increase in bearing acreage by itself, can be expected to result in similar increases in production of seven percent by about 1967.

Future production can be expected to increase as the result of a rising yield trend as well as because of an expanding bearing acreage. In the post-war period, cling-peach yields have increased at an average rate of approximately one percent per year. It was assumed that this yield trend will continue at the same rate in future years. Therefore, an additional rise in production of five percent can be expected by 1967 due to increasing average yields.

In recent years, California cling peach production has been limited through operation of a "green-drop" program, which is made possible by a cling-peach marketing order in that state. Recent sentiments expressed by industry representatives indicate that the green-drop program is becoming increasingly unpopular. These indications imply that this program may be discontinued within the next several years (6). If this occurs, further increases in

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[1] These percentages are in agreement with those suggested for medium-yielding trees in a California study of the economics of replacing cling peach trees (11, p. 27-28).

marketable production can be expected. In recent years the tonnage removed through this program has varied between six and sixteen percent of actual production. Therefore, an increase in production of 13 percent was projected by the year 1967 to account for the possible elimination of the green-drop program.

The expected increases in production of seven percent from acreage expansion, five percent from higher yields, and thirteen percent from discontinuation of the green-drop program, result in a total increase of twenty-five percent in projected production by 1967.

To estimate the effects upon future cling-peach prices, this projected production was introduced into a price-estimating equation which has been developed by Hoos (19, p. 16). This equation takes the following form:

$$Y = -12.5090 - \underset{(-5.79)}{.1635}\, X_1 + \underset{(16.57)}{3.7587}\, \log_e X_2 + \underset{(6.77)}{.0229}\, X_3$$

$$R^2 = .96$$

where: Y = annual average f. o. b. price (choice, No. $2\frac{1}{2}$) of California canned cling peaches (dollars per case)

X_1 = canners' commercial movement of California canned cling peaches (1,000,000 cases)

X_2 = index of United States disposable personal income (1947-1950 = 100)

X_3 = adjusted index of prices of competing canned fruits (1947-1950 = 100)

For use in this price-estimating equation it was assumed that disposable income in the future will rise at a rate of two percent per year. It was further assumed that the index of prices of competing canned fruits will remain equal to average levels in recent years. By introducing these values for disposable income and competing fruit prices, along with a percentage increase in commercial movement equal to the percentage increase in production, into the above equation, a future f. o. b. price of $4. 65 per case was predicted. This price level represents a decrease of about five percent from average prices during the 1958-62 period. This projected change in f. o. b. price was, then, used to estimate future farm prices of California cling peaches.

No estimates are available regarding the relative elasticities for cling peaches at the different marketing levels. Because of the lack of quantified elasticity estimates for this commodity, the rather bald assumption was made that a decrease in f. o. b. price will result in an equal percentage decrease in farm price. Therefore, the indicated decrease of five percent in f. o. b. price of canned cling peaches was assumed to result in a five percent decrease in grower returns per ton. One alternative projection is, therefore, for a decrease in cling peach prices of five percent by

1967.[1]

Alternative levels of California cling peach prices were also projected in a similar manner to that outlined above. One alternative projection was based upon a 30-percent increase in cling-peach production instead of the 25-percent increase assumed above. This increase in future production is well within the realm of possibility if, for example, yields increase at a more rapid rate than in recent years or if a smaller percentage of non-bearing acreage than that estimated above is needed to maintain a constant bearing acreage. With a 30-percent increase in production, the Hoos price-estimating equation indicates a decrease in f. o. b. price of about eight percent. Therefore, a decrease in farm price of eight percent was used as a second alternative projection.

A third alternative projection of cling-peach prices is that these prices will remain equal to average levels experienced in recent years (the five-year average for 1958-62). These price levels are possible, for example, (1) if the green-drop program is continued, (2) if growers remove relatively large bearing acreages because of disease conditions or recent low price levels, or (3) if yields increase less rapidly in the future than in the recent past.

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[1] For projected average price levels of cling peaches in dollars per ton, see Appendix Table A-6.

Exports of canned pears. In recent years, exports of canned pears have gone primarily to Canada and to countries in Western Europe -- including members of the European Common Market (European Economic Community) and non-member countries such as Great Britain and the Scandinavian countries.

Recent developments within the Common Market indicate that canned-fruit exports to such traditional receiving countries as West Germany, the Netherlands, and Belgium may be severely curtailed in future years. The planned establishment of a common external tariff by the European Economic Community, accompanied by large new plantings of pears and other deciduous fruits in France and Italy, suggests that these two countries may supply a growing portion of future canned fruit needs in the entire Common Market. The competitive position of France and Italy will be further strengthened by a growing fruit and vegetable canning industry, the development of which is actively encouraged by the government of France. Because of these conditions affecting the future export market, one alternative projection of canned-pear exports is for a decrease of 20 percent within the next ten years.

Although conditions within the European Economic Community do not appear favorable for exports of canned pears in the future, a substantial portion of past exports have gone to other European countries and to Canada. Increases in future trade restrictions for these countries do not appear imminent. Furthermore, rising incomes and growing population in importing countries will tend to raise demand for canned fruits such as pears and fruit cocktail. Because of these conditions, future exports to countries which are not members of the European Economic Community may increase sufficiently to result in net increases in canned pear exports. Therefore, a second alternative projection of export levels is for an increase of 20 percent within a ten-year period.

A third alternative projection is that exports will remain equal to the five-year average for the years 1958 to 1962. This alternative is based upon the assumption that favorable conditions for future exports will tend to just compensate for the unfavorable conditions.

Population. Data on future population in the United States were obtained from published population projections made by the Bureau of the Census (45). These published population projections are divided into four alternative series -- Series A, B, C, and D. Series A indicates the most rapid rate of population growth and Series D represents the slowest rate. In the present study, Series B was used for population projections in all cases except one. In that case, Series D was substituted into the model in order to determine possible effects of an alternative rate of population growth upon future price levels of Bartlett pears.

Future Predictions

The model was used with alternative levels of the exogenous variables to generate several series of price and production predictions for the period from 1963 to 1985. These predictions are intended to represent average price and production levels for a "normal" crop without the influence of annual fluctuations due to weather conditions.

With several alternative projections of each of four exogenous variables (production in Michigan and New York, California cling-peach price, canned-pear exports, and population), computation of the resulting predictions from all possible combinations of these alternatives would involve a large number of predicted series. Many of these resulting series would be very similar to one another. For these reasons, six alternative combinations of the exogenous-variable projections were selected. These combinations are summarized as follows:

Alternative No. 1 -- An increase in production in Michigan and New York of ten percent, no change in the California cling-peach price, an increase in canned-pear exports of 20 percent, and Series B of population projections.

Alternative No. 2 -- An increase in production in Michigan and New York of 30 percent, a decrease in California cling-peach price of eight percent, a decrease in canned-pear exports of 20 percent and Series B of population projections.

Alternative No. 3 -- An increase in production in Michigan and New York of 20 percent, a decrease in California cling-peach price of five percent, no change in canned-pear exports, and Series B of population projections.

Alternative No. 4 -- Same as Alternative No. 3, except an increase in canned-pear exports of 20 percent.

Alternative No. 5 -- Same as Alternative No. 3, except a decrease in California cling-peach price of eight percent.

Alternative No. 6 -- Same as Alternative No. 3, except Series D of population projections.

Alternative No. 1 involves the combination which will provide the highest series of price predictions of any of the alternative combinations. By contrast, Alternative No. 2 includes the combination which will provide the lowest series of price predictions. The other alternatives represent levels of future price predictions which are intermediate to the extreme range outlined by Alternatives No. 1 and No. 2.

Price Predictions

The resulting series of predicted prices are presented in Table 6. The price predictions for Alternatives No. 1 through No. 4

Table 6. Future price predictions for Pacific Coast Bartlett pears, 1963-85.

Year	Alternative No. 1	Alternative No. 2	Alternative No. 3	Alternative No. 4	Alternative No. 5	Alternative No. 6
1963	$87.10	$86.30	$88.10	$87.00	$88.00	$88.10
1964	89.70	87.50	91.10	89.30	90.90	91.10
1965	90.50	85.90	91.60	89.50	91.20	91.60
1966	92.80	85.00	92.90	91.00	92.30	92.90
1967	90.90	80.00	88.40	88.30	87.60	88.30
1968	89.00	75.40	84.00	85.80	83.30	84.00
1969	87.30	71.30	79.90	83.60	79.40	80.00
1970	85.70	67.70	76.10	81.80	76.00	76.30
1971	84.30	64.70	72.80	80.30	73.10	73.10
1972	83.10	61.90	69.60	79.00	70.60	70.10
1973	82.70	60.60	67.80	78.70	69.30	68.50
1974	83.10	60.50	67.20	79.20	69.30	68.10
1975	84.30	61.60	67.80	80.40	70.40	68.80
1976	86.10	63.90	69.70	82.20	72.50	70.60
1977	87.80	66.00	71.70	84.00	74.40	72.30
1978	89.40	67.90	73.60	85.60	76.30	73.90
1979	90.80	69.70	75.60	87.10	78.00	75.30
1980	92.10	71.30	77.40	88.40	79.50	76.60
1981	93.30	72.70	79.10	89.70	80.80	77.70
1982	94.40	74.00	80.60	90.80	82.10	78.70
1983	95.30	75.10	81.90	91.80	83.20	79.60
1984	96.20	76.10	83.10	92.60	84.20	80.30
1985	97.00	77.00	84.10	93.40	85.00	81.00

are also shown graphically in Figure 9.[1] These resulting series of price predictions indicate, in each case, rising future prices for several years -- followed by steadily decreasing price levels until 1973 or 1974. After this time, a steady rise in average price is indicated in each case.[2]

Although all of the future price series exhibit similar trend movements over time, the levels of predicted price differ in each case. In general, Alternate No. 1 provides the highest levels of predicted prices, with a low level of $82.70 per ton in 1973 and a high of $97.00 by 1985 (Figure 9). By contrast, results of Alternative No. 2 indicate the lowest predicted price levels, with a low of $60.50 in 1974 and an increase to $77.00 by 1985. Alternative No. 4 exhibits moderately high price levels with a low of $78.70 in 1973 and a high of $93.40 by 1985. The resulting price predictions for Alternatives No. 3, No. 5, and No. 6 were all similar, with low levels of $67 to $70 in 1974 and a range of $82 to $85 by 1985 (Table 6).

Alternative No. 4 was included in order to isolate the effects upon predicted price of a 20-percent increase in canned-pear exports.

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[1] Results of Alternatives No. 5 and No. 6 are omitted from the graph in Figure 9 because each of these series closely approximates that of Alternative No. 3.

[2] Price fluctuations due to effects of annual production variations may result in annual prices which are above or below the predicted levels for "average" or "normal" crop size shown in Figure 9.

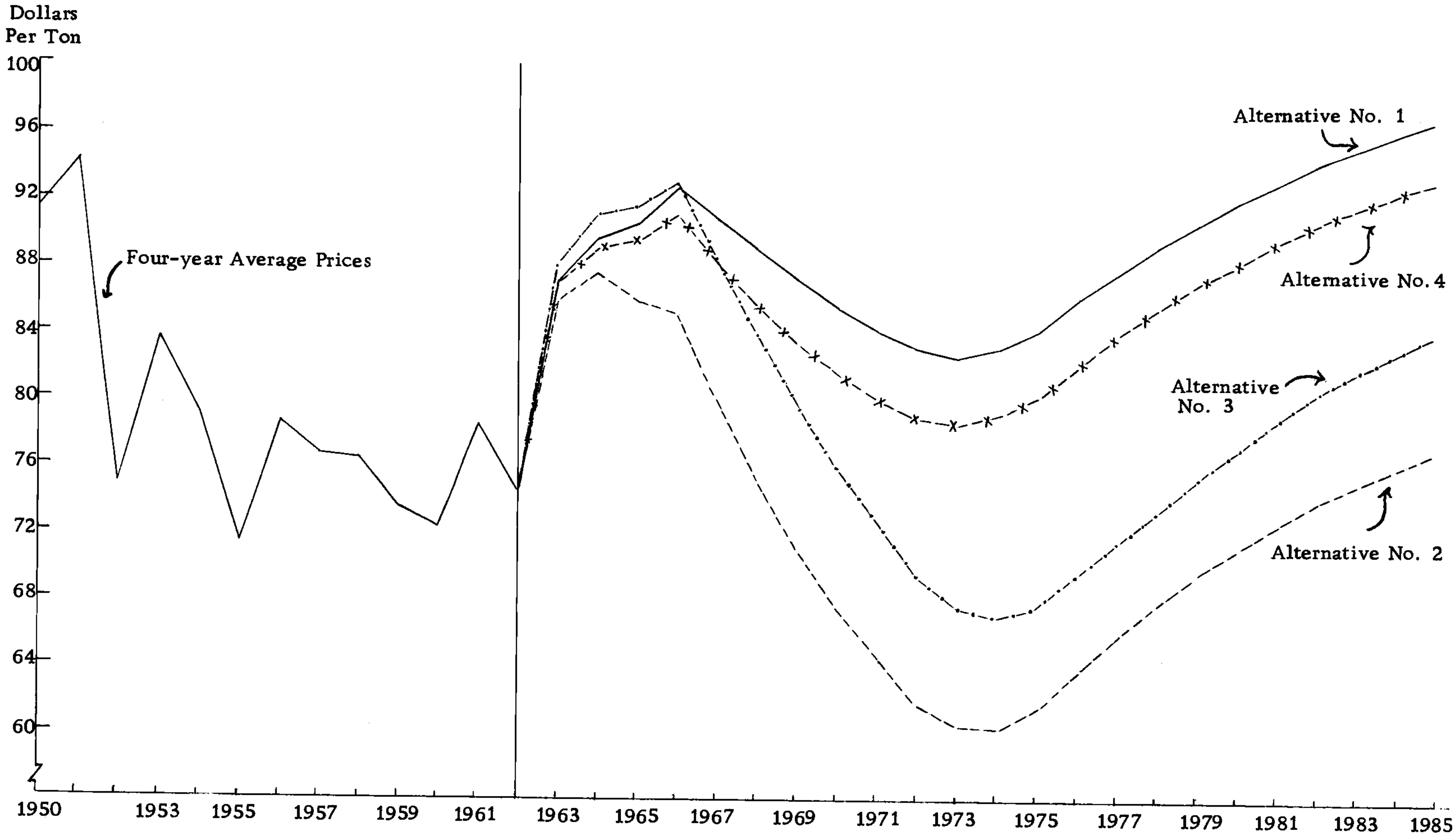

Figure 9. Average real farm prices of Pacific Coast Bartlett pears, projected to 1985.

This purpose is served by a comparison of Alternative No. 4 to Alternative No. 3, because these two alternatives include the same values of all exogenous variables except exports (Alternative No. 3 involves export levels equal to the five-year average between 1958 and 1962). After some fluctuation during the initial four-year period due to different assumptions regarding the rate of initial adjustment,[1] predicted prices with Alternative No. 4 are consistently higher than those indicated for Alternative No. 3. After the full impact of the increase in exports under Alternative No. 4 is experienced (after 1972), the price differential remains between $10 and $12 per ton during the remainder of the projection period. This difference in price can, therefore, be ascribed to the assumed 20-percent increase in exports.

The effect of an eight-percent decrease in California cling-peach price can be contrasted to the effect of a five-percent decrease by comparing Alternative No. 5 and Alternative No. 3. The results of these two alternatives show that slightly lower predictions of pear prices during the period from 1963 to 1970 are associated with the

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[1] The value of the export variable for 1962 was below the five-year average for the 1958-62 period. Under Alternative No. 3, it was assumed that the entire adjustment to the five-year average was made by the first year (1963), after which exports remain constant at this level. Under Alternative No. 4, it was assumed that exports will increase at a constant annual rate, which will result in twenty-percent increase in export levels by 1972 (based upon the five-year average for 1958-62).

larger decrease in cling-peach price (Alternative No. 5). However, in succeeding years slightly higher prices are indicated for Alternative No. 3. In both periods, the predicted pear prices differ by less than $3 per ton with the two alternative levels of cling-peach prices. Thus, it can be concluded that alternative changes in cling-peach price of this magnitude will have a relatively small effect upon Bartlett-pear prices.

Results of Alternative No. 6 can be compared to those of Alternative No. 3 to ascertain the impact upon predicted pear prices of differing rates of population growth. Predicted prices under these two alternatives differ by less than one dollar per ton for all but the last few years of the production period. During the years from 1980 to 1985, differences of three dollars per ton are shown. Comparison of these two price series indicates that an alternative low rate of population growth (Series D) has little effect upon future price levels.

Production Predictions

Predicted levels of future production are presented in Table 7. These predictions indicate that production can be expected to increase rather sharply until about 1972; after which time, moderate decreases in production are indicated (Figure 10). Although predicted production levels for all of the alternatives diminish from

Table 7. Future production predictions for Pacific Coast Bartlett pears, 1963-85.

Year	Alternative No. 1	Alternative No. 2	Alternative No. 3	Alternative No. 4	Alternative No. 5	Alternative No. 6
	(1,000 tons)	(1,000 tons)	(1,000 tons)	(1,000 tons)	(1,000 tons)	(1,000 tons)
1963	475.2	475.2	475.3	475.2	475.2	475.2
1964	492.3	492.1	492.6	492.2	492.4	492.4
1965	509.9	509.3	510.4	509.8	510.3	510.3
1966	527.7	526.2	528.4	527.3	528.1	528.3
1967	545.9	543.0	546.6	545.2	546.3	546.5
1968	563.8	558.8	564.0	562.6	563.5	563.9
1969	581.3	573.7	580.5	579.5	579.8	580.4
1970	598.4	587.7	596.1	595.9	595.4	596.0
1971	615.2	601.0	611.0	611.9	610.2	610.9
1972	631.7	613.6	625.1	627.7	624.4	625.1
1973	626.0	605.3	617.4	621.5	617.0	617.6
1974	620.5	597.1	609.9	615.6	609.7	610.1
1975	615.4	589.3	602.6	610.0	602.8	603.0
1976	610.7	582.1	595.8	604.9	596.3	596.3
1977	606.5	575.5	589.5	600.3	590.6	590.2
1978	602.8	569.7	584.0	596.3	585.4	584.7
1979	599.5	564.4	579.0	592.7	580.8	579.7
1980	596.6	559.7	574.5	589.5	576.7	575.2
1981	594.1	555.5	570.6	586.7	573.0	571.1
1982	591.9	551.7	567.2	584.3	569.7	576.4
1983	590.0	548.3	564.2	582.1	566.8	564.1
1984	588.3	545.2	561.5	580.3	564.2	561.0
1985	586.9	542.5	559.1	578.6	561.9	558.2

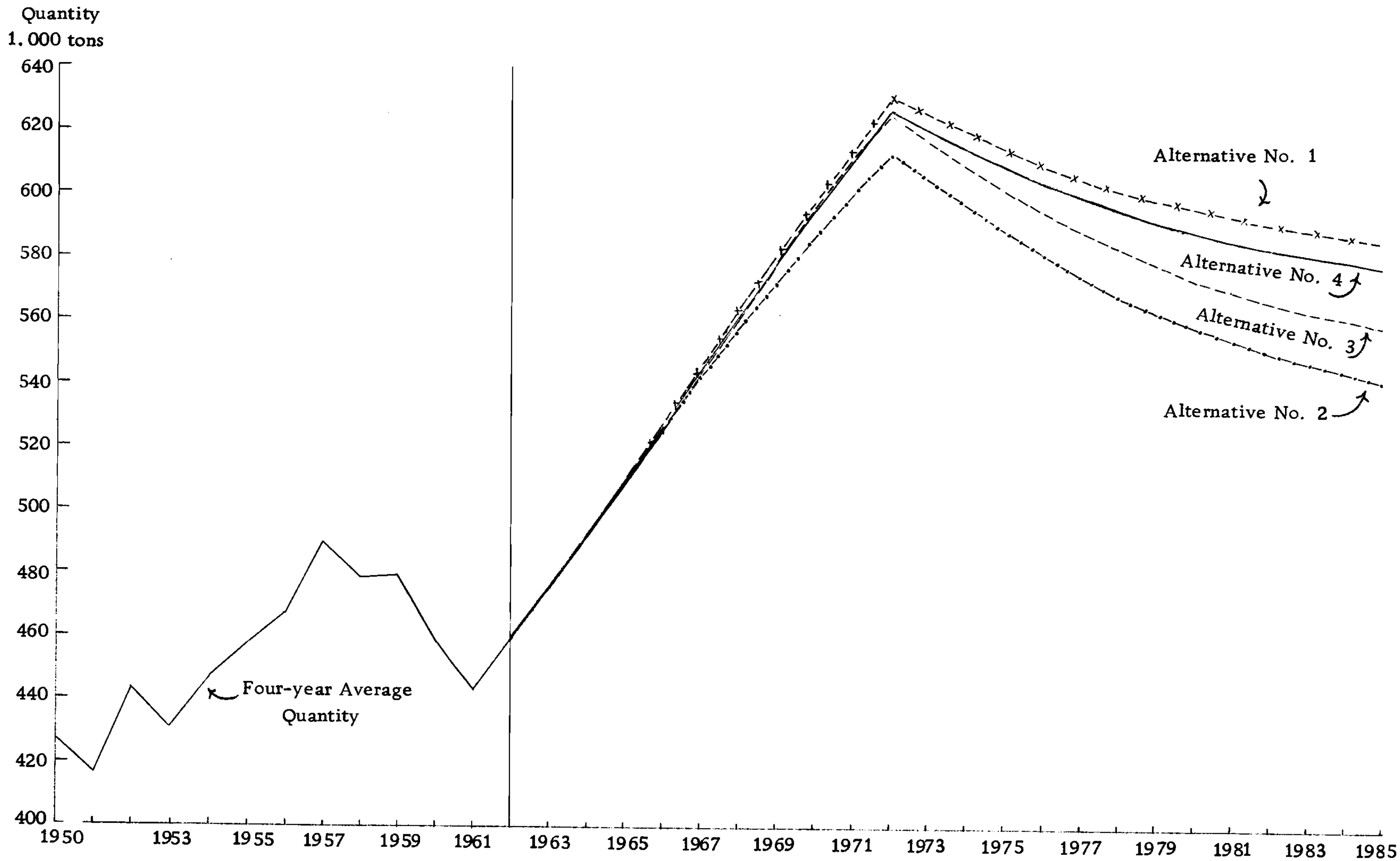

Figure 10. Future production predictions for Pacific Coast Bartlett pears, 1963 - 1985.

1972 to 1985, future production in each case is indicated to be substantially greater throughout the entire period from 1963 to 1985 than average production in recent years.

The production predictions from the various alternatives are characterized by their similarity until about 1970. During succeeding years, differences in predicted production levels become increasingly evident. High future prices predicted under Alternative No. 1 result in predictions of relatively high future production for this alternative, because of producer response to these relatively favorable price conditions. By contrast, relatively low production levels were predicted under the assumptions of Alternative No. 2 due to the lower producer response to unfavorable prices. Differences in predicted production for these two "extreme" alternatives (Alternatives No. 1 and No. 2) amount to about 18,000 tons by 1972, and gradually widen to approximately 44,000 tons by 1985. Predicted production levels of Alternatives No. 3, No. 4, No. 5, and No. 6 lie between those indicated for Alternatives No. 1 and No. 2 (Table 7). Production levels of Alternatives No. 5 and No. 6 are predicted to be very similar to those under Alternative No. 3.

Effects of Adjustments in the Model

The effects of adjustments for bias in the model and for abnormal non-bearing acreage, which were outlined in an earlier section, were determined by predicting values of future price and production for Alternative No. 3 both with and without these adjustments. The resulting adjusted and unadjusted predictions are presented in Table 8.

The adjustments for bias in the model resulted in predicted production levels which are somewhat higher than the unadjusted predictions. The difference between these two series of production predictions is greatest in 1963 (a difference of 11,400 tons) and gradually diminishes throughout the period to a difference of 3,900 tons in 1985.

Production predictions which are adjusted for abnormal non-bearing acreage are substantially higher than either those which are unadjusted or adjusted only for bias. The series of predictions which includes both adjustments increases rapidly until 1972, and then diminishes until 1985. By contrast, the other two series of production predictions increase slowly and steadily throughout the entire period from 1963 to 1985. Comparison of the series with both adjustments to the unadjusted series shows the greatest difference between the two (151,600 tons) in 1972. This difference then decreases until 1985 when a variation of 60,000 tons is indicated.

The series of predicted prices which result from the adjustment for bias are slightly lower than those obtained with no adjustments. Differences between the predicted prices of these two series

Table 8. Adjusted and unadjusted predictions of future price and production for Alternative No. 3

Year	Predicted Average Production: Unadjusted (1,000 tons)	Predicted Average Production: Adjusted For Bias (1,000 tons)	Predicted Average Production: Adjusted for Bias and for Non-bearing Acreage (1,000 tons)	Predicted Average Price: Unadjusted (Dollars per ton)	Predicted Average Price: Adjusted for Bias (Dollars per ton)	Predicted Average Price: Adjusted for Bias and for Non-bearing Acreage (Dollars per ton)
1963	450.1	461.5	475.3	90.30	88.90	88.10
1964	453.8	464.7	492.6	95.50	93.50	91.10
1965	457.9	468.3	510.4	98.90	96.30	91.60
1966	461.9	471.8	528.4	103.10	100.80	92.90
1967	465.9	475.3	546.6	101.50	99.30	88.40
1968	469.0	477.9	564.0	100.10	98.00	84.00
1969	471.2	479.7	580.5	98.80	96.80	79.90
1970	472.6	480.7	596.1	97.80	95.90	76.10
1971	473.3	481.1	611.0	97.10	95.30	72.80
1972	473.5	480.8	625.1	96.50	94.90	69.60
1973	473.1	480.1	617.4	96.10	94.50	67.80
1974	473.5	480.2	609.9	95.70	94.30	67.20
1975	474.9	481.2	602.6	95.50	94.10	67.80
1976	477.3	483.3	595.8	95.30	94.00	69.70
1977	480.7	486.5	589.5	95.10	93.90	71.70
1978	484.0	489.5	584.0	95.00	93.90	73.60
1979	487.2	492.4	579.0	95.00	93.90	75.60
1980	490.2	495.1	574.5	94.90	94.00	77.40
1981	493.0	497.7	570.6	94.90	94.00	79.10
1982	495.7	500.2	567.2	94.90	94.00	80.60
1983	498.3	502.6	564.1	94.80	94.00	81.90
1984	500.8	504.9	561.5	94.80	94.10	83.10
1985	503.2	507.1	559.1	94.80	94.10	84.10

range from \$2.60 per ton early in the projection period to only \$.70 in the last two years.

Comparison of the unadjusted series of predicted prices with that series which includes both adjustments shows that adjusted prices are considerably lower than those which are unadjusted. Differences between these two series range from \$28.50 per ton in 1974 to \$10.70 per ton in 1985.

All three series of predicted prices increase until 1966. After that year the unadjusted series decreases at a slow, steady rate throughout the remainder of the period until 1985. The series which is adjusted only for bias decreases steadily until 1977, after which time it remains constant or increases slightly. By comparison, the series which includes both adjustments decreases rapidly until 1974, and then increases again until 1985.

Limitations of the Future Predictions

Predictions of future price and production levels such as those generated by the model are, by necessity, dependent upon several critical assumptions. One of these assumptions is that future supply and demand relationships will not differ materially from the historical relationships which are estimated with the algebraic equations. Future changes in demand conditions, such as changes in the institutional factors in the market or changes in consumer tastes, would violate this assumption and therefore limit the accuracy of the predictions. These kinds of changes, however, ordinarily occur slowly over time.

Unexpected future changes in the supply relationship would, also, post limitations for the accuracy of the predictions. A common source of change which may alter a historical supply relationship is that of technological developments. The supply equation employed in this model reflects the impact of historical rates of relevant technological changes. However, if the effect of technological changes upon production is altered in the future by the development of an innovation of unusual impact, such as has occurred in the apple industry with the adoption of dwarf-trees, historical rates of technological change would no longer reflect the true situation. Although major technological developments of an unusual impact do not appear imminent for the pear-producing industry at the present time, future changes of this nature are especially difficult to predict and may well occur in the future. This possibility poses another limitation to future predictions based upon historical relationships.

Another example of future changes in production which may not be adequately reflected in the historical supply relationship is that of the production from the abnormally large non-bearing acreage in existence at the present time. To take account of the unusually extensive non-bearing acreage which has not contributed to past production, an adjustment was needed for future predictions based upon the historical relationship.

Long-run predictions which are based upon historical relationships have, of course, greater likelihood of error than short-run predictions which are based upon these same relationships. Because factors which affect demand and supply relationships tend to change slowly over time, short-run predictions based upon historical relationships can be made with a relatively high degree of accuracy. However, long-run predictions involve a greater number of years in which substantial changes can occur in the factors affecting supply and demand. The resulting greater chance for error in the long-run must be recognized as an inherent limitation of this type of prediction. This does not, however, negate the usefulness of such long-run predictions -- particularly for a crop such as pears which involves a long-run production and decision-making situation.

A second set of critical assumptions which affect future predictions of the model are those regarding projected values of the exogenous variables. Because of future uncertainties, projected estimates of these variables are necessarily speculative in nature. It is for this reason that several possible alternative projections of these variables were made and used for predictive purposes. Although a thorough analysis of these exogenous variables will permit relatively accurate projections of their values in the near future, particularly if a range of projected values is outlined, projections into the more distant future are more prone to include substantial errors. Thus, the possibility of error in these projections provides another limitation for long-run price and production predictions.

In addition to errors in future predictions from possible structural changes in the supply and demand relationships discussed above, certain other kinds of error must be recognized. The future predictions are point estimates to which an interval of error can be ascribed on the basis of probability. This interval of error, which is approximated by the standard error of the estimate, is underestimated as a consequence of the method of selecting independent variables on the basis of inspection of the data. Therefore future predictions will be subject to a greater error than is apparent from the computed standard errors of the estimates. Furthermore the fact that several of the independent variables are trending away from their average value in the period of analysis will result in a larger standard error for future predictions than that of the computed standard errors if these trends continue in the future.

V. PRODUCTION COST ESTIMATES

Estimates were made of farm production costs in each of the eight Pacific Coast production areas -- (1) Central Washington, (2) Hood River, (3) Willamette Valley, (4) Medford, (5) Lake-Mendocino, (6) Sacramento River, (7) Sierra Foothills, and (8) Santa Clara (Figures 1 and 2). These estimates of production costs were established in order to indicate the competitive position of Bartlett-pear producers in the various areas. Separate cost estimates were made for irrigated and unirrigated orchards in the Willamette Valley. Because both methods of operation are feasible in this area, these separate cost estimates were made to explore adjustment possibilities for Bartlett pears under both situations.

Data for production cost estimates were obtained from previously published cost studies, grower group interviews, county agents, and representatives of the state agricultural college in each area. Group interviews were conducted with a number of representative commercial growers from the area involved. These growers were asked to discuss and provide their collective judgment regarding typical input requirements, cost items, average yields, and size of operation for commercial orchards in their area.

Grower group interviews were conducted by the author in the Hood River, Willamette Valley, and Central Washington areas.

Although previously published cost studies were available for Hood River covering the period 1947 - 1956 (17) and for Central Washington based upon 1954 conditions (52), it was felt that subsequent changes in cost conditions have been sufficient to necessitate a more recent study in these areas. The previous studies were used, however, as a comparison for data obtained in the group interviews -- particularly for data on input and cost items which the growers indicated had not materially changed from the period of the previous studies.

Cost estimates for California producing areas were based, to a large extent, upon published data obtained by California extension personnel through grower group interviews in each area (18, 21, 27, 28). An effort was made to "standardize" the approach used in each of these California studies with that used for the studies made by the author in Oregon and Washington. Thus, some adjustments in the data reported in the California studies were necessary to obtain a common basis for cost estimates in each area. These necessary adjustments were made with the advice and cooperation of the California extension personnel who conducted the original cost studies in that state.

Production cost estimates for the Medford area were obtained by an individual-interview survey of large grower-shippers whose operations represent the bulk of the acreage in that area.

Estimated Total Costs of Production

Total Costs per Acre and per Ton

The production-cost estimates for Bartlett pears include variable costs per acre, such as labor, spray materials, and fertilizer; fixed costs for the pear enterprise, such as land and orchard overhead charges; and costs which are fixed for the farm as a whole but are used for more than one enterprise, such as buildings and certain machinery items. These estimates of production costs in each area are presented in Table 9, on a per acre basis and on a per ton basis.[1] Estimated costs per acre for each area were also broken down into major components (Table 10). Important cost differences between areas, as well as the basis for estimating each of the major cost components, will be discussed in the following sections.

From Table 9, it can be noted that the two areas with the highest estimated costs per acre (Sacramento River and Lake-Mendocino) have some of the lowest costs per ton; while the area with the lowest costs per acre (Willamette Valley - Irrigated and Unirrigated) has high costs per ton. High costs per acre in the Sacramento River and Lake-Mendocino areas are due to relatively high levels of variable

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[1] In this table, as in all tables in this chapter, the various areas are ranked in ascending order according to total costs per ton.

Table 9. Estimated costs of producing Bartlett pears in Pacific Coast production areas, 1963.

Area	Estimated Costs	
	Per Acre	Per Ton
Sacramento River (California)	$1,102.50	$52.70
Hood River (Oregon)	752.10	66.00
Lake-Mendocino (California)	991.20	67.00
Central Washington	895.75	74.20
Santa Clara (California)	946.80	75.10
Medford (Oregon)	736.80	76.70
Willamette Valley (Oregon) - Irrigated	539.40	77.00
Sierra Foothills (California)	782.90	86.00
Willamette Valley (Oregon) - Unirrigated	444.60	88.90

Table 10. Itemized components of estimated production costs for Bartlett pears in Pacific Coast production areas, 1963.

Cost Item	Sacramento River	Hood River	Lake-Mendocino	Central Washington	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
	(Dollars Per Acre)								
Labor - Pre-harvest	243.00	141.40	174.10	206.50	244.50	185.50	81.80	151.80	69.10
Labor - Harvest	280.30	109.60	214.30	98.70	172.00	102.30	72.10	119.20	53.70
Labor - Miscellaneous	26.10	12.60	19.60	15.30	20.70	14.00	7.70	13.60	6.10
Spray and Dust Materials	131.10	105.00	75.00	128.10[1]	68.00	90.00	90.00	81.30	90.00
Fertilizer	14.40	12.20	13.00	37.10	36.00	16.00	10.30	14.00	10.30
Heating Oil	----	----	65.00	58.80	----	44.60	----	----	----
Irrigation Water	----	5.70	----	10.00	6.00	13.30	----	27.50	----
Miscellaneous Supplies	7.30	8.80	7.70	16.30	8.70	8.20	9.00	6.20	7.30
Machinery Repairs and Fuel	64.50	51.40	52.90	56.20	49.10	35.00	42.50	45.80	40.50
Machinery Overhead	61.40	83.70	79.50	86.70	45.50	43.90	59.90	68.20	50.40
Property Taxes	49.00	22.80	40.50	24.80	52.00	16.00	18.10	33.60	12.30
Electricity and Utilities	7.00	12.00	23.00	5.00	5.00	2.50	3.00	3.00	2.00
Buildings Repairs and Insurance	6.60	11.30	4.30	6.90	6.10	5.30	2.60	7.70	2.60
Buildings Overhead	8.80	14.80	3.40	11.40	9.20	10.40	3.40	14.80	2.60
Irrigation System Overhead	4.60	15.90	19.10	----[2]	4.70	1.20	15.90	12.80	-----
Orchard Overhead	95.00	60.50	99.70	55.00	104.50	63.00	39.40	100.90	36.80
Land Overhead	66.00	27.50	60.50	27.50	77.30	55.00	35.80	44.00	24.70

(Continued)

Table 10 (Continued)

Cost Item	Sacramento River	Hood River	Lake-Mendocino	Central Washing-ton	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
				(Dollars Per Acre)					
Management	30.00	50.00	33.30	44.40	31.00	25.00	44.40	33.30	33.30
Interest on Operating Capital	7.40	6.90	6.30	7.50	6.50	5.60	3.50	5.20	3.00
TOTAL ESTIMATED COST	1,102.50	752.10	991.20	896.20	946.80	736.80	539.40	782.90	444.60

[1] Includes custom airplane dusting.

[2] Included in "land overhead."

input use and to relatively high land and orchard values in these areas. On the other hand, favorable climatic conditions and land quality allow growers in these areas to obtain relatively high average yields (Table 11). These high yields per acre more than compensate for the high costs per acre, and result in low costs per ton.

Yields per Bearing Acre

As the above example illustrates, yields are an important factor in the determination of total costs per ton. Table 11 shows typical yields for the various production areas. These yields represent long-run averages over a period of several years. In each case the yields are higher than the county or area average for all bearing acreage, but are lower than those obtained in some of the more favorable years of the recent past. These yields are based upon the practices for which the cost estimates were made. So far as data were available, the yields are based upon 120 percent of the area average for the six-year period 1957-62.

Long-run average yields are determined largely by climatic conditions, quality of the land resources, and orchard site location, as well as by the amount and type of variable inputs and production practices used. Differences in long-run average yields in the various production areas are probably due largely to differences in climatic conditions, land quality, and site location; as it is doubtful

Table 11. Typical acreage, enterprise combinations, and yields in Pacific Coast pear-production areas

Area	Acres of Cropland per Farm	Other Crops Commonly Raised	Bartlett Pears	
			Acres Per Farm	Yield Per Bearing Acre (Tons)
Sacramento River	100	Field Crops Tomatoes	30	20.9
Hood River	40	Winter Pears Apples	10	11.4
Lake-Mendocino	60	Walnuts	30	14.8
Central Washington	45	Apples Winter Pears Peaches Cherries	15	12.0
Santa Clara	80	Cherries Apricots Prunes Walnuts	60	12.6
Medford	450	Winter Pears	200	9.6
Willamette Valley -- irrigated	45	Cherries Filberts Walnuts Prunes	15	7.0
Sierra Foothills	60	Plums	30	9.1
Willamette Valley -- unirrigated	60	Cherries Prunes Filberts Walnuts	15	5.0

that quality of management decisions or the degree of technological adoption differ appreciably between entire areas.

Estimates of Cost Components

Labor Costs

Labor costs for pre-harvest operations depend upon the number and intensity of cultural practices employed and upon prevailing wage rates in the area. With the exception of such operations as pruning, thinning, and propping, labor costs per acre for pre-harvest operations vary only slightly with differences in yields. Harvest-labor costs per acre, on the other hand, vary almost proportionally with yield.

Estimated labor costs per acre by operation are presented in Table 12. All labor, including that of the owner-operator, was charged at prevailing wage rates for hired labor. These labor-cost estimates are based upon the following hourly wage rates: (1) Sacramento River - $1.35 per hour, (2) Lake-Mendocino - $1.65 per hour, (3) Hood River - $1.40 per hour for pre-harvest labor and $1.60 for hourly harvest labor, (4) Central Washington - $1.45 per hour for pre-harvest labor and $1.60 per hour for hourly harvest labor, (5) Santa Clara - $1.60 for tractor driving, $1.45 for pruning and irrigating, and $1.35 for all other labor, (6) Medford - $1.60 for

Table 12. Estimated labor costs of producing Bartlett pears in Pacific Coast production areas. 1963.

Operation	Sacramento River	Hood River	Lake-Mendocino	Central Washington	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
Pre-harvest:				(Dollars Per Acre)					
Prunes	151.20	39.20	99.00	77.70	156.60	51.00	52.50	78.10	35.00
Brush Removal	6.70	2.10	3.30	2.40	2.70	3.00	1.80	3.00	1.80
Fertilize	.70	.70	.80	4.20	.80	1.10	.60	.70	.60
Heat(all phases)	----	----	16.50	17.80	----	23.00	----	----	----
Spray	10.80	6.70	5.00	7.00	9.60	8.00	10.00	12.00	10.00
Dust	1.40	----	3.30	----	----	----	----	1.80	----
Mow	----	4.40	----	4.40	----	----	----	2.30	----
Cultivate	4.00	3.30	3.30	1.90	4.80	8.40	4.60	1.50	4.60
Rill	----	----	----	3.00	----	----	----	-----	----
Maintain Checks	1.80	----	----	----	3.20	----	----	-----	----
Irrigate	6.70	8.40	11.60	21.70	14.50	14.80	3.80	30.00	----
Inspect and Cut Blight	40.50	1.40	8.20	2.30	27.00	3.30	----	-----	----
Thin	----	53.20	----	46.40	----	54.00	----	-----	10.00
Prop and Tie	}	[1]	}		}	}	[1]	7.50	[1]
Seed Cover Crop	} 5.40	----	} 13.20	----	} 10.10	} 4.60	1.10	}	.60
Remove and Replant Trees	}	4.20	}	2.90	}	}	----	} 5.00	----
Miscellaneous Cultural Practices	}	9.80	}	3.00	}	}	2.50	}	2.50
Supervision (Pre-harvest)	13.80	8.00	9.90	11.80	15.20	14.30	4.90	9.90	3.90
Total Pre-harvest	243.00	141.40	174.10	206.50	244.50	185.50	81.80	151.80	69.00

(Continued)

Table 12. (Continued)

Operation	Sacramento River	Hood River	Lake-Mendocino	Central Washing-ton	Santa Clara	Medford	Willamette Valley - Irrigated[1]	Sierra Foothills	Willamette Valley - Unirrigated
				(Dollars Per Acre)					
Harvest:									
Yard, load, and pre-place containers	11.40	8.70	9.70		8.00	9.40	3.30	5.40	2.70
Haul	11.30	4.30	9.80	7.50	8.00	5.50	3.80	5.40	4.00
Supervision (Harvest)	6.80	4.40	9.90		4.80	9.60	2.00	3.70	2.00
Pick	250.80	92.30	185.00	91.20	151.20	77.80	63.00	104.70	45.00
Total Harvest	280.30	109.60	214.30	98.70	172.00	102.30	72.10	119.20	53.70
Total Harvest Per Ton	13.40	9.60	14.50	8.20	13.70	10.70	10.30	13.10	10.80
Miscellaneous Labor	26.10	12.60	19.60	15.30	20.70	14.00	7.70	13.60	6.10
Total Labor	549.40	263.60	408.00	320.50	437.20	301.80	161.60	284.60	128.80

[1] Included in "Miscellaneous cultural practices."

supervision, $1.30 for thinning, and $1.40 for all other labor, (7) Sierra Foothills - $1.50 for tractor driving and $1.25 for all other labor, and (8) Willamette Valley - $1.25 for pre-harvest labor and $1.35 for harvest labor. Picking-labor costs are based upon the following piecework rates: (1) Sacramento River - $12.00 per ton, (2) Lake-Mendocino - $12.50 per ton, (3) Hood River - $8.10 per ton, (4) Central Washington - $7.60 per ton, (5) Santa Clara - $12.00 per ton, (6) Medford - $8.10 per ton, (7) Sierra Foothills - $11.50 per ton, and (8) Willamette Valley - $9.00 per ton. These hourly and piecework rates include allowances for social security and liability insurance.

Table 13 shows estimated man-hour requirements for each operation in the various areas. These estimates of man-hour requirements reflect the intensity and method employed for the various operations as well as the size and type of equipment used. Total per-acre labor requirements are conditioned by the fact that certain operations are not commonly practiced in all areas. For example, orchard heating for frost protection during bloom periods is common in only three areas -- Lake-Mendocino, Medford, and Central Washington (Table 14).

High labor requirements for pruning and blight cutting in the Sacramento River and Santa Clara areas are conditioned by the large amounts of annual tree growth obtained in these areas. Although

Table 13. Estimated man-hour requirements by operation for producing Bartlett pears in Pacific Coast production areas. 1963.

Operation	Sacramento River	Hood River	Lake-Mendocino	Central Washington	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
	(Man Hours Per Acre)								
Pre-harvest:									
Prune	112.0	28.0	60.0	53.6	108.0	36.4	42.0	62.5	28.0
Brush Removal	5.0	1.5	2.0	1.7	2.0	2.1	1.5	2.0	1.5
Fertilize	0.5	0.5	0.5	2.9	0.5	0.8	0.5	0.5	0.5
Heat (all phases)	----	---	10.0	12.3	----	16.4	---	---	---
Spray	8.0	4.7	3.0	4.8	6.0	5.7	8.0	8.0	8.0
Dust	1.0	---	2.0	---	---		---	1.2	---
Mow	----	3.0	---	3.0	---	---	---	1.5	---
Cultivate	3.0	2.2	2.0	1.3	3.0	6.0	3.7	1.0	3.7
Rill	----	---	---	2.1	---		---	---	---
Maintain Checks	1.3	---	---	---	2.0	---	---	---	---
Irrigate	5.0	6.0	7.0	15.0	10.0	10.6	3.0	24.0	---
Inspect and Cut Blight	30.0	1.0	5.0	1.6	20.0	2.4	---		---
Thin	----	38.0	---	32.0	---	41.5	---	---	8.0
Prop and Tie		[1]					[1]	6.0	[1]
Seed Cover Crop	4.0	---	8.0	---	7.5	3.3	0.9		0.5
Remove and Replace Trees		3.0		2.0			---	4.0	---
Miscellaneous Cultural Practices		7.0		2.1			2.0		2.0
Supervision (Pre-Harvest)	10.2	5.7	6.0	8.1	9.5	8.9	3.9	6.6	3.1
Total Pre-Harvest	180.0	100.6	105.5	142.5	168.5	134.1	65.5	117.3	55.3

(Continued)

Table 13. (Continued)

Operation	Sacramento River	Hood River	Lake-Mendocino	Central Washing-ton	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
Harvest:									
Pick	146.3	79.8	103.6	84.0	88.2	67.2	49.0	63.7	35.0
Yard, load, and pre-place containers	8.4	5.4	5.9		5.0	6.7	2.5	3.6	2.0
Haul	8.4	2.7	5.9	4.7	5.0	3.9	2.8	3.6	3.0
Supervision (Harvest)	5.0	2.7	6.0		3.0	6.0	1.5	2.5	1.5
Total Harvest	168.1	90.6	121.4	88.7	101.2	83.8	55.8	73.4	41.5
Miscellaneous Labor	19.4	9.0	11.9	10.6	12.9	10.0	6.2	9.0	4.9
Total Labor	367.5	200.2	238.8	241.8	282.6	227.9	127.5	199.7	101.7

[1] Included in "Miscellaneous cultural practices."

Table 14. Typical pre-harvest operations practiced in producing Bartlett pears in Pacific Coast production areas.

Operation	Sacramento River	Hood River	Lake-Mendocino	Central Washington	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
	(Number of Times Performed)								
Prune	1	1	1	1	1	1	1	1	1
Brush Removal	2	2	1	2	1	1	2	2	2
Fertilize	1	1	1	2	1	1	1	1	1
Heat	--	--	4	2	--	4	--	--	--
Spray	8	8	6	5	8	7	8	8	8
Dust	6	--	6	3[1]	--	--	--	3	--
Mow	--	4	--	3	--	--	--	3	--
Cultivate	6	3	4	1	6	6	7	2	7
Rill	--	--	--	2	--	2	--	--	--
Maintain Checks	5	--	--	--	4	--	--	--	--
Irrigate	5	4	5	5	4	5	2	15	--
Inspect and Cut Blight	1	1	1	1	1	1	--	1	--
Thin	--	1	--	1	--	1	--	--	1
Prop and Tie	1	1	1	1	1	1	1	1	1
Seed Cover Crop	--	--	--	--	1	--	1	--	1
Remove and Replace Trees	--	1	--	1	--	--	--	--	--
Miscellaneous Cultural Practices	1	1	1	1	1	1	1	1	1
Supervision (Pre-harvest)	1	1	1	1	1	1	1	1	1

[1] Airplane dusting.

cultivation is practiced in all areas, mowing is substituted for some cultivation in certain areas such as Hood River, Central Washington, and Sierra Foothills. High labor requirements for irrigation in the Sierra Foothills are the result of shallow soils in this area which necessitate the application of approximately 15 irrigations per year (Table 14). Labor requirements for irrigation in the Willamette Valley, on the other hand, are low because only two applications per year are usually made if irrigation is practiced at all. Thinning to allow adequate fruit size is commonly practiced only in the areas of Hood River, Central Washington, and Medford -- and to a lesser extent on unirrigated orchards in the Willamette Valley.

Accurate estimates of pre-harvest supervision were difficult to obtain in many areas. However, supervisory labor varies largely in proportion to the amount of other labor which is required. Therefore, pre-harvest supervision was estimated on the basis of a percentage (six percent)[1] of other pre-harvest labor.

Per acre labor requirements for harvest operations vary directly with the tonnage harvested per acre. Therefore, harvest costs <u>per acre</u> are relatively high in areas with high average yields and low in areas where relatively low yields are obtained. Harvest

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[1] This percentage appears to be a reasonable estimate based upon the results of previous surveys (17) and upon the comments made by growers and others interviewed in the course of the present study.

costs per ton (Table 12), however, depend upon wage rates (especially piecework rates for picking) and the method used for handling the picked fruit. Piecework rates for picking are relatively high in California production areas; and as a consequence, costs per ton for harvest labor are relatively high in these areas. Handling picked fruit in bulk bins, which involves a relatively low labor requirement in relation to conventional handling methods, has recently become a common practice in all production areas except Medford. Labor costs for fruit handling are, therefore, relatively high in the Medford area. Nevertheless, total harvest labor costs per ton are relatively low in this area because of relatively low piecework picking rates.

Labor requirements for miscellaneous labor are assumed to include non-productive labor and general maintenance labor for the farm as a whole. Because accurate estimates for this category were difficult to obtain, these requirements were estimated on the basis of a percentage (five percent) of pre-harvest and harvest labor.[1]

Machinery Costs

Costs associated with the necessary machinery and equipment

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[1]See footnote on page 145.

were broken down into two main components: (1) costs of repairs, fuel, and lubrication, which vary to a large extent with the number of hours of use; and (2) fixed or overhead costs, which include annual charges for depreciation and interest on the investment.

Costs for repairs and fuel were based upon estimated hourly use of each implement per acre of pears. These estimates were then multiplied by published standards of average hourly costs of repairs and fuel for each implement (31).[1] One exception to this general approach was made in the Medford area where costs for machinery repairs and fuel per acre were based upon farm record data obtained in a survey of pear producers.

Overhead costs for machinery and equipment were based upon annual costs of depreciation and interest for the farm as a whole divided by acres of use for each implement. In most areas, machinery and equipment were used on acreages of other orchard crops as well as pears, and thus machinery overhead costs were spread over several enterprises. Charges for depreciation and interest on investment were based on 1963 replacement costs (31). Because it was assumed that differences in replacement costs between areas are small, equal estimates of these replacement costs were used for all areas. Depreciation was computed on a straight-line basis

[1] Estimates of hourly costs for repairs and fuel for implements employed in pear production are presented in Appendix Table A-9.

for the estimated average life of each implement. Interest on investment was computed at a rate of 5.5 percent per year on one-half of estimated replacement cost.

Machinery overhead costs per acre depend upon size of operation (acreage) and upon size and type of machinery and equipment employed. Table 15 shows the machinery by size and type which is typically employed for pear production in Pacific Coast areas. In areas where Bartlett pears are commonly raised in combination with other tree-fruit or nut crops, total orchard acreage is a relevant measure of size of operation. With this type of enterprise combination, all machinery items which are employed in Bartlett-pear production are also used in the production of other orchard crops. On the other hand, if Bartlett pears are commonly grown in combination with field-crop enterprises, some machinery items will be used for the pear enterprise alone. In this case, size of the Bartlett-pear enterprise becomes a relevant measure of size of operation.

Table 11 shows typical acreages of total cropland and Bartlett pears per farm in the various production areas, as well as other enterprises which are commonly raised in combination with Bartlett pears. Other tree-fruit or nut crops are commonly combined with Bartlett pears in all production areas except Sacramento River. In this area, economies of scale attained by a relatively large

Table 15. Typical equipment used in producing Bartlett pears in Pacific Coast production areas. 1963.

Equipment	Sacramento River	Hood River	Lake-Mendocino	Central Washing-ton	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
Tractor - 40 h.p. crawler. diesel	1	--	1	--	--	--	--	--	--
Tractor - 30 h.p. crawler. diesel	--	--	--	--	1	3	--	--	--
Tractor - 20 h.p. crawler. diesel	--	--	--	--	--	--	--	1	--
Tractor - 40 h.p.. wheel. gas	--	1	--	--	--	2	--	--	--
Tractor - 40 h.p.. wheel. diesel	--	--	--	1	--	--	--	--	--
Tractor - 30 h.p.. wheel. gas	1	1	1	--	1	2	1	--	2
Tractor - 20 h.p.. wheel. gas	--	--	--	1	--	--	1	1	--
Speedsprayer - Large	--	1	--	1	1	3	--	--	--
Speedsprayer - Medium	1	--	1	--	--	--	--	1	--
Speedsprayer - Small	--	--	--	--	--	--	1	--	1
Duster	1	--	1	--	--	1	--	1	--
Disc - Tandem. 10 Ft.	--	1	1	--	1	2	--	--	--
Disc - Tandem. 8 Ft.	--	--	--	1	--	--	--	1	--
Disc - Tandem. 6 Ft.	--	--	--	--	--	--	1	--	1
Disc - Offset - 10 Ft.	1	--	--	--	--	2	--	--	--
Springtooth Harrow - 12 Ft.	--	--	--	--	--	3	--	--	--
Springtooth Harrow - 8 Ft.	--	--	--	--	--	--	1	--	1
Spiketooth Harrow - 8 Ft.	--	--	--	--	--	--	1	--	1
Disc Ridger	1	--	--	--	1	--	--	--	--
Ditcher - 4 Ft.	--	--	--	1	--	3	--	--	--
Subsoiler - 4 Ft.	--	--	--	--	--	1	--	--	--
Rotary mower - Brush Chopper - 7 Ft.	1	1	--	--	--	1	1	1	1
Fertilizer spreader - 10 Ft.	1	--	--	--	1	1	--	1	--
Fertilizer spreader - 8 Ft.	--	--	--	--	--	--	1	--	1
Grain Drill - 7 Ft.	--	--	--	--	--	--	--	--	1
Weed Sprayer	--	1	--	--	--	--	--	--	--
Steel Squirrel	--	0.5	--	--	--	--	--	--	--
Fork-Lift -- High Lift	1	1	1	1	1	3	1	1	1

(Continued)

Table 15. (Continued)

Equipment	Sacramento River	Hood River	Lake-Mendocino	Central Washington	Santa Clara	Medford	Willamette Valley - Irrigated	Sierra Foothills	Willamette Valley - Unirrigated
Fork-Lift -- Three-Point	1	1	--	1	1	--	1	1	1
Truck - 2 T.	1	1	--	--	1	--	--	--	--
Truck - 1-1/2 T.	--	--	--	--	--	5	1	1	1
Pickup Truck - 1/2 T.	1	1	1	--	1	3	1	1	1
Pickup Truck - 3/4 T.	--	--	--	1	--	--	--	--	--
Bus	--	--	--	--	--	1	--	--	--
Orchard Trailer	2	1	3	1	2	5	1	1	1
Oil-filling Tank	--	--	1	1	--	4	--	--	--
Oil-storage Tank	--	--	1	1	--	3	--	--	--
Heaters- return-stack	--	--	750	775	--	5,500	--	--	--
Heaters - Smudge Pots	--	--	--	800	--	5,500	--	--	--
Ladders	30	17	25	12	25	100	10	20	10
Props	--	$900		--		--		$6,000	
Miscellaneous and Small Tools	$2,000	$1,500	$1,500	$1,570	$2,000	$4,500	$1,000	$1,000	$1,200

typical acreage of total cropland are partially offset by the fact that the entire overhead costs of specialized orchard machinery, such as speedsprayers, must be charged to the pear enterprise.

Differences in typical acreage of orchard in the various areas are not great, except in the case of the Medford area. In this area a relatively few large firms, which also operate as packer-shippers, operate a large percentage of the pear acreage. The large acreages of pears operated by these firms enable them to attain some economies of scale in regard to machinery overhead costs per acre.

Although producers in areas with relatively large typical acreages attain some economies of scale in regard to machinery overhead costs, these economies are somewhat balanced by differences in equipment requirements between areas. Nevertheless, the two areas with the highest estimates of machinery overhead costs per acre -- Central Washington and Hood River -- are areas with relatively small typical acreages of orchard (Table 11).

Materials Costs

Costs of spray and dust materials, fertilizer, heating oil, irrigation water, and miscellaneous supplies will be discussed in this section. A portion of the variation in materials costs between production areas (Table 10) is due to the fact that certain material inputs such as heating oil are not commonly used in all areas.

Differences in the level of use of such materials as fertilizer also account for some of the variation in materials costs.

A primary source of variation in costs for spray materials and dusts is provided by differences in type of materials used and accompanying differences in costs per pound. These variations in commonly-used types of materials arise from differences in kind and severity of insect and disease pests which are prevalent in the various areas. Thus, for example, growers in areas where mites are an intense problem find it necessary to use large amounts of miticides which have a high cost per pound. The amount of materials used is also a source of variation in these costs; for example, more sprays or dusts are necessary for fire blight in certain areas than in others.

Although irrigation is practiced in all areas (except some orchards in the Willamette Valley), costs for irrigation water itself are not necessary in certain areas. For example, in the Lake-Mendocino area and the Willamette Valley, irrigation water is usually obtained from individual wells on each farm. This source of water precludes the need for direct irrigation-water expenses. In the Sacramento River area, irrigation water is commonly pumped directly from the river for which no water charge is required. (Costs for electricity for pumping is included under the category of electricity and utilities.)

Miscellaneous supplies include mouse and gopher bait, ties, bee rental, etc. Because of difficulty in obtaining accurate estimates for the numerous small items included in this category, costs of miscellaneous supplies were estimated on the basis of a percentage (five percent) of costs for other supplies.[1]

Land and Orchard Costs

Overhead costs for land involve interest on investment, which was charged at a rate of 5.5 percent per year. Estimates of land costs were based upon market value of typical land used for Bartlett-pear orchards in the various production areas (Table 16). Land values are relatively high in the California production areas of Santa Clara, Sacramento River, and Lake-Mendocino; with the highest values found in the Santa Clara area where a relatively high degree of urban pressure exists. Market values for land in the Northwest areas of Hood River, Central Washington, and the Willamette Valley are comparatively low.

Estimated values per acre of bearing Bartlett-pear orchards were based upon a combination of market value and estimated cost to establish and raise an orchard. In most areas, it is generally accepted that market values based upon recent sales are somewhat

[1] See footnote on page 145.

Table 16. Estimated value and overhead costs for typical Bartlett-pear orchards and land in Pacific Coast production areas, 1963.

Area	Land		Orchard		
	Estimated Value	Overhead Cost (Interest at 5.5% Per Year)	Estimated Value	Years Life	Overhead Cost (Depreciation and Interest at 5.5% per Year)
	(Per Acre)	(Per Acre)	(Per Acre)		(Per Acre)
Sacramento River	$1,200.00	$66.00	$2,000.00	50	$ 95.00
Hood River	500.00	27.50	1,100.00	--[1]	60.50
Lake-Mendocino	1,100.00	60.50	2,100.00	50	99.70
Central Washington	500.00	27.50	1,000.00	--[1]	55.00
Santa Clara	1,400.00	77.30	2,200.00	50	104.50
Medford	1,000.00	55.00	1,200.00	40	63.00
Willamette Valley -- irrigated	650.00	35.80	750.00	40	39.40
Sierra Foothills	800.00	44.00	1,800.00	35	100.90
Willamette Valley -- unirrigated	450.00	24.70	700.00	40	36.80

[1]Orchard perpetuated by continued replanting; therefore, no depreciation charged.

lower than current total costs per acre to establish and raise a young orchard to bearing age. Estimated values of bearing orchards in the various areas (Table 16) are calculated to lie between the relatively low figure of market value and the relatively high figure of cost of establishment.

Estimated values of orchard in California production areas are comparatively high, in part, because of relatively high market values in these areas. Total costs of orchard establishment are also fairly high in these areas; even though the trees grow relatively rapidly and reach bearing maturity at a fairly young age. Orchard values are lowest in the Willamette Valley because of low market values and relatively low establishment and growing costs.

Orchard overhead costs include annual depreciation charges and interest on investment. However, in two areas -- Hood River and Central Washington -- no depreciation was charged because orchards in these areas are commonly perpetuated by continual replanting of individual trees as the need arises. In areas for which depreciation was charged because orchards are commonly removed and replanted in large blocks, the average life of an orchard, as well as value per acre, are important factors in the determination of depreciation charges.

Accurate estimates of average orchard life in different geographical areas are difficult to obtain. This is partly due to the fact that there are wide differences in the length of life of individual orchards in the same area because of differences in site and care. The fact that pear trees often outlive more than one generation of owners and that inaccurate records are available regarding orchard ages also adds to the difficulty. Nevertheless, an estimate was made, which is believed to be reasonably accurate, of comparative average ages in the various areas (Table 16).

Interest on orchard investment is computed at a rate of 5.5 percent per year. One-half of the current orchard value was used as a basis for computing interest charges in areas where orchard values gradually diminish through depreciation. Interest was charged on the basis of 100 percent of current orchard value in Hood River and Central Washington in which areas an orchard of relatively constant productivity is maintained over time.

Costs of Buildings and Irrigation System

Investment requirements for buildings were estimated for each of the Pacific-Coast production areas (Table 17). Building requirements for pear production include machine storage, housing for harvest labor, and tenant houses for permanent labor. In some areas, however, housing for harvest labor and/or permanent labor is not commonly provided by pear growers. Overhead costs for buildings include annual depreciation and interest charges which are

Table 17. Estimated investments and overhead costs for buildings and irrigation system used for producing Bartlett pears in Pacific Coast production areas, 1963.

AREA	BUILDINGS: Investment Per Acre: Machine Shed & Shop (Dollars)	BUILDINGS: Investment Per Acre: Harvest Labor Housing (Dollars)	BUILDINGS: Investment Per Acre: Tenant House (Dollars)	BUILDINGS: Overhead Costs Per Acre[1] (Dollars)	IRRIGATION SYSTEM: Type	IRRIGATION SYSTEM: Investment Per Acre (Dollars)	IRRIGATION SYSTEM: Overhead Costs per Acre[1] (Dollars)
Sacramento River	30.00	--	100.00	8.80	Surface - basin	60.00	4.60
Hood River	50.00	65.00	62.50	14.80	Sprinkler	125.00	15.90
Lake-Mendocino	50.00	--	--	3.40	Sprinkler	150.00	19.10
Central Washington	66.60	--	88.90	11.40	Surface - rill	--[2]	--
Santa Clara	37.50	100.00	--	9.20	Surface - basin	60.00	4.70
Medford	26.70	40.00	66.70	10.40	Surface - rill	15.00	1.20
Willamette Valley - irrigated	44.40	--	--	3.40	Sprinkler	125.00	15.90
Sierra Foothills	66.70	100.00	--	14.80	Sprinkler	100.00	12.80
Willamette Valley - unirrigated	33.30	--	--	2.60	--	--	--

[1] Depreciation and interest (interest at 5.5 percent per year).

[2] Included with land investment.

based upon estimated investments per acre. Costs for buildings repairs and insurance (Table 10) are estimated on the basis of 3.4 percent of building investments.

Investment per acre, and hence overhead costs for irrigation systems vary between areas depending, to a large extent, upon the type of irrigation system which is commonly employed. Sprinkler irrigation systems generally involve a greater investment per acre and thus greater overhead costs. Sprinkler irrigation predominates in the areas of Lake-Mendocino, Hood River, Willamette Valley, and Sierra Foothills. Of these areas, Lake-Mendocino has the greatest estimated investment per acre because of the need for relatively deep wells and large pumps in this area. While rill irrigation is commonly practiced in the Medford and Central Washington areas, the basin type of irrigation is typical in the Sacramento River and Santa Clara areas.

Miscellaneous Costs

Costs of property taxes, management, and interest on operating capital will be discussed in this section.

Property taxes were estimated on the basis of prevailing tax rates in each production area and estimated values of taxable property. Prevailing tax rates in the various areas were approximated by the following percentages of market value of taxable property:

(1) Lake-Mendocino and Sierra Foothills - 1.00 percent, (2) Central Washington - 1.10 percent, (3) Medford - 1.25 percent, (4) Sacramento River and Santa Clara - 1.30 percent, (5) Willamette Valley - 1.75 percent, and (6) Hood River - 2.00 percent.

Relatively high rates in Oregon are offset, to some extent, by the fact that orchard values are not included as taxable property in this state. High property tax costs per acre in California areas are primarily due to relatively high values of land, orchard, and machinery and because of the fact that orchards are included as taxable property in these areas.

Per acre estimates of management costs in each area are based on an annual management charge for the farm as a whole. The following annual charges for management were estimated by size of farm: (1) 40 to 60 acres - $2,000, (2) 80 acres - $2,500, (3) 100 acres - $3,000, and (4) 450 acres - $11,000. These annual management charges were divided by typical acreage in each area. Thus, areas in which the typical farm is relatively small, such as Hood River, Central Washington, and the Willamette Valley, have high estimates of management costs per acre. On the other hand, the large typical acreage in the Medford area results in a relatively low cost of management on a per acre basis.

Estimates were made of interest costs on operating capital. These interest costs were based upon the assumption that funds for one-half of pre-harvest and general cash costs would be borrowed for six months of each year (until payment is received for the pear crop). Interest charges were computed on the basis of 5.5 percent per year; although it is recognized that in some instances growers may have to pay somewhat higher rates for short-term loans for operating capital.

VI. FUTURE CHANGES IN THE REGIONAL PATTERN OF PRODUCTION

Changing economic and production conditions tend to alter the established pattern of regional production. Thus, in the future, production may become more concentrated in certain areas while others decline in relative importance. New or relatively minor areas may also become more prominent in the future. Shifts in regional production depend upon the competitive position of various areas and upon the varying impact of changing conditions in each. In this chapter, possible future shifts in production between the various Pacific-Coast areas will be explored. Indications of future production patterns can be obtained from an analysis of: (1) trends in bearing and non-bearing acreage, (2) comparative costs of production in relation to expected future prices, and (3) relative elasticities of supply in the various states or areas.

Acreage Trends

Trends of bearing acreage in individual areas are particularly useful as indicators of production shifts in the immediate future. Data on non-bearing acreage, on the other hand, provide insights into production changes in the more distant future. Both the absolute amount of non-bearing acreage and the proportion of non-bearing to bearing acreage provide indications of future production changes.

Substantial increases in non-bearing acreage usually indicate an increasing trend of future bearing acreage and production, particularly if non-bearing acreage is equal to an abnormal percentage of existing bearing acreage in the area. Comparison of the existing percentage of non-bearing acreage to an estimate of the percentage which is required to maintain current levels of bearing acreage provides an indication of future changes in bearing acreage within a given area.[1] While these percentages provide an indication of the direction and amount of future production changes within a given area, absolute levels of bearing and non-bearing acreage in the various areas disclose comparative magnitudes of change between areas.

Bearing Acreage

Data regarding bearing acreage of Bartlett pears indicate unequal changes over time in the different production areas (Figure 11). Bearing acreage in the Central Washington area remained nearly constant throughout the period from 1940 to 1961.[2] By contrast,

[1] Percentages of non-bearing acreage which are required to maintain existing bearing acreage will vary between geographical areas depending upon such factors as climate. soil types. disease conditions. and age distribution of bearing trees. as well as upon economic incentives such as relative price prospects and potential urbanization developments.

[2] Acreage estimates for Washington are based on Census of Agriculture data on tree numbers for 1940 to 1959 (47). and on a special fruit-tree census in 1961 (51). These data were converted to acreage on the basis of 85 trees per acre.

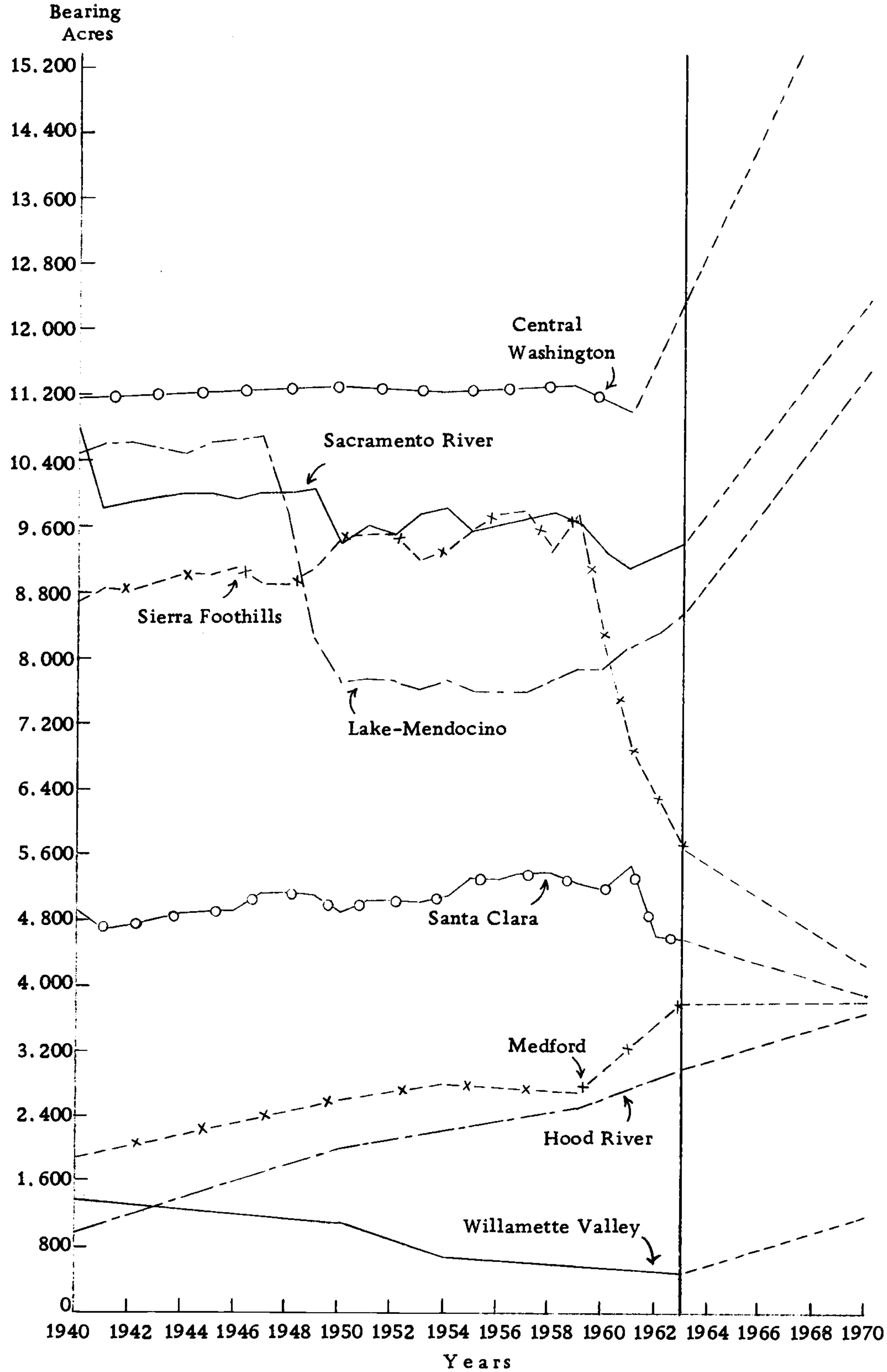

Figure 11. Trends in bearing acreage of Bartlett pears in Pacific Coast production areas. 1940 - 1963 and projected to 1970.

bearing acreage in the Lake-Mendocino area (2) decreased substantially during a portion of this period. This decrease, which occurred immediately after World War II, was followed by a period of constant bearing acreage in this area until about 1958, after which bearing acreage has exhibited a slow steady increase.

In the Sacramento River area, bearing acreage remained fairly constant from 1941 to 1963, with a small decrease during the latter few years (2). Bearing acreage in the Sierra Foothills remained relatively constant from 1940 to 1959 while exhibiting a slight increasing trend during this period. Following the advent of pear-decline in serious proportions in 1959, however, bearing acreage in this area has diminished rapidly (Figure 11).

In the Santa Clara area bearing acreage has remained fairly stable throughout the period from 1940 to 1963, with a small decrease during the last few years. Both urbanization and pear-decline have contributed to this recent decrease in bearing acreage.

Bearing acreage of Bartlett pears in the Medford area [1] has exhibited a slow, steadily increasing trend during the period from 1940 to 1963. Although pear-decline has been a problem in this

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[1] Acreage estimates for Oregon areas are based on Census of Agriculture data on tree numbers for 1940 to 1959 (47), and on a special tree survey in 1963 (26). These data were converted to acreage on the basis of 90 trees per acre in the Medford and Willamette Valley areas and 85 trees per acre in Hood River.

area, young plantings have been sufficient to maintain and increase the bearing acreage.

In the Hood River area, bearing acreage has increased steadily during the 1940-63 period. This trend has been conditioned by a rather large acreage of young plantings, as well as by the fact that decline has not been a serious problem in the area. Bearing acreage in the Willamette Valley has shown a slow, steady decrease during the period from 1940 to 1963.

Non-bearing Acreage

Acreages of non-bearing Bartlett pears were at low levels in each of the California production areas from 1940 until about 1950 (Figure 12 and Table 18). At this time, non-bearing acreage began to increase in all areas, with particularly notable gains registered in the Sierra Foothills area. Non-bearing acreage in the Sierra Foothills remained at moderately high levels until the outbreak of pear-decline in 1959, after which sharp decreases have occurred. Marked increases in non-bearing acreage in the Lake-Mendocino and Sacramento River areas took place between 1955 and 1962 (Figure 12). Although data for 1963 indicate that the surge of new plantings in these areas has begun to taper off, existing non-bearing trees are equal to a high percentage of the bearing acreage (Table 19). Non-bearing acreage in the Santa Clara area has remained relatively low throughout the period from 1940 to 1963;

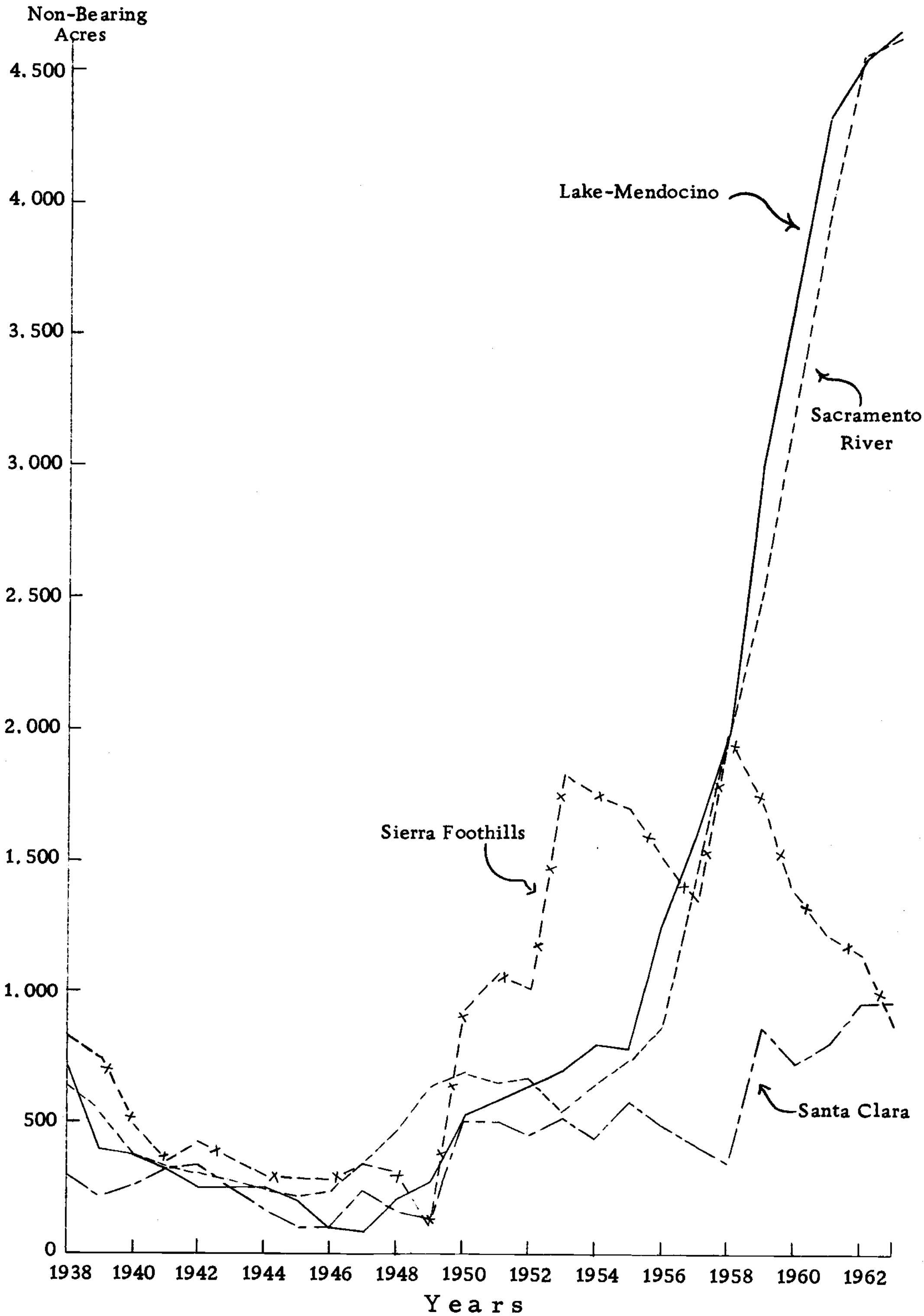

Figure 12. Trends in non-bearing acreage of Bartlett pears in California production areas, 1938 - 1963.

Table 18. Non-bearing acreage of Bartlett pears in Pacific Coast production areas, 1940-63.[1]

Area	1940	1950	1954	1959	1963
	Acres	Acres	Acres	Acres	Acres
Sacramento River	372	684	646	2,524	4,638
Lake-Mendocino	372	530	793	3,001	4,649
Santa Clara	278	542	505	988	1,090
Sierra Foothills	491	928	1,759	1,726	878
Medford	339	248	274	668	974
Hood River	558	1,152	1,348	1,540	1,698
Central Washington	732	2,379	4,572	6,915	9,299[2]
Willamette Valley	94	209	141	318	771

[1] Computed from data reported in (2) and (47).

[2] 1961.

although moderate gains have been registered since 1958.

The situation in Northwest production areas is highlighted by extensive non-bearing acreage in Central Washington (Figure 13). Large acreages of non-bearing Bartlett pears have been present in this area since 1950, and have increased at a rapid rate since that time. These non-bearing acreages expressed as a percentage of bearing acreage have exhibited a sharply rising trend (Table 19).

In the Hood River area, non-bearing acreage has remained at moderately high levels and has shown a slow, steady increasing

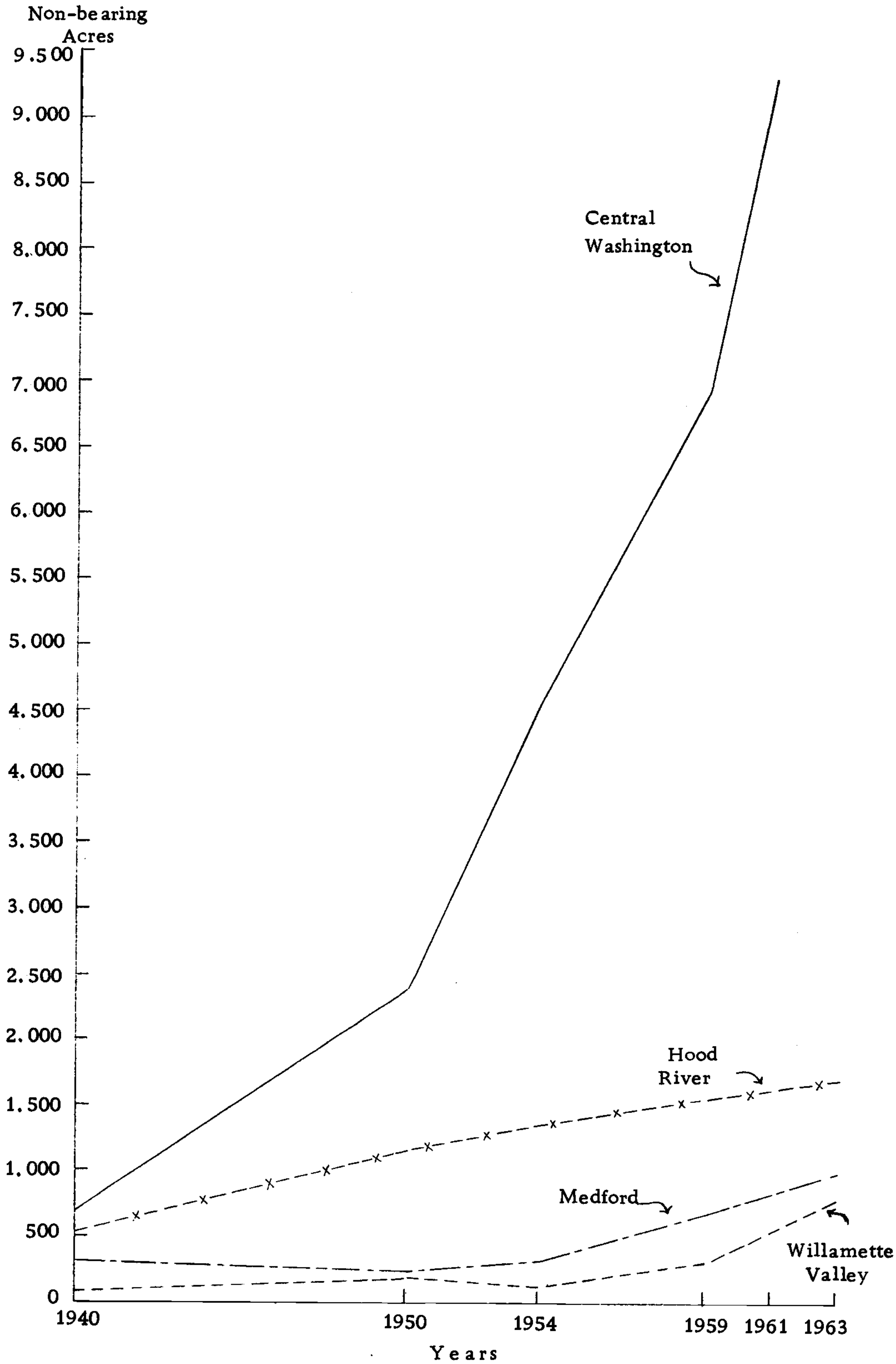

Figure 13. Trends in non-bearing acreage of Bartlett pears in Northwest production areas. 1940 - 1963.

trend throughout the period from 1940 to 1963. Non-bearing acreage in this area has consistently been equal to a relatively high percentage of bearing acreage during this period.

The Medford area has had relatively small amounts of non-bearing acreage during 1940-63 period; even though moderate increases have been shown since 1954. Non-bearing acreage in the Willamette Valley has been low throughout the period since 1940. However, modest increases have occurred in this area since 1954 -- and particularly since 1959. Although these increases in non-bearing

Table 19. Non-bearing acreage of Bartlett pears as a percentage of bearing acreage in Pacific Coast production areas, 1940-63.[1]

Area	1940	1950	1954	1959	1963
	Percent	Percent	Percent	Percent	Percent
Sacramento River	3	7	7	26	49
Lake-Mendocino	4	7	10	38	54
Santa Clara	6	11	10	18	23
Sierra Foothills	6	10	19	18	15
Medford	18	9	10	25	25
Hood River	53	57	61	60	56
Central Washington	7	21	41	61	86[2]
Willamette Valley	6	18	19	50	136

[1] Computed from data reported in (2) and (47).

[2] 1961.

acreage are moderate on the basis of actual amount of acreage involved, they represent substantial increases in acreage on a percentage basis (Table 19).

Future Production Pattern Indicated by Acreage Trends

Combined knowledge of bearing and non-bearing acreage trends, as well as the proportion of non-bearing to bearing acreage provides a basis for suggestions of future production changes in each geographical area. Such changes will be outlined in this section for each of the Pacific Coast pear-producing areas.

On the basis of planted acreage, Central Washington offers the most notable prospect of future production increases. A relatively stable bearing acreage has been accompanied by large increases in non-bearing acreage since 1950. A total of 9, 300 acres of non-bearing trees were present in the year of the state's last tree census (1961). This acreage was equal to about 86 percent of the bearing acreage. Such a high percentage of non-bearing acreage clearly indicates a substantial increase in future bearing acreage and production in this area.

Although some of this exceptionally large non-bearing acreage will be needed to replace orchards which are removed because of pear-decline, the impact of this disease upon future removals is expected to be much less than that which was experienced during the 1950's. However, even in light of the pear-decline situation, the percentage of non-bearing acreage needed to maintain a constant bearing in this area will probably not exceed 25 percent.[1]

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[1] The percentages of non-bearing acreage which are needed to maintain a constant bearing acreage in each production area were estimated in the following manner: Estimates were made, on the basis of information obtained from growers and extension personnel, of the average number of years required to raise a young tree to bearing age and of the average bearing life of Bartlett-pear trees in each area. The proportion of estimated non-bearing years to bearing years provides one criterion for determining the average percentage needed to maintain a constant bearing acreage. Examination of historical changes in bearing acreage in relation to non-bearing percentages during previous periods provide a second criterion for the estimation of needed percentages of non-bearing acreage. Both of these criteria were used to estimate the percentage needed to maintain a constant bearing acreage under "normal" conditions. This percentage was then adjusted to take account of the unusual pear-decline situation in certain areas.

An example of procedure which was used can be shown in the determination of the estimated percentage needed in Central Washington. It was estimated that an average of seven years are necessary to raise a tree from planting to bearing age in this area, after which an average bearing life of 35 years can be expected. On this basis, a non-bearing acreage equal to 20 percent of the bearing acreage is indicated. Although historical acreage data is limited in Washington, past proportions of non-bearing to bearing acreage do not contradict the 20-percent estimate. However, the continued presence of pear-decline in Washington will raise the percentage of non-bearing trees needed to maintain a constant bearing acreage during the next five to ten years. Even though precise predictions of future removals because of pear-decline are difficult to obtain, an increase of five percent in the required non-bearing acreage seems to provide a reasonable estimate of future effects of the disease. Therefore, it is estimated that a non-bearing acreage equal to 25 percent of existing bearing acreage is necessary to maintain this bearing acreage under current conditions.

Comparison of existing non-bearing acreage on a percentage basis to the estimated percentage required to maintain current bearing acreage indicates the existence of sufficient non-bearing trees in Central Washington to provide an increase of about 60 percent in future bearing acreage (Figure 11). With average yields which are comparable to those obtained in recent years, future production in this area can be expected to increase by an equal percentage.

Both the Sacramento River and Lake-Mendocino areas contained substantial non-bearing acreage in 1963 with about 4,650 non-bearing acres in each area. This acreage amounted to about 50 - 55 percent of bearing acres in these areas. During the 1950's relatively stable bearing acreages were maintained in these areas with non-bearing acreages equal to between eight and fourteen percent of bearing. These percentages are in agreement with those suggested by average tree life in these areas. Thus, although effects of pear-decline will probably raise the percentage of non-bearing acres needed to a range of 15 to 20 percent, existing non-bearing acreages in these areas indicate an increase in future bearing acreage of about 30 to 35 percent. Because of high average yields in these two areas, an increase in bearing acreage of this magnitude will result in a substantial rise in the areas' future production.

Non-bearing acreage in the Hood River area has been consistently equal to a high percentage (50 - 60 percent) of the area's bearing acreage during the period since 1940 (Table 19). These high percentages of non-bearing trees have resulted in a steadily increasing bearing acreage. Bearing acreage trends in relation to past percentages of non-bearing acreage indicate that a non-bearing acreage equal to 25 to 30 percent of bearing is necessary to maintain a stable bearing surface in this area. Thus, with a non-bearing acreage in 1963 equal to about 56 percent of bearing, future increases in bearing acreage of 25 to 30 percent can be expected (Figure 11).

Although the Willamette Valley contains only a small acreage of non-bearing trees, in relation to other production areas, this small acreage constitutes an extremely high percentage of the area's bearing acreage. Because the non-bearing acreage is equal to 136 percent of bearing, an increase in production over 100 percent is indicated for the future.

Although moderate levels of non-bearing acreage in the Medford area have been accompanied by a slowly expanding bearing acreage, a greater percentage of non-bearing acres will be required for a stable future situation because of pear-decline. Current non-bearing acreage, which is equal to approximately 25 percent of bearing acreage, is estimated to be sufficient to maintain a constant bearing surface -- or at most provide a slight future increase if removals due to pear-decline are small. Future production in this area can likewise be expected to remain fairly stable or to experience a slight increase.

Bearing acreage in the Santa Clara area has decreased somewhat in recent years; while moderate increases in non-bearing acreage have been experienced. Data for 1963 show non-bearing acreage equal to 23 percent of bearing acreage in this area. Although the extent of pear-decline is less serious in this area than in certain other production regions, a percentage of established orchards will undoubtedly be removed because of its effects. Urbanization pressures also promise to bring about future removals of pear acreage in this area. In light of these conditions, current non-bearing acreage probably is not sufficient to maintain present levels of bearing acreage. Therefore, moderate decreases in bearing acreage and production can be expected in the future. The extent of these decreases is difficult to measure, however, because of difficulty in accurately predicting rates of urbanization.[1]

Both bearing and non-bearing acreage in the Sierra Foothills have experienced a continuous, rapid decrease since 1959. Non-bearing acreage as a percent of bearing acreage has also diminished

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[1] The bearing acreage projection in Figure 11 for the Santa Clara area is based upon a decrease of 15 percent.

to a level of 15 percent in 1963. The effects of pear-decline will necessitate continued removal of established orchards in this area, although the rate of removal will undoubtedly be slower than that experienced during recent years. In view of the pear-decline situation and the fact that pear orchards in this area normally have a relatively short life, current levels of non-bearing acreage are probably insufficient to maintain bearing acreage. It was estimated that under current conditions, non-bearing acres equal to about 40 percent of bearing are necessary to maintain existing bearing acreage in this area. If this is the case, existing non-bearing trees which are equal to 15 percent of the bearing acreage, will lead to a further decrease of approximately 25 percent in the area's bearing acreage.

As a result of the indicated acreage projections, bearing acreage and production in Central Washington can be expected to increase at a very rapid rate; while bearing acreage in the Sacramento River, Lake-Mendocino, and Willamette Valley areas are also expected to increase rapidly (Figure 11). Moderate increases can be expected in the Hood River area. On the other hand, moderate decreases are expected in the Sierra Foothills and Santa Clara areas; while bearing acreage in the Medford area will remain nearly constant.

The relative position of Central Washington, Sacramento

River, and Lake-Mendocino in regard to bearing acreage and production, will therefore, be substantially increased over that of the other Pacific Coast areas. Projections indicate that the Willamette Valley will gain in its relative position; although future production in this area will remain comparatively minor in relation to pear production in the other areas. A gain in the relative importance of the Hood River area will be accompanied by a decline in the position of the Sierra Foothills, Santa Clara, and Medford areas. As a result, all four of these areas will contain similar amounts of bearing acreages by approximately 1970. (However, considerable differences in production between these four areas may continue because of differences in average yields.) Thus, the projections indicate a dominant future position for the areas of Central Washington, Sacramento River, and Lake-Mendocino. The projections also suggest that the areas of Sierra Foothills, Santa Clara, Medford, and Hood River will compose an intermediate group in respect to production and the Willamette Valley will occupy a relatively minor position.

Future Pattern of Production Indicated by Comparative Costs and Expected Prices

The expected future prices which were developed in Chapter IV can be combined with estimates of comparative production costs in the various areas to provide indications of future patterns of production. Lower farm prices of Bartlett pears in the future will reduce the profit potential of growers in all areas. The impact upon profit conditions will be particularly great in the areas with high production costs, in which cases profits may be reduced to zero or negative levels. Continued losses over a period of years will encourage growers in high-cost areas to reduce their bearing acreage; while prospects of continued profits in the low-cost areas will result in a greater incentive for growers in these areas to maintain bearing acreage. As a result, production in the high-cost areas will become relatively less important; while that in low-cost areas will represent a growing proportion of the total.[1]

Production-cost estimates which were developed in Chapter V indicate that growers in the Sacramento River area have the lowest production costs with an average of approximately $53.00 per ton (Table 9). Estimated costs in the Hood River and Lake-Mendocino areas are also relatively low with figures of $66 to $67 per ton. The cost estimates indicate that the Sierra Foothills area and unirrigated orchards in the Willamette Valley have the highest production costs

[1] Although opportunity costs also play a part in determining future shifts in regional production, adequate data were not available to project future changes in opportunity costs for the various areas. Therefore, for this portion of the analysis, the assumption was made that relative opportunity costs in the various areas will remain unchanged from those in the past.

with a range of \$86 to \$89 per ton. The areas of Central Washington, Santa Clara, Medford, and irrigated orchards in the Willamette Valley form an intermediate group in respect to production costs with estimates of \$74 to \$77 per ton.

Future prices under Alternatives No. 1, No. 3, and No. 4 in Chapter IV are predicted to be between \$88 and \$92 per ton during the period from 1963 to 1967 (Figure 9). With these relatively high prices, growers in the high-cost Sierra Foothills area and with unirrigated orchards in the Willamette Valley can expect to break even or, at best, make small profits per ton. However, predicted prices during the rest of the projection period with Alternative No. 3, and during the entire period under Alternative No. 4, will result in losses to these growers. The magnitude of these expected losses is particularly great during the ten-year period from 1970 to 1980. Relatively high prices which are predicted under Alternatives No. 1 and No. 4 will permit moderate profits in these two high-cost situations after about 1979. However, even with the high predicted prices of these alternatives, losses will be incurred by these growers during the period between 1970 and about 1977. Therefore, on the basis of cost estimates and future price predictions, it appears evident that the Sierra Foothills area will become less important in the production of Bartlett pears in the future. Prospects of future production from unirrigated orchards in the Willamette Valley appear equally dim.

Cost estimates for Central Washington, Santa Clara, Medford, and irrigated orchards in the Willamette Valley indicate that predicted prices under Alternatives No. 1 and No. 4 will permit growers in these areas to make positive profits throughout the period from 1963 to 1985. These indicated profits will be relatively low during the period of low prices between 1970 and 1975 and somewhat higher during the years before and after this period. On the other hand, prices which are predicted under Alternatives No. 2 and No. 3 will result in substantial losses to growers in these areas during the 1970's, although positive profits are indicated until about 1970 with both alternatives and again with Alternative No. 3 after about 1978. Thus, if future price conditions approximate those assumed under Alternatives No. 2 and No. 3, the resulting negative profits will provide special incentives for growers in these areas to reduce their bearing acreage and production. On the other hand, if future price conditions are more nearly like those predicted with the high-price Alternatives No. 1 and No. 4, realized profits will encourage growers to maintain production in these areas. No clear-cut indication of the change in future relative positions of these areas is thus afforded by the price and cost comparisons.

Cost estimates for irrigated orchards in the Willamette Valley are based upon average yields of seven tons per acre. Because of the relatively small number of yield observations obtainable in this area, a rather wide margin of error is possible for this estimate. The effects upon costs per ton of an increase in yield of 25 percent were therefore examined. Increases in yield of this magnitude (from 7.0 tons to 8.8 tons per acre) result in a reduction in average cost per ton to $63.60. Therefore, if cost-influencing assumptions are unchanged in other areas, an increase in average yields of this amount will change the ranking of irrigated Willamette Valley orchards from a relatively high-cost situation to a low-cost one. Similarly, increased yields per acre of 25 percent for unirrigated Willamette Valley orchards (from 5.0 tons to 6.3 tons) will change its ranking from a high-cost situation to one of intermediate rank (cost per ton - $73.10). On the basis of these changes in average yield, comparison of cost estimates to future prices suggest a rise in the relative future position of Willamette Valley in relation to overall Pacific Coast production.

Comparison of cost estimates for the Hood River and Lake-Mendocino areas ($66 to $67 per ton) to predicted prices from Alternatives No. 1, No. 3, and No. 4 indicate positive profits throughout the entire projection period from 1963 to 1985. With the low prices of Alternative No. 2, however, negative profits are indicated during the period from 1970 to 1977. Thus, although profit conditions under Alternative No. 3 will be minimal (and those under

Alternative No. 2 will be negative) during several years in the 1970's, indicated profits during much of the period will provide an incentive for growers to maintain bearing acreage and production in these areas.

In comparison to the areas of Central Washington, Santa Clara, Medford, and irrigated Willamette Valley, lower production costs in Hood River and Lake-Mendocino will provide less of an incentive for growers to remove pear acreages in face of lower future prices. Because of this apparent advantage in the competitive position of Hood River and Lake-Mendocino,gains in their relative positions in regard to overall production seem likely.

Because of low costs in the Sacramento River area, substantial future profits are indicated for this area with each series of predicted prices. Even the low prices predicted with Alternative No. 2 will permit moderate profit levels per ton in this low-cost area. Because of a relatively great advantage of this area in regard to comparative production costs, a rise in the relative position of this area is clearly indicated on the basis of costs and future prices.

Future Pattern of Production Indicated by Comparative Elasticities of Supply

Although adequate data were not available to estimate supply elasticities for each production area, the supply elasticities for the individual states which were outlined in Chapter III provide an indication of future changes in the regional pattern of production. Computed long-run supply elasticities (California - 3.51, Oregon - .75, and Washington - .01) indicate a relatively elastic supply in California and a relatively inelastic response in the state of Washington.

These elasticity coefficients indicate that production response to recent high levels of farm prices will be greatest in California production areas. Similarly, production decreases in response to predicted lower prices in the future will presumably be greatest in California.

By contrast, the elasticity coefficient indicates a very small production response in Washington. On this basis, increases in production as a result of recent high prices would be expected to be small in this state. Decreases in production in response to lower future price levels would also be expected to be small.

Supply response in Oregon production areas is indicated to be intermediate to those of California and Washington on the basis of the elasticity coefficients.

Comparison of Indicated Patterns of Future Production

The three criteria which were used to indicate future production patterns each provide useful suggestions regarding changes in the relative position of each area. An attempt is made in this section to compare the indicated changes of these three criteria and to reconcile apparent differences which are suggested.

In the Sacramento River and Lake-Mendocino areas all three criteria indicate a rise in future production levels and a gain in the relative position of these two areas. Existing non-bearing and bearing acreage indicate a sharp increase in future productive capacity (Figure 11). Low costs of production, which permit continued positive profits despite prospects of lower future prices, further suggest an increase in the relative positions of these areas. In addition, the high relative supply elasticity for California suggests that areas in this state will experience a large response to recent expectations of high prices. Therefore, an increasing importance of these areas in future years seems evident.

The analysis of non-bearing and bearing acreages in the Santa Clara and Sierra Foothills indicate a declining position for these areas. High cost conditions in the Sierra Foothills area also suggest a less important position for this area. Comparison of costs in the Santa Clara area to predicted future prices provides a less-clear indication of the area's future relative position. Despite moderate costs of production in the Santa Clara area, high-return opportunities for non-agricultural uses of land should encourage a reducti on in future bearing acreage and production in the area. A high supply elasticity for the state of California suggests increases in the relative position of both Santa Clara and the Sierra Foothills. However, large supply responses in the other California areas of Sacramento River and Lake-Mendocino may well result in an elastic supply response for the state as a whole while the Santa Clara and Sierra Foothills areas exhibit negative supply responses. The situation in regard to existing acreages in the four California areas indicates that this will be the case in the future. Therefore, it seems evident that a decrease in absolute production can be expected in the Santa Clara and Sierra Foothills areas; and that a decline in the relative future position of these areas can be expected as well.

In Central Washington, existing acreages indicate a large increase in future production. Although comparison of costs and future prices give a less clear-cut indication of future changes, relatively low costs per ton indicate generally favorable incentives for future expansion of production. On the other hand, the low elasticity of supply for Washington Bartletts (which are almost entirely from the Central Washington area) indicates that a very meager response to recent high price expectations will occur. Thus, the acreage criterion and the supply elasticity criterion provide contradictory indications of future change. This contradiction can be explained by the fact that this is probably a case in which future supply responses will differ from those which have occurred in the past. The existence of large non-bearing acreages in the area and the fact that growers are reluctant to remove young orchards once they are established means that future production will likely expand greatly despite the indications of historical supply responses. Therefore, an increase in the relative position of the area is projected.

Non-bearing and bearing acreage trends in the Hood River area, as well as low comparative costs of production, indicate that production in this area will continue to increase in the future. A gain in the relative position of this area is, therefore, expected. The relative supply elasticity for Oregon also indicates moderate production increases. Thus, it appears evident that the Hood River area will become relatively more important in relation to total production of Bartlett pears in the future.

Both existing acreage and comparative cost conditions in the Medford area indicate a relatively stable bearing acreage and production in the future. The moderate supply elasticity for Oregon as a whole does not contradict these indications -- particularly in view of the expected production increases in Hood River. This situation, coupled with expected production increases in certain other areas, suggests that the relative position of the Medford area will diminish in the future.

Existing non-bearing and bearing acreage in the Willamette

Valley indicate a substantial rise in future production in this area. On the other hand, cost estimates presented in Chapter V indicate this area to be one of high comparative costs. These costs would, therefore, not encourage further increases in bearing acreage and production in light of lower future prices. However, changes in the assumed yields indicate that if 25 percent higher yields can be obtained (with no changes in the cost conditions of other areas), the Willamette Valley will be a comparatively low-cost area. The profits allowed by these lower costs per ton will provide incentives for growers in this area to expand future production. This cost situation would, therefore, support the indication of increased future production which is provided by acreage trends. The supply elasticity coefficient for Oregon provides little indication of future production levels in the Willamette Valley. In view of the above situations regarding the future position of this area, it seems unlikely that production in the area will increase substantially in the near future. However, there are indications that gains in the relative position of this area could be much greater in the more distant future.

VII. SUMMARY AND CONCLUSIONS

The advent of the pear-decline disorder in many producing areas of the Pacific Coast has threatened to seriously reduce future Bartlett-pear production. The resulting expectations of high farm prices have led growers to establish extensive new plantings in many areas. In addition, farm owners in potential pear-producing areas, such as the Willamette Valley, have become increasingly interested in developing new pear orchards. Since the effects of pear-decline have diminished in recent years, the large acreages of non-bearing trees may be sufficient to bring about substantial increases in future production and accompanying low price levels.

This study was undertaken in an effort to clarify the future economic situation of the Pacific Coast Bartlett-pear industry by predicting future price and production levels and developing a pattern of future regional production.

In order to predict future price and production, long-run supply and demand equations were developed for the industry. The demand, or price-estimating, equation which was accepted includes the following independent variables: (1) per capita production of Pacific Coast Bartlett pears, (2) per capita pear production in Michigan and New York, (3) real farm price of California cling peaches, (4) canners' stocks of canned pears per capita, and (5) canned-pear exports. The coefficient of multiple determination which was obtained for this equation indicates that these five independent variables accounted for 95 percent of the annual variation in real farm prices of all sales of Pacific Coast Bartlett pears during the postwar period. The supply equation which was accepted includes lagged price and lagged production as independent variables. Statistical results indicate that these independent variables explain about 98 percent of the variation in four-year average quantity supplied of Pacific Coast Bartlett pears.

The supply and demand equations, along with projected values of the exogenous variables, were combined into a model to predict future "average" price and production levels. For use in the model, an adjustment was made in the supply equation to account for future production from the large existing non-bearing acreage. Because of uncertainty involved in projections of the exogenous variables (pear production in Michigan and New York, prices of cling peaches, canners' stocks, exports, and population), several alternative levels of each were projected. These alternative levels of the exogenous variables were then substituted into the model to determine several possible series of predicted future price and production levels.

Each series of price predictions indicates that future prices will continue to increase for several years, and then decrease steadily until about 1972-1975 as expanding production from existing non-bearing acreage occurs. The predictions in each case indicate steadily rising price levels from 1975 to 1985. These price increases during the latter years of the projection period result from reduced per capita production as population expands and pear growers adjust to lower prices in the earlier portion of the period.

Price levels of the individual series of predictions vary with the alternative combination of the values of the projected exogenous variables. The projection yielding the highest series of predicted prices indicates a level of $83 - $84 per ton during the low-price period from 1972 to 1975; while the lowest price series shows a price of $60 - $62 per ton during this period. The highest series of prices involves predictions which rise to $97 per ton by 1985; while the lowest series indicates a price of $77 per ton in this year. All other alternative combinations of the exogenous variables yielded series of predicted prices which are intermediate to the range indicated above. The alternative series of predicted prices which involves the intermediate values of all exogenous variables indicates low prices of $67 - $69 during the 1972-1975 period, and rising prices to a level of $84 per ton in 1985.

One alternative series of predicted prices shows the individual effects of a 20-percent increase in exports of canned pears. Comparison of this alternative to one that involves stable export levels indicates that farm price levels can be expected to be $10 per ton higher if increases in exports of this magnitude occur in the future. Comparison of alternatives which involve decreases in future cling-peach prices of five percent and eight percent indicates that the larger decrease will result in lower pear prices of one to three dollars per ton during much of the projection period. Predicted prices with an alternative involving a low population projection indicate that alternative rates of population growth will have little effect upon future Bartlett-pear prices.

All alternative production predictions indicate that future production will increase substantially until about 1972, and then decrease slowly until 1985. Predicted production increases until 1972 are similar under all alternatives with a range of 614,000 to 634,000 tons predicted for this year. Greater differences in production predictions from the various alternatives are shown in later years, with a range of 543,000 to 587,000 tons predicted by the year 1985. These production levels in the latter portion of the projection period are conditioned by predicted price levels under the various alternatives in the earlier years. Therefore, the alternatives which involve relatively high predicted prices result in correspondingly high levels of production in later years.

Single-value estimates were made of average farm production costs in each of the major Pacific Coast producing areas of (1) Central Washington, (2) Hood River, (3) Medford, (4) Lake-Mendocino,

(5) Sacramento River, (6) Sierra Foothills, and (7) Santa Clara. Similar estimates were also made for the potentially important area of the Willamette Valley in order to explore the comparative position of this area to that of major producing areas. Separate cost estimates were made for irrigated and unirrigated orchards to the Willamette Valley to determine the future potential of both types of operations in this area. The cost estimates in all areas were based upon information obtained from grower interviews and from recent published cost studies when available.

Based upon the best available information regarding average yields, size of operation, and input costs, the following average costs per ton were estimated by area: (1) Sacramento River -- $52.70, (2) Hood River -- $66.00, (3) Lake-Mendocino -- $67.00, (4) Central Washington -- $74.20, (5) Santa Clara -- $75.10, (6) Medford -- $76.70, (7) Willamette Valley, irrigated -- $77.00, (8) Sierra Foothills -- $86.00, and (9) Willamette Valley, unirrigated -- $88.90. These estimates indicate that production costs are lowest in the Sacramento River area; while Hood River and Lake-Mendocino are also relatively low-cost areas. The areas of Central Washington, Santa Clara, Medford, and irrigated orchards in the Willamette Valley form an intermediate group in respect to comparative costs of production; while the Sierra Foothills area and unirrigated orchards in the Willamette Valley exhibit high costs.

Changes in the regional production pattern were projected on the basis of (1) trends in bearing and non-bearing acreage, (2) comparative costs of production in relation to expected future prices, and (3) relative elasticities of supply in the various states. Although the indications of future regional shifts from each of these three criteria were not wholly consistent, the combined use of all three criteria facilitated the determination of future changes in the relative position of each area.

The three criteria clearly point to a substantial increase in production in the Sacramento River and Lake-Mendocino areas of California and thus a gain in the future relative position of these areas. Increases in the position of the Central Washington and Hood River areas in relation to total production levels are also indicated. Relatively stable production can be expected in the Medford area, which will result in a decline in the relative position of this area as production rises in other areas. Indications point to future decreases in production in the Sierra Foothills and Santa Clara areas and, therefore, a less important position in relation to future total production.

The future position of the Willamette Valley in respect to Bartlett-pear production is not completely clear. Extremely high percentages of existing non-bearing acreage indicate that production and the relative position of the area will rise in the future; although, in terms of absolute production, the area will remain one of relatively minor importance. The cost estimates outlined above indicate that the Willamette Valley is a relatively high-cost area. Comparison of these high costs per ton to decreasing future prices shows unpromising prospects for further expansion of pear acreage in this area. However, because the high costs per ton in this area are largely the result of low average yields, possible increases in yields would greatly improve the area's comparative cost position. In this manner, increases in average yields of 25 percent (with cost conditions remaining constant in other production areas) will change the ranking of this area from a high-cost area to one of relatively low costs per ton. This would enhance the economic prospects for expansion into a major pear-producing area. Therefore, it seems reasonable to conclude that production in the Willamette Valley will remain relatively minor, in relation to total Bartlett-pear production, in the near future; although the area may develop into a major producing area in the more distant future.

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APPENDICES

APPENDIX A

DATA AND PROJECTIONS

Table A-1. Season average grower prices received for Bartlett pears and index of prices received for alternative California fruits and nuts, 1919 - 1962.

	1	2	3	4	5	6	7
	Returns from All Uses				Returns from sales for canning (Pacific Coast)	Returns from fresh sales (Pacific Coast)	Index of Prices Received for Alternative California Fruits and Nuts[3] (1957-1959= 100)
Year	California[1]	Oregon[2]	Washington[2]	Pacific Coast			
	(Dollars Per Ton)						
1919	85.70	70.00	56.80	78.70	76.70	84.90	72.5
1920	94.80	71.50	55.20	85.00	91.80	89.10	70.7
1921	63.60	48.10	46.40	57.60	53.50	60.90	51.9
1922	47.60	39.10	29.20	43.10	53.10	37.70	53.5
1923	45.20	52.25	45.20	45.80	35.20	52.10	43.3
1924	70.10	79.00	59.60	68.80	55.90	80.80	54.8
1925	51.50	68.00	52.40	52.70	63.00	45.90	53.7
1926	36.60	42.80	24.00	34.30	36.00	34.60	53.5
1927	54.00	55.60	50.00	53.50	45.10	62.40	47.2
1928	42.90	48.00	34.80	41.50	37.10	47.10	48.9
1929	73.50	79.60	72.80	74.00	75.10	78.70	58.3
1930	25.40	21.60	17.60	23.20	25.90	21.90	41.9
1931	28.80	27.60	23.60	27.40	19.10	34.90	27.9
1932	15.20	9.60	6.40	12.40	11.50	12.20	20.2
1933	22.90	17.20	13.20	19.40	14.80	24.80	27.0
1934	34.30	32.40	26.00	31.80	31.10	34.20	30.3
1935	29.30	24.40	15.60	23.90	21.40	26.80	32.6
1936	26.30	24.80	20.80	24.60	22.90	27.30	30.3
1937	28.20	25.60	21.20	25.70	23.20	29.50	32.9
1938	14.10	14.80	12.40	13.70	13.30	12.90	26.5
1939	28.20	27.60	27.20	27.90	27.40	29.90	26.1
1940	27.40	27.60	22.40	25.90	26.40	25.80	35.7
1941	40.80	42.80	39.60	40.60	42.10	40.60	37.2

(Continued)

Table A-1 (Continued)

	1	2	3	4	5	6	7
1942	64.50	63.60	67.60	65.40	66.00	65.20	52.8
1943	77.10	108.00	84.00	81.30	70.00	99.90	87.1
1944	87.10	85.20	68.80	79.90	77.20	85.20	78.7
1945	79.30	80.40	69.20	79.60	72.60	83.30	85.3
1946	96.20	89.60	74.00	88.00	91.70	86.80	89.5
1947	75.00	89.20	72.00	75.50	74.00	80.30	70.4
1948	118.33	78.40	106.40	110.60	115.00	102.45	73.0
1949	32.50	34.80	29.20	32.10	31.00	32.80	58.4
1950	75.40	93.60	104.00	82.90	81.50	87.90	82.3
1951	97.90	88.00	104.40	98.10	98.70	100.10	83.4
1952	50.80	54.00	48.80	50.80	46.00	59.60	90.6
1953	72.90	63.20	59.20	67.90	63.80	78.10	83.6
1954	75.00	82.00	75.60	75.60	71.70	82.20	85.9
1955	75.80	70.40	64.00	72.40	69.20	83.60	92.3
1956	76.70	87.60	86.00	79.20	78.30	82.20	83.2
1957	65.80	65.60	56.40	64.40	60.30	74.40	85.8
1958	85.40	68.00	69.60	80.60	81.20	77.10	111.2
1959	67.10	66.80	64.80	66.70	61.40	79.90	103.0
1960	84.20	89.20	92.80	85.60	80.10	103.50	105.6
1961	95.80	83.60	85.20	92.50	90.80	100.90	94.3
1962	75.40	53.60	52.00	68.80	68.90		99.5

[1]Price per ton converted from price per bushel on the basis of 41.67 bushels per ton.

[2]Price per ton converted from price per bushel on the basis of 40 bushels per ton.

[3]Includes apricots. cherries. plums. prunes. and walnuts.

Sources: Columns 1. 2. 3. and 5. 1919-56 (43. p. 59); 1957-58 (44. p. 62-65); 1959-62 (42. p. 14-16). Columns 4 and 6. computed from data reported in the following sources: 1919-56 (43. p. 59); 1957-58 (44. p. 62-65); 1959-62 (42. p. 14-16). Column 7. computed in the manner described in Appendix C-1 from data reported in the following sources: 1919-55 (3. p. 17. 23. 95. 100. 102); 1956-61 (4. p. 8. 10. 41-43); 1962 (5. p. 3. 6)

Table A-2. Production and sales of Bartlett pears in Pacific Coast states, 1919-1962.

	1	2	3	4	5	6
	All sales of Bartlett Pears					
	California	Oregon	Washington	Pacific Coast	Pacific Coast (Adjusted for Average Yield Trend)	Production - Pacific Coast (1,000 Tons)
Year	(1,000 Tons)					
1919	102.40	9.50	29.20	141.10	218.71	145.58
1920	96.70	11.20	26.57	134.47	205.07	139.12
1921	77.70	14.20	30.10	122.00	183.00	126.70
1922	135.70	13.80	39.60	189.10	278.92	193.90
1923	122.80	16.40	46.62	185.82	269.44	190.30
1924	117.80	17.70	35.87	171.37	244.20	176.12
1925	166.70	14.62	46.78	228.10	319.34	235.17
1926	185.70	26.00	62.30	274.00	376.75	281.88
1927	159.90	16.68	34.52	211.10	284.99	220.10
1928	200.00	27.80	68.90	296.70	393.13	306.58
1929	171.20	28.75	58.50	258.45	335.99	265.85
1930	209.20	30.80	75.43	315.43	402.17	354.13
1931	177.50	17.43	64.68	259.61	324.51	282.50
1932	156.50	24.05	60.65	241.20	295.47	316.28
1933	157.60	20.29	81.65	259.54	311.45	301.22
1934	192.70	25.98	87.00	305.68	359.17	321.88
1935	145.80	32.65	95.71	274.16	315.28	285.33
1936	208.90	36.80	98.49	344.19	387.21	355.52
1937	189.90	29.72	104.37	323.99	356.39	344.45
1938	218.90	28.70	85.10	332.70	357.65	393.10
1939	216.90	38.23	92.30	347.26	364.62	368.65
1940	183.90	41.00	102.51	327.41	335.60	349.40
1941	204.90	41.45	124.85	371.20	371.20	380.35
1942	208.90	41.10	121.40	371.40	362.11	384.18

(Continued)

Table A-2 (Continued)

	1	2	3	4	5	6
1943	264.90	31.97	91.70	388.57	369.14	403.30
1944	215.90	41.35	159.00	416.25	385.03	436.97
1945	285.90	51.65	129.05	466.60	419.94	496.25
1946	266.90	54.75	162.80	484.45	423.89	495.13
1947	294.90	45.87	143.32	484.10	411.48	499.28
1948	224.90	42.77	89.75	357.42	294.87	367.03
1949	301.00	55.75	95.50	452.25	361.80	502.00
1950	295.00	43.75	82.55	421.30	326.51	429.25
1951	303.00	48.75	87.50	439.25	329.44	448.00
1952	334.00	50.50	79.60	464.10	336.47	472.75
1953	238.00	53.12	109.00	400.12	280.08	407.50
1954	357.00	33.77	96.10	486.87	328.64	493.75
1955	308.00	61.90	112.62	482.52	313.64	489.75
1956	374.00	58.92	68.80	501.72	313.57	508.00
1957	359.00	57.10	75.82	491.92	295.15	510.50
1958	313.10	51.67	76.75	441.52	253.87	447.50
1959	365.20	49.42	70.75	484.67	266.57	489.50
1960	330.20	43.00	46.20	419.40	220.18	424.25
1961	312.20	50.50	81.10	443.80	221.90	450.75
1962	347.20	70.50	74.80	492.50	233.94	499.75

Sources: Columns 1 and 3, 1919-43 (37, p. 62-66)
1944-48 (38, p. 21-25)
1949-59 (39, p. 80-83)
1960-61 (40, p. 19)
1962 (41, p. 17)

Columns 2, 4, and 6,1919-24 (34, p. 226-227)
1925-43 (37, p. 62-66)
1944-48 (38, p. 21-25)
1949-59 (39, p. 80-83)
1960-61 (40, p. 19)
1962 (41, p. 17)

Column 5, computed from data in Column 4.

Table A-3. Disposable income, consumer price index, index of prices paid by farmers, and population, 1944-1962.

	1	2	3	4
Year	U. S. Disposable Personal Income. Current Prices (Billions of Dollars)	Consumer Price Index (1957-59 = 100	Index of Prices Paid by Farmers Including Interest. Taxes and Wage Rates (Parity Index) (1957-59 = 100)	U. S. Population (1,000 Persons)
1944	146.8	61.3	62	138,916
1945	150.4	62.7	65	140,468
1946	160.6	68.0	71	141,936
1947	170.1	77.8	82	144,698
1948	189.3	83.8	89	147,208
1949	189.7	83.0	86	149,767
1950	207.7	83.8	88	152,271
1951	227.5	90.5	97	154,878
1952	238.7	92.5	98	157,553
1953	252.5	93.2	95	160,184
1954	256.9	93.6	95	163,026
1955	274.4	93.3	94	165,931
1956	292.9	94.7	95	168,903
1957	308.8	98.0	98	171,984
1958	317.9	100.7	101	174,882
1959	337.1	101.5	102	177,830
1960	349.9	103.1	102	180,676
1961	364.4	104.2	103	183,742
1962	384.4	105.4	105	186,591

Sources: Columns 1 through 3, (48, p. 227, 260, 292)

Column 4, (46, p. 5)

Table A-4. Quantities of competing fruits, 1944-1962.

	1	2	3	4	5	6
	Competing Fresh Fruits				Competing Canning Fruits	
Year	Pear Production Michigan and New York (1.000 Tons)[1]	Pears - other than Bartlett- Pacific Coast Total Sales (1.000 Tons)	Apples- Total U.S. Fresh Sales (1.000 Tons)[2]	Index of Quantities of Competing Fresh Fruits (1947-50 = 100)	All Peaches Sold For Canning Pacific Coast (1.000 tons)[4]	Index of Quantities of Competing Canning Fruits[5] (1947-50 = 100)
1944	53.7	136.9	1,867.2	122.6	419.4	95.9
1945	10.3	170.5	1,134.2	106.9	418.7	83.6
1946	33.5	187.4	1,815.6	115.3	573.3	125.9
1947	32.3	191.6	1,852.8	118.0	561.1	104.4
1948	13.6	144.9	1,557.1	95.4	556.7	108.6
1949	42.4	149.3	1,921.8	99.2	531.8	95.9
1950	31.4	162.6	1,804.3	87.7	467.0	91.1
1951	34.7	139.4	1,659.5	91.6	638.9	116.6
1952	35.8	136.4	1,573.9	88.5	524.9	95.2
1953	43.8	166.9	1,560.4	87.7	597.5	108.8
1954	27.0	140.1	1,662.5	83.1	523.9	91.1
1955	41.3	154.4	1,627.9	77.8	607.2	111.1
1956	45.3	173.1	1,521.7	77.8	706.9	119.1
1957	32.0	168.3	1,885.1	82.4	596.2	99.6
1958	55.0	142.1	1,975.0	85.1	616.5	94.7
1959	51.3	143.8	1,916.8	85.8	710.0	117.4
1960	44.4	123.1	1,683.8	76.6	692.2	113.5
1961	57.5	134.3	1,864.7	78.2	744.0	113.2
1962	53.3	144.4	1,837.4		797.4	117.9

[1] Converted from bushels to tons on the basis of 40 bushels per ton.

[2] Converted from bushels to tons on the basis of 41.67 bushels per ton.

[3] Includes per capita fresh sales of U.S. apples and peaches. California grapes. plums. nectarines. and oranges.

[4] Washington production converted from bushels to tons on the basis of 40 bushels per ton.

[5] Includes per capita canning sales of Pacific Coast peaches and apricots.

Sources: Columns 2 and 3. 1944-48 (38. various pages); 1949-59. (39. various pages); 1960-61 (40. various pages); 1962. (41. various pages)

Columns 1 and 5. computed from data reported in the above sources.

Columns 4 and 6. computed in the manner described in Appendix C-2 and C-4 from data reported in the above sources.

Table A-5. California cling-peach prices, canners' stocks, f.o.b. price of canned pears, gross processor profit per case, and canned-pear exports, 1944-1962.

	1	2	3	4	5
Year	Farm Price California Cling Peaches (Dollar per Ton)	Canners Stocks of Canned Pears at Beginning of Year (June 1) (1,000 cases, 24 No. 2-1/2 basis)	F.o.b. price Canned pears (Dollars per Case of 24 No. 2-1/2, Choice Grade)	Estimated Gross Processor Profit Per Case (Dollars)	Canned Pear Exports[1] (Tons)
1944	62.30	900	5.70	3.56	6,984
1945	63.50	430	5.75	3.73	8,830
1946	63.50	240	7.50	4.95	13,725
1947	49.70	200	7.10	5.04	8,530
1948	63.30	726	8.10	4.91	6,423
1949	40.00	761	5.30	4.44	7,224
1950	60.00	448	7.80	5.54	10,350
1951	77.40	566	7.86	5.12	8,253
1952	65.00	1,575	6.49	5.21	10,520
1953	54.70	1,361	6.91	5.16	9,272
1954	54.60	747	6.92	4.98	17,119
1955	80.60	1,545	6.72	4.90	23,977
1956	71.00	1,609	6.89	4.83	19,181
1957	64.00	2,587	6.25	4.73	20,103
1958	65.00	2,411	6.88	5.00	16,889
1959	58.70	1,932	6.15	4.78	20,860
1960	55.90	2,018	6.50	4.69	21,406
1961	67.50	2,336	6.53	4.48	27,342
1962	64.10	3,102	5.64	4.08	31,217

[1]Includes pears in fruit cocktail.

Sources: Column 1, 1944-48 (3, p. 76)
1949-60 (4, p. 33)
1961-62 (5, p. 6 and 7)
Columns 2 and 3, 1944-47 (13, p. 94)
1948-62 (19, p. 20)
Column 5, (36, various pages)

Column 4 computed as described in Appendix C-5 from data reported in (3, 4, 5, 13, 19) and from personal correspondence.

Table A-6. Alternative projections of California cling-peach prices, canners' stocks, and canned-pear exports, 1963-1972.

	1	2	3	4	5
	Farm Price California Cling Peaches			Canned Pear Exports[1]	
Year	5% Decrease From 1958-62 Average (Dollars per Ton)	8% Decrease From 1958-62 Average (Dollars per Ton)	Canners' Stocks at Beginning of Year (June 1) (1,000 Cases,24 No. 2-1/2 Basis	20% Increase From 1958-62 Average (Tons)	20% Decrease From 1958-62 Average (Tons)
1963	60.14	59.78	2,466	21,226	20,284
1964	59.47	58.74	2,501	22,007	20,123
1965	58.78	57.69	2,537	22,788	19,962
1966	58.10	56.65	2,572	23,569	19,801
1967	57.42	55.60	2,609	24,350	19,640
1968	57.42	55.60	2,646	25,131	19,479
1969	57.42	55.60	2,684	25,912	19,318
1970	57.42	55.60	2,723	26,693	19,157
1971	57.42	55.60	2,764	27,474	18,996
1972	57.42	55.60	2,807	28,255	18,835

[1] Includes pears in fruit cocktail.

Table A-7. Alternative projections of pear production in Michigan and New York and population projections, 1963-1972.

	1	2	3	4	5
	Pear Production in Michigan and New York			Population Projections[1]	
Year	10% Increase From 1958-62 Average (Tons)	20% Increase From 1958-62 Average (Tons)	30% Increase From 1958-62 Average (Tons)	SERIES B (1.000 Persons)	SERIES D (1.000 Persons)
1963	52,820	53,350	53,870	189,278	189,278
1964	53,350	54,390	55,440	191,967	191,731
1965	53,870	55,440	57,010	194,671	194,127
1966	54,390	56,480	58,580	197,413	196,489
1967	54,920	57,530	60,150	200,212	198,819
1968	55,440	58,580	61,710	203,050	201,126
1969	55,960	59,620	63,280	205,964	203,469
1970	56,480	60,670	64,850	208,996	205,886
1971	57,010	61,720	66,420	212,145	208,364
1972	57,530	62,760	67,990	215,409	210,900

[1] Source: (45)

Table A-8. California bearing and non-bearing acreage, new plantings and removals of Bartlett pears, 1930-1962

	1	2	3	4
Year	Bearing Acreage	Non-bearing Acreage	New Plantings (Acres)	Removals (Acres)
1930	57,850	14,530	1,010	3,340
1931	57,520	11,790	950	4,020
1932	58,210	9,790	830	2,240
1933	57,040	8,320	620	3,150
1934	53,580	6,890	510	5,400
1935	49,170	6,030	500	5,770
1936	45,900	4,900	220	4,620
1937	45,140	4,200	320	1,770
1938	43,750	3,660	260	2,200
1939	42,190	3,050	230	2,390
1940	39,560	2,850	350	3,180
1941	39,010	2,340	110	1,780
1942	38,880	2,340	340	480
1943	38,800	2,140	170	440
1944	38,700	1,740	270	760
1945	38,410	1,700	360	700
1946	37,890	1,660	450	1,010
1947	37,120	1,950	520	1,010
1948	36,470	2,370	610	840
1949	35,460	2,890	800	1,290
1950	34,530	3,140	620	1,310
1951	34,640	3,580	770	220
1952	34,450	3,980	910	700
1953	34,200	4,010	830	1,050
1954	34,440	3,930	860	700
1955	34,240	4,000	760	890
1956	34,130	4,410	1,100	800
1957	34,280	5,200	1,730	790
1958	34,070	6,980	2,220	650
1959	34,400	8,930	2,690	420
1960	32,490	9,920	2,230	3,150
1961	30,880	11,700	1,600	1,420
1962	30,230	12,750	1,830	1,420

Sources: Columns 1 and 2, 1930-55 (3, p. 85); 1956-61 (4, p. 36); 1962 (5, p. 2)

Column 3, (2, various pages)

Column 4, computed from Columns 1, 2, and 3

Table A-9. Annual costs for equipment used in Bartlett pear production in Pacific Coast production areas, 1963.

1	2	3	4	5	6	7	8
				Annual Fixed (Overhead) Costs			Hourly Variable Costs (Fuel and Repairs) (Dollars)
Implement	Size	Replace-ment Costs (1963) (Dollars)	Esti-mated Life (Years)	Depre-ciation	Interest on Invest-ment	Total	
				- - Dollars - -			
Tractor-Crawler. diesel	40 h.p.	11.000	15	$733.30	$302.50	$1.035.80	$1.40
Tractor-Crawler. diesel	30 h.p.	7.000	15	466.70	192.50	659.20	1.15
Tractor-Crawler. gas	20 h.p.	4.100	10	410.00	112.70	522.70	1.00
Tractor-wheel. diesel	40 h.p.	5.400	10	540.00	148.50	688.50	.85
Tractor-wheel. gas	40 h.p.	5.000	10	500.00	137.50	637.50	1.20
Tractor-wheel. gas	30 h.p.	3.750	10	375.00	103.10	478.10	.95
Tractor-wheel. gas	20 h.p.	3,100	10	310.00	85.20	395.20	.80
Speedsprayer	Large	6.500	15	433.30	178.70	612.00	3.50
Speedsprayer	Medium	5.500	15	366.70	151.20	517.90	2.65
Speedsprayer	Small	4.200	15	280.00	115.50	395.50	2.15
Duster		800	10	80.00	22.00	102.00	.50
Disc. Tandem	10 Ft.	750	10	75.00	20.60	95.60	.25
Disc. Tandem	8 Ft.	600	10	60.00	16.50	76.50	.20
Disc. Tandem	6 Ft.	575	10	57.50	15.80	73.30	.20
Disc. Offset	10 Ft.	1.500	10	150.00	41.30	191.30	.35
Springtooth Harrow	12 Ft.	750	10	75.00	20.60	95.60	.10
Springtooth Harrow	8 Ft.	400	10	40.00	11.00	51.00	.05
Spiketooth Harrow	8 Ft.	200	10	20.00	5.50	25.50	.02
Disc Ridger		650	10	65.00	17.90	82.90	.30
Ditcher	4 Ft.	350	15	23.30	9.60	32.90	.10
Subsoiler	4 Ft.	1.000	10	100.00	27.50	127.50	.15
Rotary Mower (Brush Chopper)	7 Ft.	850	10	85.00	23.40	108.40	.45
Fertilizer Spreader	10 Ft.	370	8	46.30	10.20	56.50	.20
Fertilizer Spreader	8 Ft.	300	8	37.50	8.20	45.70	.20
Grain Drill	7 Ft.	700	10	70.00	19.20	89.20	.15
Weed Sprayer		400	10	40.00	11.00	51.00	.35
Steel Squirrel		2.400	10	240.00	66.00	306.00	.55
Fork-lift - High lift		1.250	12	104.20	34.40	138.60	.20
Fork-lift - Three-point		100	12	8.30	2.70	11.00	
Truck	2 T.	3.700	8	462.50	101.80	564.30	.08 per mi.
Truck	1-1/2 T.	2.500	8	312.50	68.70	381.20	.07 per mi.
Pickup Truck	3/4 T.	2.600	5	520.00	71.50	591.50	.04 per mi.
Pickup Truck	1/2 T.	2.300	5	460.00	63.20	523.20	.04 per mi.
Bus		600	8	75.00	16.50	91.50	.04 per mi.

(Continued)

Table A-9 (Continued)

1	2	3	4	5	6	7	8
Orchard Trailer		400	15	53.30	22.00	75.30	.10
Oil-filling Tank	500 Gal.	500	15	33.30	13.70	47.00	.35
Oil-storage Tank	5.000 Gal.	500	20	25.00	13.70	38.70	
Heaters - Return Stack		6.60	10	.70	.20	.90	
Heaters - Smudge Pots		2.00	10	.20	.05	.25	
Ladders	12 Ft.	12	8	1.50	.30	1.80	

Source: (31)

APPENDIX B

STATISTICAL RESULTS OF REGRESSION ANALYSES

B-1. Detailed Results of Stepwise Regression for Farm Price of Pacific Coast Bartlett Pears -- All Sales, 1947 - 1962.

Step 1.	$\hat{\beta}_o$	= - 7.18570	
	$\hat{\beta}_1$	= -62.71769	(-4.32063)[1]
	S_{yx}	= 24.33342	
	R^2	= .57144	
Step 2.	$\hat{\beta}_o$	= - 4.31761	
	$\hat{\beta}_1$	= -46.57391	(-3.61604)
	$\hat{\beta}_5$	= 1.00745	(2.94974)
	S_{yx}	= 19.54463	
	R^2	= .74327	
Step 3.	$\hat{\beta}_o$	= - .14826	
	$\hat{\beta}_1$	= -48.52608	(-5.53195)
	$\hat{\beta}_5$	= 1.05015	(4.51684)
	$\hat{\beta}_6$	= -44.83947	(-4.01408)
	S_{yx}	= 13.29066	
	R^2	= .89041	
Step 4.	$\hat{\beta}_o$	= .35549	
	$\hat{\beta}_1$	= -42.41690	(-5.20748)
	$\hat{\beta}_2$	= -82.57291	(-2.18528)
	$\hat{\beta}_5$	= 1.02809	(5.06385)
	$\hat{\beta}_6$	= -44.63921	(-4.58167)
	S_{yx}	= 11.59167	
	R^2	= .92358	

[1] Figures in parentheses are T-ratios.

B-1. (Continued)

Step 5.	$\hat{\beta}_o$	= - 1.16675	
	$\hat{\beta}_1$	= -43.47234	(-5.95756)
	$\hat{\beta}_2$	= -77.60454	(-2.2939)
	$\hat{\beta}_5$	= .98502	(5.39076)
	$\hat{\beta}_6$	= -46.52603	(-5.31243)
	$\hat{\beta}_9$	= .00196	(1.94492)
	S_{yx}	= 10.35559	
	R^2	= .94456	
Step 6.	$\hat{\beta}_o$	= - 1.92430	
	$\hat{\beta}_1$	= -42.97438	(-6.20256)
	$\hat{\beta}_2$	= -71.54450	(-2.21000)
	$\hat{\beta}_5$	= .91983	(5.13938)
	$\hat{\beta}_6$	= -50.18630	(-5.78331)
	$\hat{\beta}_7$	= -11.68963	(-1.45573)
	$\hat{\beta}_9$	= .00226	(2.31041)
	S_{yx}	= 9.82062	
	R^2	= .95512	
Step 7.	$\hat{\beta}_o$	= - 1.25446	
	$\hat{\beta}_1$	= -47.58532	(-6.10711)
	$\hat{\beta}_2$	= -78.85695	(-2.44776)
	$\hat{\beta}_4$	= .41716	(1.19502)
	$\hat{\beta}_5$	= 1.00696	(5.31494)
	$\hat{\beta}_6$	= -52.40975	(-6.03783)
	$\hat{\beta}_7$	= -15.89068	(-1.84834)
	$\hat{\beta}_9$	= .00241	(2.49732)
	S_{yx}	= 9.59507	
	R^2	= .96192	

B-1. (Continued)

Step 8.	$\hat{\beta}_o$	= - 1.82922	
	$\hat{\beta}_1$	= -49.73569	(-5.38072)
	$\hat{\beta}_2$	= -82.04466	(-2.38267)
	$\hat{\beta}_4$	= .52527	(1.23434)
	$\hat{\beta}_5$	= .95348	(4.22128)
	$\hat{\beta}_6$	= -52.13229	(-5.70711)
	$\hat{\beta}_7$	= -13.87728	(-1.40376)
	$\hat{\beta}_8$	= .03896	(.50060)
	$\hat{\beta}_9$	= .00240	(2.36614)
	S_{yx}	= 10.07874	
	R^2	= .96323	
Step 9.	$\hat{\beta}_o$	= - 1.81620	
	$\hat{\beta}_1$	= -49.79211	(-4.93356)
	$\hat{\beta}_2$	= -82.40740	(-2.14635)
	$\hat{\beta}_3$	= .61084	(.03799)
	$\hat{\beta}_4$	= .53084	(1.10046)
	$\hat{\beta}_5$	= .95435	(3.89502)
	$\hat{\beta}_6$	= -51.99932	(-4.96764)
	$\hat{\beta}_7$	= -13.75032	(-1.22910)
	$\hat{\beta}_8$	= .03874	(.45979)
	$\hat{\beta}_9$	= .00239	(2.15682)
	S_{yx}	= 10.88497	
	R^2	= .96324	

where: Y = first difference average annual grower returns per ton for Pacific Coast Bartlett pears -- all sales, expressed in real terms (1957-59 dollars)

(Continued)

B-1. (Continued)

X_1 = first difference total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

X_3 = first difference production of Pacific Coast pears other than Bartlett (tons per 1,000 persons)

X_4 = first difference index of quantities of competing fresh fruits (includes tons per 1,000 persons of fresh sales of U. S. apples, U. S. peaches, and California grapes, weighted by average farm price of each)

X_5 = first difference average annual grower returns of California cling peaches for canning, expressed in real terms (1957-59 dollars)

X_6 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases -- 24 No. 2½ basis - per 1,000 persons)

X_7 = first difference canners' f.o.b. price minus raw product cost per case in year t-1

X_8 = first difference U.S. disposable income per capita, in real terms (1957-59 dollars)

X_9 = first difference two-year moving average of canned pear exports in period t-1 (tons)

B-2. Stepwise Regression Analyses of Farm Prices of Pacific Coast Cannery Bartlett Pears, 1925-1941 and 1946-1961.

Analysis A. Factors affecting farm prices of Pacific Coast cannery Bartlett pears for the period from 1925 to 1941.

Independent Variable	Coefficient	T-Ratio	Step
X_1	-.10655	-.98666	2
X_2	1.25077	3.30033	1
X_3	-.04367	-.40491	6
X_4	-.33845	-1.06282	4
X_5	-.05628	-.22027	7
X_6	-.01388	-1.69281	3
X_7	.78187	.74859	5

Constant term -- 21.80284
R^2 = .810
Standard Error Y.X = 9.99128

Analysis B. Factors affecting farm prices of Pacific Coast cannery Bartlett pears for the period from 1946 to 1961.

Independent Variable	Coefficient	T-Ratio	Step
X_1	-.18549	-1.64138	1
X_2	-.46536	-.22893	6
X_3	.23141	1.32393	4
X_4	.85357	2.12224	2
X_5	-1.05924	-1.70883	3
X_6	-.00352	-.26351	5
X_7	2.36865	.21296	7

B-2. (Continued)

Constant term = 153.16544
R^2 = .669
Standard Error Y.X = 15.95269

where: X_1 = total farm production of Pacific Coast Bartlett pears (1,000 tons)

X_2 = U. S. disposable income per capita (current dollars)

X_3 = f. o. b. price Pacific Coast canned pears per case (choice No. 2 ½) in year t-1

X_4 = index of quantities of competing fruits for canning (index includes tons of Pacific Coast cannery peaches and California cannery apricots -- 1947-1950 = 100)

X_5 = total production all pears Michigan and New York (1,000 tons)

X_6 = canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. 2 ½ basis)

X_7 = time (in Analysis A. 1925 = 0) (in Analysis B. 1946 = 0)

B-3. Regression Analyses of Farm Prices of Pacific Coast Bartlett Pears -- All Sales, 1946 - 1961.

Analysis A. With the variables expressed as first differences of the actual data, the following price-estimating equation was obtained:

$$\hat{Y}_1 = .85552 - \underset{(-5.13865)}{45.97422}\, X_1 + \underset{(4.57958)}{1.00812}\, X_2 - \underset{(-4.49652)}{48.76412}\, X_3$$

$$- \underset{(-1.43242)}{53.56465}\, X_4$$

$R^2 = .908$

Standard Error Y.X = 12.58435

where: $\hat{Y}_1$ = first difference average annual grower returns per ton for Pacific Coast Bartlett pears -- all sales, expressed in real terms (1957-1959 dollars)

X_1 = first difference total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = first difference average annual grower returns California cling peaches for canning, expressed in real terms (1957 - 1959 dollars)

X_3 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. 2½ basis -- per 1,000 persons)

X_4 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

B-3. (Continued)

Analysis B. With the variables expressed in terms of the actual data, the following price-estimating equation was obtained.

$$\hat{Y}'_1 = 147.57019 \underset{(-2.65378)}{-35.51237} X_1 \underset{(3.56190)}{+1.14690} X_2 \underset{(-2.63762)}{-30.81892} X_3 \underset{(.82941)}{-61.87224} X_4$$

$R^2 = .745$

Standard Error Y.X = 14.54693

where: $\hat{Y}'_1$ = average annual grower returns per ton for Pacific Coast Bartlett pears -- all sales, expressed in real terms (1957-1959 dollars)

X_1 = total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = average annual grower returns for California cling peaches for canning, expressed in real terms (1957-1959 dollars)

X_3 = canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. $2\frac{1}{2}$ basis - per 1,000 persons)

X_4 = production of all pears in Michigan and New York (tons per 1,000 persons)

B-4. Regression Analyses of Season Average Farm Prices of Pacific Coast Cannery Bartlett Pears, 1946-1961

Analysis A. Farm price of Pacific Coast cannery Bartlett pears expressed in real terms (1957-1959 dollars).

Independent Variable	Coefficient	T-Ratio
X_1	-9.21386	-1.81335
X_2	1.20059	2.80969
X_3	-221.23923	-2.34914
X_4	-32.13380	-2.15162

Constant term = 102.94881
R^2 = .669
Standard Error Y.X = 18.34494

where: X_1 = f.o.b. price of Pacific Coast canned pears per case (choice No. 2½) in year t-1, expressed in real terms (1957 - 1959 dollars)

X_2 = index of quantities of competing fruits for canning (index includes cannery sales in tons per 1,000 persons of the following fruits: Pacific Coast peaches (cling and freestone), California apricots, and Pacific Coast prunes -- 1957-1959 = 100)

X_3 = total production of all pears in Michigan and New York (tons per 1,000 persons)

X_4 = canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. 2½ basis -- per 1,000 persons)

B-4. (Continued)

Analysis B. Farm price of Pacific Coast cannery Bartlett pears, expressed in current dollars.

Independent Variable	Coefficient	T-Ratio
X_1	-.17770	-1.83637
X_2	.24025	1.61730
X_3	.80802	2.70562
X_4	-1.01352	-1.97957
X_5	-.00524	-.83437

Constant term = 99.46711
R^2 = .667
Standard Error Y.X = 14.31738

where: X_1 = total farm production of Pacific Coast Bartlett pears (1,000 tons)

X_2 = f. o. b. price of Pacific Coast canned pears per case (choice No. $2\frac{1}{2}$) in year t-1

X_3 = index of quantities of competing fruits for canning (index includes tons of Pacific Coast cannery peaches and California cannery apricots -- 1947-1950 = 100)

X_4 = total production of all pears in Michigan and New York (1,000 tons)

X_5 = canners' stocks of canned pears at beginning of year (June 1) (1,000 cases -- 24 No. $2\frac{1}{2}$ basis)

B-4. (Continued)

Analysis C. Farm price of Pacific Coast cannery Bartlett pears, expressed in real terms (1957-1959 dollars) and in first differences of actual data.

Independent Variable	Coefficient	T-Ratio
X_1	-59.36745	-4.01322
X_2	.13584	1.43832
X_3	186.67814	1.54748
X_4	-100.15958	-1.32518
X_5	-41.12149	-2.11664

Constant term = -4.64240

R^2 = .803

Standard Error Y.X = 21.30666

where: X_1 = first difference total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = first difference disposable income per capita, expressed in real terms (1957-1959 dollars)

X_3 = first difference production of Pacific Coast cannery peaches (tons per 1,000 persons)

X_4 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

X_5 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. $2\frac{1}{2}$ basis - per 1,000 persons)

B-5. Regression Analyses of Farm Prices of Pacific Coast Bartlett Pears -- Fresh Sales, 1946 - 1961, Expressed in Real Terms (1957 - 1959 dollars)

Analysis A.

Independent Variable	Coefficient	T-Ratio
X_1	-9.39408	-.68118
X_2	-.03756	-1.25477
X_3	-12.55908	-2.75555
X_4	1.27485	4.48015
X_5	.81757	2.70476
X_6	-235.66403	-4.38964

Constant term = 122.22170

R^2 = .802

Standard Error Y.X = 12.03102

where: X_1 = total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = U. S. disposable income per capita, expressed in real terms (1957-1959 dollars)

X_3 = f. o. b. price of Pacific Coast canned pears per case (choice No. 2½) in year t-1, expressed in real terms (1957-1959 dollars)

X_4 = index of quantities of competing fruits for canning (index includes cannery sales in tons per 1,000 persons of the following fruits: Pacific Coast cling and freestone peaches, California apricots, and Pacific

B-5. (Continued)

Coast prunes -- 1947-1950 = 100)

X_5 = index of quantities of competing fresh fruits (index includes fresh sales in tons per 1,000 persons of the following fruits: U.S. apples, U.S. peaches, California nectarines, California plums, and California grapes, and California oranges -- 1947-1950 = 100)

X_6 = total production of all pears in Michigan and New York (tons per 1,000 persons)

Analysis B.

Independent Variable	Coefficient	T-Ratio
X_1	-10.65807	-.79805
X_2	-.04612	-1.69782
X_3	-12.86067	-2.92731
X_4	1.33844	4.88403
X_5	.95832	2.94511
X_6	-258.03712	-4.75021

Constant term = 127.00303
R^2 = .817
Standard Error Y.X = 11.58533

where: X_1, X_2, X_3, X_4 and X_6 are the same as listed in Analysis A above.

X_5 = index of quantities of competing fresh fruits (index includes fresh sales in tons per 1,000 persons of the

B-5. (Continued)

following fruits: U.S. apples, U.S. peaches, California nectarines, California plums, and California grapes -- 1947-1950 = 100)

Analysis C.

Independent Variable	Coefficient	T-Ratio
X_1	.02378	1.02446
X_2	.76522	9.47012
X_3	-1.18620	-.53885
X_4	-25.04810	-.54135

Constant term = 5.09667
R^2 = .914
Standard Error Y.X = 7.49928

where: X_1 = U.S. disposable income per capita, expressed in real terms (1957-1959 dollars)

X_2 = annual average farm price per ton for Pacific Coast cannery Bartlett pears, expressed in real terms (1957-1959 dollars)

X_3 = total fresh sales of U.S. apples (tons per 1,000 persons)

X_4 = total production of all pears in Michigan and New York (tons per 1,000 persons)

B-6. Regression Analysis of Farm Prices of Pacific Coast Bartlett Pears -- All Sales, 1946 - 1961, Expressed in Real Terms (1957 - 1959 dollars) and in First Differences.

Independent Variable	Coefficient	T-Ratio
X_1	-45.95596	-4.83767
X_2	1.00775	4.32777
X_3	-48.73110	-4.17103
X_4	-53.57294	-1.36578
X_5	-.23158	-.01231

Constant term = .84203

R^2 = .908

Standard Error Y.X = 13.19848

where: X_1 = first difference total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = first difference average annual grower returns for California cling peaches for canning, expressed in real terms (1957 - 1959 dollars)

X_3 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. 2½ basis - per 1,000 persons)

X_4 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

X_5 = first difference three-year average gross profit per case in period t-1, expressed in real terms (1957 - 1959 dollars)

B-7. Price-estimating Equation for Farm Price of Pacific Coast Bartlett Pears -- All Sales, 1948 - 1963.

$$\hat{Y}_1 = -.32134 \underset{(-4.575)}{-34.03323} X_1 \underset{(-2.141)}{-91.43689} X_2 \underset{(4.440)}{+1.10035} X_5 \underset{(-3.750)}{-38.77158} X_6$$

$R^2 = .905$

Standard Error Y. X = 13.098

where: the dependent and independent variables are the same as those outlined on page 47 of the text. (The independent variable X_9, canned pear exports, was excluded from this equation because the t-ratio of the partial regression coefficient was not significantly different from zero.)

B-8. Actual and Estimated Real Farm Prices for All Sales of Pacific Coast Bartlett Pears, 1948 - 1963.

Year	Actual Price (Dollars per Ton)	Estimated Price (Dollars per Ton)	Difference (Dollars per Ton)	Percent Difference
1948	131.90	140.16	- 8.26	6.26
1949	38.67	54.41	-15.74	40.70
1950	98.91	97.45	1.46	1.47
1951	108.41	107.16	1.25	1.15
1952	54.95	62.66	-7.71	14.04
1953	72.85	59.15	13.70	18.80
1954	80.74	80.42	0.32	0.39
1955	77.58	88.12	-10.54	13.59
1956	83.67	60.06	23.61	28.22
1957	65.64	60.17	5.47	8.33
1958	80.07	71.61	8.46	10.57
1959	65.72	79.61	-13.89	21.14
1960	80.07	77.69	2.38	2.97
1961	88.80	75.93	12.87	14.50
1962	65.31	63.59	1.72	2.63
1963	102.45	117.55	-15.10	14.74

B-9. Detailed Results of Stepwise Regression for Farm Price of Pacific Coast Cannery Bartlett Pears, 1947-1962.

Step 1.

$$\hat{\beta}_o = -7.79021$$
$$\hat{\beta}_1 = -68.10293 \quad (-4.31187)$$
$$S_{yx} = 26.47649$$
$$R^2 = .57044$$

Step 2.

$$\hat{\beta}_o = -4.55577$$
$$\hat{\beta}_1 = -49.89705 \quad (-3.65236)$$
$$\hat{\beta}_3 = 1.13614 \quad (3.13616)$$
$$S_{yx} = 20.73094$$
$$R^2 = .75546$$

Step 3.

$$\hat{\beta}_o = -.33772$$
$$\hat{\beta}_1 = -51.87203 \quad (-5.26497)$$
$$\hat{\beta}_3 = 1.17933 \quad (4.51627)$$
$$\hat{\beta}_4 = -45.36313 \quad (-3.61566)$$
$$S_{yx} = 14.92750$$
$$R^2 = .88296$$

Step 4.

$$\hat{\beta}_o = -2.20064$$
$$\hat{\beta}_1 = -52.73093 \quad (-5.86200)$$
$$\hat{\beta}_3 = 1.12389 \quad (4.68338)$$
$$\hat{\beta}_4 = -47.70407 \quad (-4.14480)$$
$$\hat{\beta}_7 = .00245 \quad (1.85296)$$
$$S_{yx} = 13.61106$$
$$R^2 = .91080$$

Step 5.

$$\hat{\beta}_o = -1.64879$$
$$\hat{\beta}_1 = -47.44792 \quad (-5.37270)$$
$$\hat{\beta}_2 = -70.65333 \quad (-1.72446)$$

B-9. (Continued)

	$\hat{\beta}_3$	= 1.10861	(5.01309)
	$\hat{\beta}_4$	= 47.38091	(-4.47013)
	$\hat{\beta}_7$	= .00229	(1.87649)
	S_{yx}	= 12.53300	
	R^2	= .93124	
Step 6.	$\hat{\beta}_o$	= -2.51396	
	$\hat{\beta}_1$	= -48.10699	(-5.38953)
	$\hat{\beta}_2$	= -88.29198	(-1.94105)
	$\hat{\beta}_3$	= 1.09566	(4.90795)
	$\hat{\beta}_4$	= -43.21172	(-3.72683)
	$\hat{\beta}_5$	= -10.29101	(- .92302)
	$\hat{\beta}_7$	= .00199	(1.56490)
	S_{yx}	= 12.62681	
	R^2	= .93719	
Step 7.	$\hat{\beta}_o$	= -4.02536	
	$\hat{\beta}_1$	= -49.39919	(-5.29443)
	$\hat{\beta}_2$	= -91.43128	(-1.94989)
	$\hat{\beta}_3$	= .96167	(3.28387)
	$\hat{\beta}_4$	= -42.53033	(-3.56231)
	$\hat{\beta}_5$	= -12.38151	(-1.04983)
	$\hat{\beta}_6$	= .05481	(.73489)
	$\hat{\beta}_7$	= .00198	(1.51020)
	S_{yx}	= 12.96236	
	R^2	= .94116	

where: Y = first difference average annual grower returns per ton for Pacific Coast Bartlett pears -- all sales, expressed

B-9. (Continued)

in real terms (1957-59 dollars)

X_1 = first difference total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = first difference production of all pears in Michigan and New York (tons per 1,000 persons)

X_3 = first difference average annual grower returns of California cling peaches for canning, expressed in real terms (1957-59 dollars)

X_4 = first difference canners' stocks of canned pears at beginning of year (June 1) (1,000 cases - 24 No. $2\frac{1}{2}$ bases -- per 1,000 persons)

X_5 = first difference canners' f.o.b. price minus raw product cost per case in year t-1

X_6 = first difference U.S. disposable income per capita, in real terms (1957-59 dollars)

X_7 = first difference two-year moving average of canned pear exports in period t-1 (tons)

B-10. Regression Analyses of Farm Prices of Pacific Coast Bartlett Pears -- Fresh Sales, 1946 - 1961.

Analysis A.

$$\hat{Y}_3 = 49.99853 - 43.66079\ X_1 + .04689\ X_2 + .32385\ X_3$$
$$(-1.93990) \qquad (.76413) \qquad (.53895)$$
$$+114.02929\ X_4 - 157.51193\ X_5$$
$$(2.18757) \qquad (-1.45159)$$

$R^2 = .513$
Standard Error Y.X = 18.71765

where: $\hat{Y}_3$ = average annual grower returns per ton for fresh sales of Pacific Coast Bartlett pears, expressed in real terms (1957-1959 dollars)

X_1 = total farm production of Pacific Coast Bartlett pears (tons per 1,000 persons)

X_2 = U. S. disposable income per capita, expressed in real terms (1957 - 1959 dollars)

X_3 = index of quantities of competing fresh fruits (index includes fresh sales in tons per 1,000 persons, weighted by annual average grower price, for the following fruits: U.S. apples, U.S. peaches, and California grapes.)

X_4 = total fresh sales of winter pears (pears other than Bartlett and Hardy) in Pacific Coast states (tons per 1,000 persons)

B-10. (Continued)

X_5 = total production of pears in Michigan and New York (tons per 1,000 persons)

Analysis B.

$$\hat{Y}_3 = 27.92321 + .75341 \underset{(10.31143)}{X_1}$$

$R^2 = .884$

Standard Error Y. X = 7.73201

where: $\hat{Y}_3$ = average annual grower returns per ton for fresh sales of Pacific Coast Bartlett pears, expressed in real terms (1957-1959 dollars)

X_1 = average annual grower returns per ton of Pacific Coast cannery Bartlett pears, expressed in real terms (1957 - 1959 dollars)

B-11. Statistical Results of Supply Model No. 1

Analysis A. Estimating equation for all sales of California Bartlett pears, adjusted for average yield trend, in the period 1933 to 1963.

$$\hat{Y} = 214.10436 + .07557\ X_1 - .02928\ X_2 + 1.51997\ X_3 - 1.65430\ X_4$$

$$\qquad\qquad (.06681) \qquad (-.01975) \qquad (2.13005) \qquad (-2.11284)$$

$R^2 = .183$
Standard Error Y.X = 42.423

where: $\hat{Y}$ = all sales of California Bartlett pears, adjusted for average yield trend, in year t (1,000 tons)

X_1 = four-year average grower returns per ton for all sales of California Bartlett pears in the period including years t-14 to t-11; divided by index of prices paid by farmers for production items, including interest, wages, and taxes in the same period.

X_2 = four-year average of index of prices received by growers for alternative California fruit crops, including plums, prunes, cherries, apricots, and walnuts (1957-1959 = 100) during the period from year t-14 to year t-11; divided by index of prices paid by farmers for production items, including interest, wages, and taxes in the same period

B-11. (Continued)

X_3= same as X_1, except a two-year average for the period including years t-2 and t-1

X_4= same as X_2, except a two-year average for the period including years t-2 and t-1

Analysis B. Estimating equation for all sales of California Bartlett pears in the period 1933 to 1963.

$$\hat{Y}' = -42.17531 \underset{(-.81265)}{-1.30931} X_1 \underset{(1.33871)}{+2.82683} X_2 \underset{(-.81403)}{-.82748} X_3 \underset{(2.36547)}{+2.63836} X_4$$

R^2 = .322
Standard Error Y.X = 60.433

where: $\hat{Y}'$ = all sales of California Bartlett pears in year t (1,000 tons)

X_1, X_2, X_3, and X_4 are the same as in Analysis A. above

B-12. Statistical Results of Alternative Analyses Using the Distributed-lags Model (Model No. 2).

Analysis A. Alternative supply equations for the period 1919 to 1962.

(1) Pacific Coast -- $\hat{Y}'_4 = 11.39070 + .20306\, X_{11} + .91574\, X_{21}$
$(2.47080) \quad (17.68705)$

$R^2 = .897$
Standard Error Y.X = 14.64149

(2) California -- $\hat{Y}'_5 = -.11207 + .13926\, X_{12} + .94271\, X_{22}$
$(2.22150) \quad (12.35655)$

$R^2 = .811$
Standard Error Y.X = 10.99594

(3) Oregon -- $\hat{Y}'_6 = 3.08137 + .01609\, X_{13} + .87629\, X_{23}$
$(1.78951) \quad (19.42064)$

$R^2 = .911$
Standard Error Y.X = 1.90089

(4) Washington -- $\hat{Y}'_7 = 3.92850 + .02017\, X_{14} + .93685\, X_{24}$
$(.53056) \quad (19.71564)$

$R^2 = .917$
Standard Error Y.X = 7.33087

where: $\hat{Y}'_4$, $\hat{Y}'_5$, $\hat{Y}'_6$, and $\hat{Y}'_7$ = four-year moving average of all sales of Bartlett pears, adjusted for average yield trend, in period t for the respective states (1,000 tons)

X_{11}, X_{12}, X_{13}, and X_{14} = annual average grower returns in dollars per ton from all sales of Bartlett pears in period t-1 for the respective states; divided by index

B-12. (Continued)

of prices paid by farmers for production items, including interest, wages, and taxes in period t-1

X_{21}, X_{22}, X_{23}, and X_{24} = four-year moving average of all sales of Bartlett pears adjusted for average yield trends for the respective states (1,000 tons)

Analysis B. Estimating equations for new plantings of Bartlett pears in California for the period 1930 to 1961.

$$(1) \quad \hat{Y} = -76.59106 + \underset{(.81227)}{1.23537} X_1 + \underset{(13.01738)}{.99742} X_2$$

$R^2 = .855$

Standard Error Y.X = 252.349

where: $\hat{Y}$ = acres of new plantings of Bartlett pears in California in year t

X_1 = annual average grower returns in dollars per ton from all sales of California Bartlett pears in period t-1; divided by index of prices paid by farmers for production items, including interest, wages, and taxes in period t-1

X_2 = acres of new plantings of Bartlett pears in California in year t-1

B-12. (Continued)

Analysis C. Estimating equation for removals of Bartlett pears in California for the period 1931 to 1961.

$$\hat{Y} = 1147.66620 \underset{(-1.04845)}{-7.39869} X_1 \underset{(4.94248)}{+.66631} X_2$$

$R^2 = .556$

Standard Error Y.X = 1042.434

where: $\hat{Y}$ = acres of removals of Bartlett-pear trees in California in year t

X_1 = annual average grower returns in dollars per ton from all sales of California Bartlett pears in period t-1; divided by index of prices paid by farmers for production items, including interest, wages, and taxes in period t-1

X_2 = acres of removals of Bartlett-pear trees in California in year t-1

APPENDIX C

COMPUTATIONAL METHODS FOR INDICES AND OTHER VARIABLES

C-1. Index of Prices Received for Alternative California Fruits:

This index includes prices of the following California fruits: apricots, cherries, plums, prunes, and walnuts. Annual average price received by growers for all sales of each fruit was converted to an index number on the basis of 1957-1959 = 100. Each of the five resulting index numbers of the individual fruits were then averaged to obtain the overall index of prices received by growers.

C-2. Index of Quantities of Competing Fresh Fruits:

This index includes per capita fresh sales of United States apples and peaches of California grapes, plums, nectarines, and oranges. The total fresh sales of each of these fruits were added together to form a combined total tonnage of competing fresh fruits. This total tonnage was then divided by United States population; and the resulting per capita figures were converted to an index number on the basis of 1947-1949 = 100.

C-3. Price-weighted Index of Quantities of Competing Fresh Fruits:

This index includes per capita fresh sales of United States apples, United States peaches, and California grapes. Per capita fresh sales of each of the three fruits were weighted by annual average price received by growers for fresh sales of the respective fruits. This weighted average of per capita fresh sales was then converted to an index number on the basis of 1957-1959 = 100.

C-4. Index of Quantities of Competing Canning Fruits:

This index includes per capita sales for canning of Pacific Coast peaches (cling and freestone) and California apricots. The canning sales of each of these two fruits were added together to form a combined total tonnage of competing canning fruits. This total tonnage was then divided by United States population; and the resulting per capita figures were converted to an index number on the basis of 1947-1949 = 100.

C-5. Estimated Gross Processor Profit per Case:

Annual average grower returns per ton for Pacific Coast Bartlett pears sold for canning were divided by annual estimates of average case yield per ton of raw product[1] to obtain a raw-product cost per case. Raw product cost per case was subtracted from annual average f. o. b. price per case received by canners to obtain estimated gross profit per case.

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[1] Estimates of average case yield per ton were obtained from personal correspondence with Robert Eaton, In Charge, Northwest Marketing Field Office, Agricultural Marketing Service, U. S. Department of Agriculture. These estimates were based upon a survey of representative canners.