An economic analysis of supply response in the California-Arizona lemon industry

AN ECONOMIC ANALYSIS OF SUPPLY RESPONSE IN THE CALIFORNIA-ARIZONA LEMON INDUSTRY

by

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I wish to dedicate this study to my parents who have always encouraged me in my endeavors.

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ABSTRACT

This thesis analyzes the supply response that has taken place in the California-Arizona lemon industry from 1954 through 1978. The industry has operated under the Federal Lemon Marketing Order since 1941.

Two models of aggregate-level supply response were developed. The first model comprises identities for production and for bearing acreage, and equations for yield, plantings, and removals. Lack of data limited the model to being estimated by a reduced-form equation. The estimated equations were statistically insignificant due to too few degrees of freedom and the extensive use of proxies.

The second model considered the expected profits of lemons and the expected profits of oranges, the major alternative crop, as determining bearing acreage. The estimation equations in this model were considered satisfactory and predictions were made of bearing acreage, yield and production. Model projections for 1977 to 1983 were compared to those made during the annual meetings of the California-Arizona Citrus League. The two sets of projections compare closely with each other and with the available historical data.

The thesis concludes with a discussion of an allocation model that could be used to evaluate the economic impacts of the Lemon Marketing Order.

CHAPTER 1

INTRODUCTION

In the United States, and capitalist systems in general, the theory of perfect competition has provided the basis for many models used in economic analysis. Agricultural production in the United States is typically considered by economists as operating under condi-ions approximating perfect competition (Samuelson, 1967, p. 390). The following conditions are assumed to exist in a market operating under perfect competition (Henderson and Quandt, 1971):

1. Firms produce a homogeneous commodity and all consumers appear identical to the seller.
2. Both firms and consumers are numerous and transactions of individuals are small in relation to the aggregate.
3. Both firms and consumers possess perfect information about the prevailing price and current bids, and they take advantage of every opportunity to increase profits and utility, respectively.
4. Entry into and exit from the market are free for firms and consumers in the long run.

In the California-Arizona lemon industry there are several thousand growers with an average holding of approximately 35 acres. Lemons are marketed in three general markets: products, fresh domestic (including Canada), and fresh export. Within the fresh markets there are numerous buyers with equal access to growers. For lemons sold in the products market, however, there are only a few private and cooperative processing plants. Except for a certain percentage of poor quality fruit, which is suitable only for the products market, and superior fruit, which is often allocated to certain export markets such as Japan, lemons may be considered a homogeneous product. While adjustments of production to demand are not immediate, due to the nature of perennial crops, there appears to be no long-run constraint on the exit and entry behavior of the producers and consumers. Firms have free access to market information and are assumed to attempt to maximize profits. There is, however, a constraint on marketing firm behavior through the Lemon Marketing Order (LMO) implemented by the Lemon Administrative Committee (LAC). Because of the close relationship between marketing firms and growers, the LMO is expected to influence producers as well as the marketing firms. To understand the role of the LMO in the lemon industry, it is important to understand growers' supply response.

The Lemon Marketing Order

The Federal Lemon Marketing Order for the California-Arizona lemon industry was first enacted in 1941 according to provisions of the Agricultural Marketing Act of 1937. At present, Order No. 910 (United States Department of Agriculture [USDA], 1971) is in effect. As in the case for all fruit and vegetable marketing orders, the Lemon Marketing Order had to be approved by two-thirds of the growers in the industry in order to be activated. Once approved, it became binding for all handlers of California-Arizona lemons. The purpose of the Lemon Marketing Order is to ensure orderly marketing, that is, to provide a steady and adequate supply of fresh fruit to the domestic consumer at reasonable prices and to maintain adequate prices to farmers. It has been argued by Jamison (1971) and others that these two aspects of orderly marketing are not always compatible. Nicolatus (1977) determined that demand at the farm level is price elastic, although under such conditions, if the LAC increased shipments of fresh lemons into the domestic market, retailers and consumers would benefit by greater total revenues and lower prices, respectively, but growers would experience decreased total revenues.

The LAC is the implementing body of the LMO and is composed of 13 members, each with an alternate, serving 2-year terms. There are 8 grower members, 4 handler members, and 1 non-industry memeber on the committee. Sunkist Growers, Inc., a grower cooperative, handles about 80 percent of the total volume of lemons marketed, and nominates 4 grower members and 2 handler members. Pure Gold, the second largest cooperative, nominates 3 grower members and 1 handler member, while the independent growers, including the remaining cooperatives, are represented by 1 grower member and 1 handler member. The non-industry member is chosen by the committee. All members must be approved by the Secretary of Agriculture.

The LAC has two principal means of intervening in the domestic market for fresh lemons:

1. Fixing minimum size requirements to prevent inferior lemons from entering the market.
2. Regulating the rate-of-flow of fresh lemons into the domestic market. Marketing quotas are established on a weekly prorate basis by district and by handler.

Nicolatus (1977) observed that the LAC has maintained the same minimum-size regulation from 1964 through 1975, an indication that the committee does not consider size regulation an effective tool in accomplishing its objectives. However, when supply is short the size regulation is suspended or changed to allow smaller fruit to enter the fresh market. This occurred in the Spring of 1979 to handle an anticipated shortage of lemons during the summer of 1979 (Lemon Administrative Committee [LAC], 1979). The processing market absorbs the undersized portion of the crop, which nomrally does not restrict the availability of fruit to the fresh market (Jamison, 1971). The rate-of-flow provision ensures that all growers have access to the fresh domestic market and that the total quantity entering this market will be controlled.

Previous to each crop year the LAC meets to determine the marketing policy for the forthcoming season. According to the Lemon Marketing Order No. 910 (USDA, 1971), the marketing policy for each year must contain the following information:

1. Available supply of lemons, with an estimation of size and quality.

2. Estimated allocation of the crop to the domestic, export, and processing markets.
3. A schedule of estimated weekly shipments by district.
4. Level and trend of consumer income.
5. Estimated supplies of competitive citrus commodities.
6. Any other pertinent factors, such as changes in production or marketing costs.

The committee meets weekly throughout the year and may alter the weekly recommendations for shipments made in the annual marketing policy. The LAC is directed to give consideration to the following in making its decisions:

1. The quantity of lemons in storage.
2. Lemons on hand in, and enroute to, the principal markets.
3. Trend in consumer income.
4. Present and predicted weather conditions.
5. Present and prospective prices of lemons.
6. Other relevant factors such as labor and transportation problems.

The expenses of the LAC are covered by a per-carton assessment on all fruit entering the fresh domestic market. The fact that the LMO is entirely financed by the growers and does not require government funds as do programs involving direct subsidies is often put forth in support of the LMO.

Prediction and Explanation in Supply Response

Economic success by producers depends on the accuracy of their knowledge about both the present and future economic and physical environments in which they operate. To further knowledge of this environment, the intent of this thesis is to develop a model of supply response in the California-Arizona lemon industry.

There are alternative approaches to the analysis of supply response (Tomek and Robinson, 1977). If the purpose of the researcher is to offer a behavioral explanation of supply response, he is likely to formulate a structural model that attempts to represent the decisions leading to supply. The variables in the model will include all relevant factors by which the producer makes his decisions. The structural model is suitable for historical explanation and analysis of decision-making on the part of the producer. If appropriate variables are included, the model may also serve for the analyses of policy changes. The usefulness of the model in making predictions will depend upon the particular form (e.g., containing lagged variables) of the equations in the model. There seems to be no necessity that a model that explains past activity well should accurately predict future behavior. Of course, if a model does explain well and predictions are made from it, our sense of the underlying regularity of the world would lead us to place confidence in the predictions.

Many times, however, reduced form equations are utilized in supply response modeling. This may be by default, due to lack of data necessary for estimating the structural model giving rise to problems of identification, or by the deliberate use of a simplified model with the intention of predicting output. Due to the lack of specification of the structure, these models may not be useful if structure changes. Since they do not include all decision variables, some decisions are only implicitly accounted for. Hence it is the statistical reliability of these equations that determines their value. If they tend to predict well for the long or short run, they are called successful predictive models.

This thesis develops both a structural model capable of explaining behavior and a simplified model capable of predicting output in the California-Arizona lemon industry. It is believed that the development and empirical application of these models will provide information useful for planning and policy analysis by interested parties such as the growers, the Lemon Administrative Committee, and the marketing organizations.

CHAPTER 2

A DESCRIPTIVE ANALYSIS OF THE CALIFORNIA-ARIZONA LEMON INDUSTRY

The analysis of supply response requires knowledge of the specific situation in which the production and marketing activities occur. This chapter provides a foundation upon which such an analysis may be based. The salient features of the California-Arizona lemon industry are examined at both the industry and district levels. The districts have distinct characteristics. Knowledge of the differences among districts will enable assumptions as to the homogeneity of the industry to be made with greater awareness of their limitations.

A review of the characteristics of the growers and the cultural practices used in the lemon industry is followed by an analysis of the historical patterns in acreage, production, yield, prices, and costs.

Unless otherwise noted, all data presented in Chapter 2 are from the Annual Reports of the Lemon Administrative Committee (1955-1978) or the Citrus Fruit Industry Statistical Bulletin, published by Sunkist Growers, Inc. (1961-1978). When data conflict, the Annual Reports take precedence. Crop years are referred to by the years in which they end. For example, the 1977-78 season is referred to as 1978.

Lemons are grown in the tropical and subtropical regions of the world in which climatic, soil, and water requirements are met.

Most of the world's production of lemons is in the United States, Italy, Brazil, Argentina, Spain, Greece, and Turkey. These countries together produced 90 percent of the total production in 1969-70 and 94 percent in 1976-77. The United States is the world's largest producer of lemons, followed by Italy.

The U.S. share of world lemon production was 45-50 percent through the 1940s. Since the 1950s, U.S. production has steadily decreased as a percentage of world production. In the 1950s it was 40-45 percent, in the 1960s, 30-40 percent, and in the 1970s, 20-30 percent. The greatest increase in production in recent years has been in Brazil, which produced 6.9 million cartons in 1970-71 and 22 million cartons in 1976-77.

The U.S. lemon production has increased steadily since the twenties when approximately 10 million cartons were producted. In the 1976-77 season, 52 million cartons were produced. Most U.S. production before 1960 was from acreage in five counties in Southern California: Los Angeles, Ventura, Santa Barbara, Orange, and Riverside.

Since the early 1960s, lemon production has become increasingly significant in Central California and the desert region of California and Arizona. There have been small amounts of lemons grown in Florida, but Florida production has never exceeded 10 percent of U.S. production and averaged 6.5 percent in the years 1967-1977.

The production districts for California-Arizona lemons as referred to in this thesis correspond to the prorate districts established by the Lemon Administrative Committee: Central California--

District 1; Southern California--District 2; Desert region of California and Arizona--District 3 (Figure 1).

General Characteristics

The Growers

Most lemon growers in California and Arizona are members of cooperatives. The cooperatives which handle citrus are primarily involved with the packing, processing, and marketing operations of the industry. Fresh fruit is sold in the domestic market according to the prorate established by the Lemon Administrative Committee. Cooperatives also provide their members with much needed information on growing conditions, policy changes, and marketing opportunities. The cooperatives have been especially active in working with the U.S. and Japanese governments to open up the Japanese market. Sunkist Growers, Inc. has its own processing plants to handle fruit not marketed in the fresh domestic and fresh export markets.

Sunkist Growers, Inc. is the largest cooperative with 7,500 grower members in 1977, representing approximately 75 percent of the citrus growers in California and Arizona. Since 1921 Sunkist has handled over 70 percent of all California-Arizona citrus. During the period 1971-1977 Sunkist handled 83 percent of the total California-Arizona lemon crop (Sunkist Growers, Inc., 1976-77). Other cooperatives, notably Pure Gold, and independent shippers represent the remainder of the California-Arizona citrus growers.

One phenomenon, the effect of which has not been examined in great detail, is urban expansion, which has resulted in land

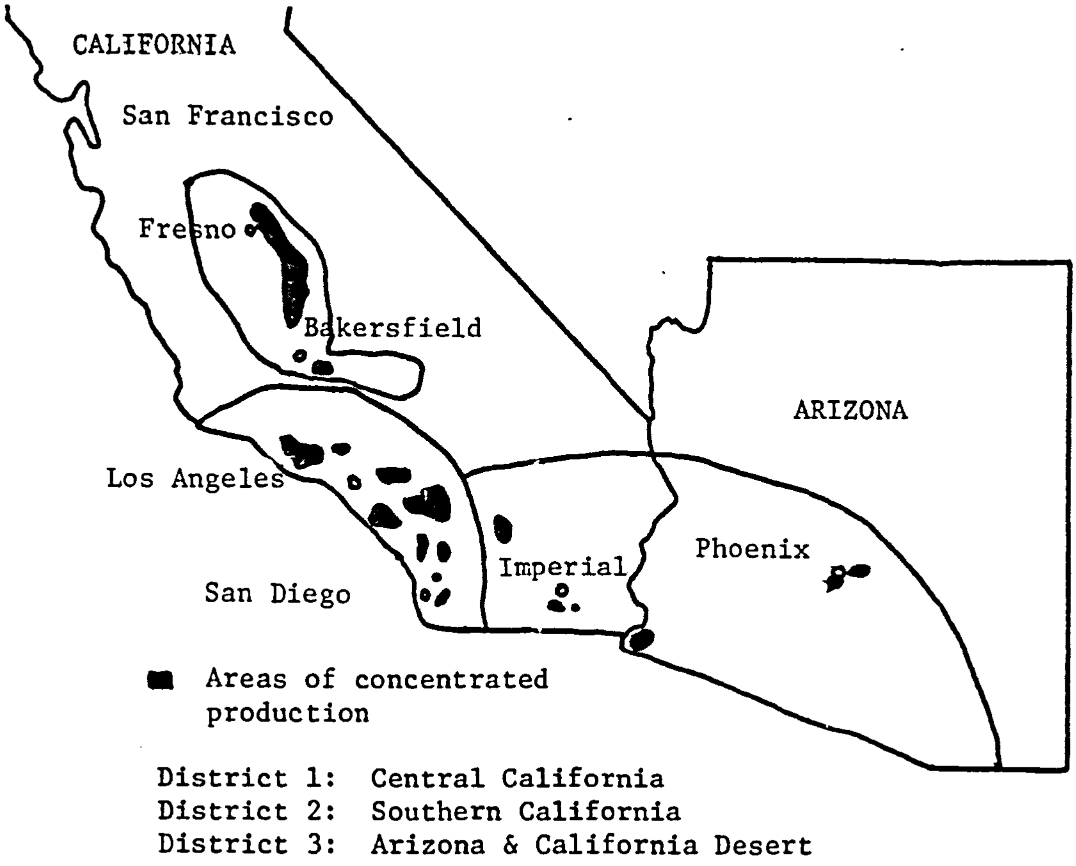

Figure 1. Lemon Production Districts in Arizona and California

Source: Fox, Cable, and Gotsch (1970).

speculation in the prime lemon-producing area of District 2. This speculation has been accompanied by an increasing number of nonowner-operated farms. Some of the groves intended for urban development use a minimum of inputs to keep down costs whereas others operate so as to maximize profits through the production of lemons as is typical of owner-operated farms. If such divergent behavior is extensive in the industry, problems of aggregation could hamper the analysis of grower behavior as it relates to supply response.

Cultivation and Harvest of Lemons

There are two varieties of lemons grown in California and Arizona: the Lisbon, which originated in Australia, and the Eureka, which was developed in Southern California from the seed of a Sicilian lemon. For most purposes the varieties are not differentiated. Choice depends on the rootstock and the particular conditions of the producing area.

When choosing land for a citrus grove, the following factors must be considered (Hilgeman and Rodney, 1961):

1. The grove must be relatively sheltered from freezing temperatures. Several hours of temperatures below freezing can severely damage a crop, while several nights of freeze conditions can damage the tree itself.
2. There must be adequate water, depending on the soil. More is needed if the soil is sandy or gravelly. If there is good drainage, a greater saline content is permissible.

3. The best soils for citrus are deep, sandy soils, sandy loam, or clay loam. Each soil type will demand an appropriate rootstock for best growth.
4. Fields must be slightly sloped or terraced and level for irrigation, although in recent years pressurized irrigation systems (drip, sprinkler, etc.) have been used in some groves, removing this requirement.

Lemons are considered of bearing age within 4-5 years after planting. Yield increases until the tree is around 10 years old. From 10-20 years of age the tree bears at maximum yield. Beyond 20-25 years, yield begins to decline. Trees may attain ages up to 60 years and more, but most commercially grown trees are removed much earlier, depending on economic and physical factors.

Harvesting seasons vary for each district. In District 1, picks are greatest from November through February. In District 2 there are picks all year around, but the heaviest picking occurs from February through June. In District 3 the harvest is normally from late September through the beginning of March.

Except in District 3, where it is necessary to market the crop before the lemons of District 1 and 2 appear, most lemons are stored after picking. Curing lemons through storage in a controlled atmosphere increases the juice content and allows the lemons to gain better color. It also allows for greater flexibility in marketing the fruit (Jamison, 1971, p. 259).

Acreage

Bearing acreage for the California-Arizona lemon industry in 1930 was approximately 40,000 acres. There was a steep rise in bearing acreage through the end of the Second World War as a result of the lack of removals during the war years when many groves were left untended. After 1945 bearing acreage dropped precipitously. Some planting took place in the early 1950s, but this did not offset the downward trend in nonbearing acreage that continued until the 1960s (Figure 2). At this time there were high levels of planting activities in all three districts. One impetus to the new plantings was the opening of the export market to Japan in 1964 (Heimpel, 1977). The industry reached a record high level of non-bearing acreage in 1974, while bearing acreage continued to climb until 1978 when it reached 76,423 acres. Due to conditions of oversupply, planting activity has declined since 1974. Other factors remaining equal, reduced planting should be reflected in a decline of bearing acreage in the next few years.

Bearing acreage in District 1 was low and rising slowly through the 1960s, reaching a maximum of 5.1 percent of total bearing acreage in 1960 (Table 1). Since 1969 bearing acreage has increased rapidly and was 12.8 percent of total bearing acreage in 1978. Non-bearing acreage (Figure 3) reached a peak in 1974, however, and has since declined rapidly.

In District 2, both bearing acreage and nonbearing acreage have declined substantially since the record high levels in the late 1950s when 55,000 acres were bearing lemons. Despite high levels of plantings in the late 1950s, bearing acreage declined rapidly until a

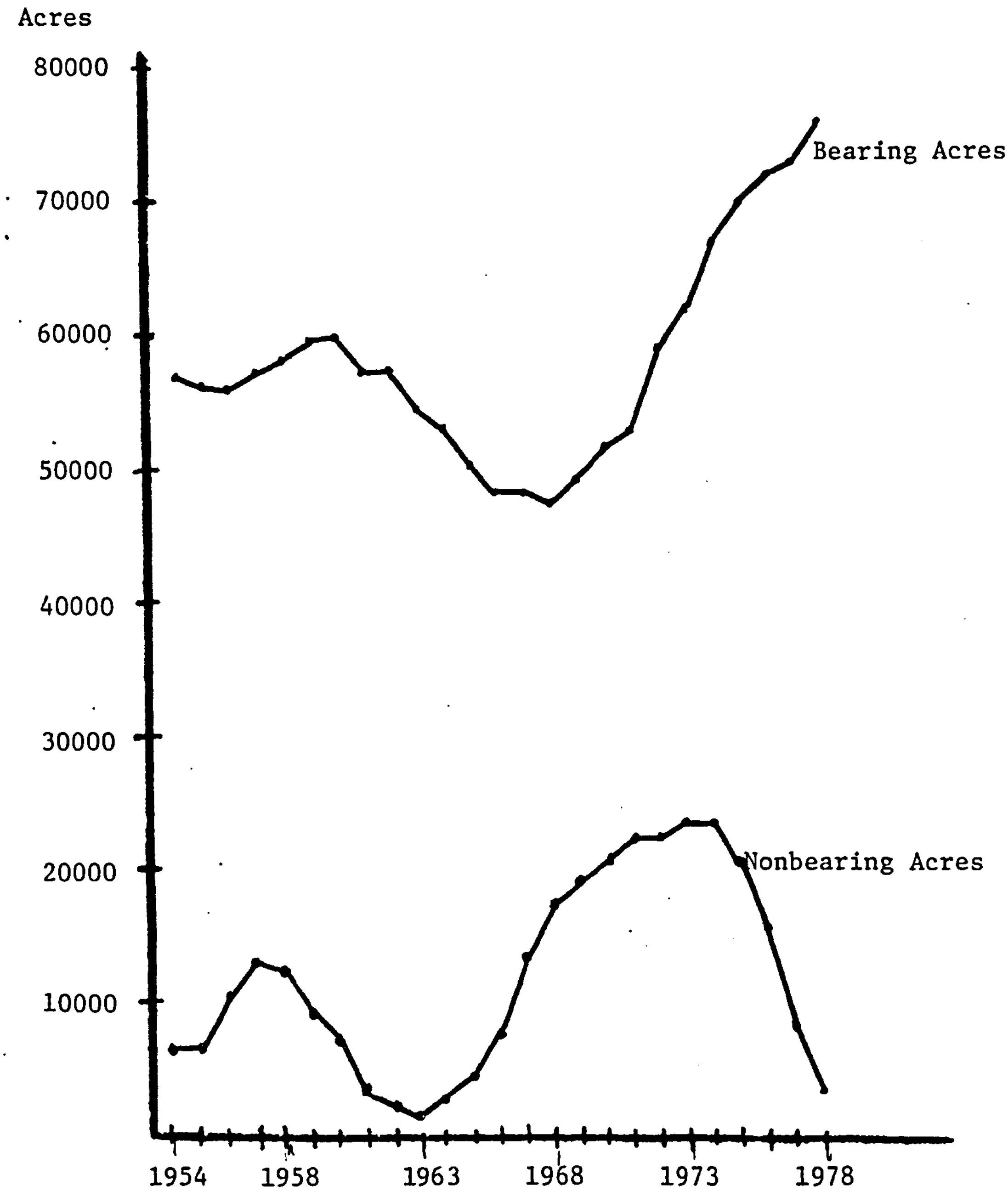

Figure 2. Bearing and Nonbearing Acreage of California-Arizona Lemons, 1954-1978

Sources: Appendix A, Tables A-1 and A-2.

Table 1. Bearing Acreage by District as a Percentage of Total Bearing Acreage

	% Total Bearing Acreage		
	District 1	District 2	District 3
1954	2.2	96.3	1.5
1955	2.3	96.2	1.5
1956	2.6	94.6	2.8
1957	2.5	94.3	3.1
1958	2.6	93.8	3.6
1959	2.8	90.5	6.7
1960	3.0	88.9	8.2
1961	3.0	87.3	9.7
1962	3.4	84.4	12.1
1963	3.4	84.1	12.5
1964	3.2	82.5	14.3
1965	3.5	81.6	14.9
1966	3.6	80.7	15.7
1967	4.1	79.9	16.0
1968	4.1	79.0	16.9
1969	5.1	73.6	21.3
1970	6.2	71.6	22.2
1971	6.8	70.3	22.9
1972	8.4	63.0	27.8
1973	8.2	62.8	28.9
1974	8.7	58.0	33.3
1975	10.2	56.2	33.9
1976	10.7	56.5	32.8
1977	12.9	49.2	37.6
1978	12.8	49.1	38.1

Source: Table A-1, Appendix A

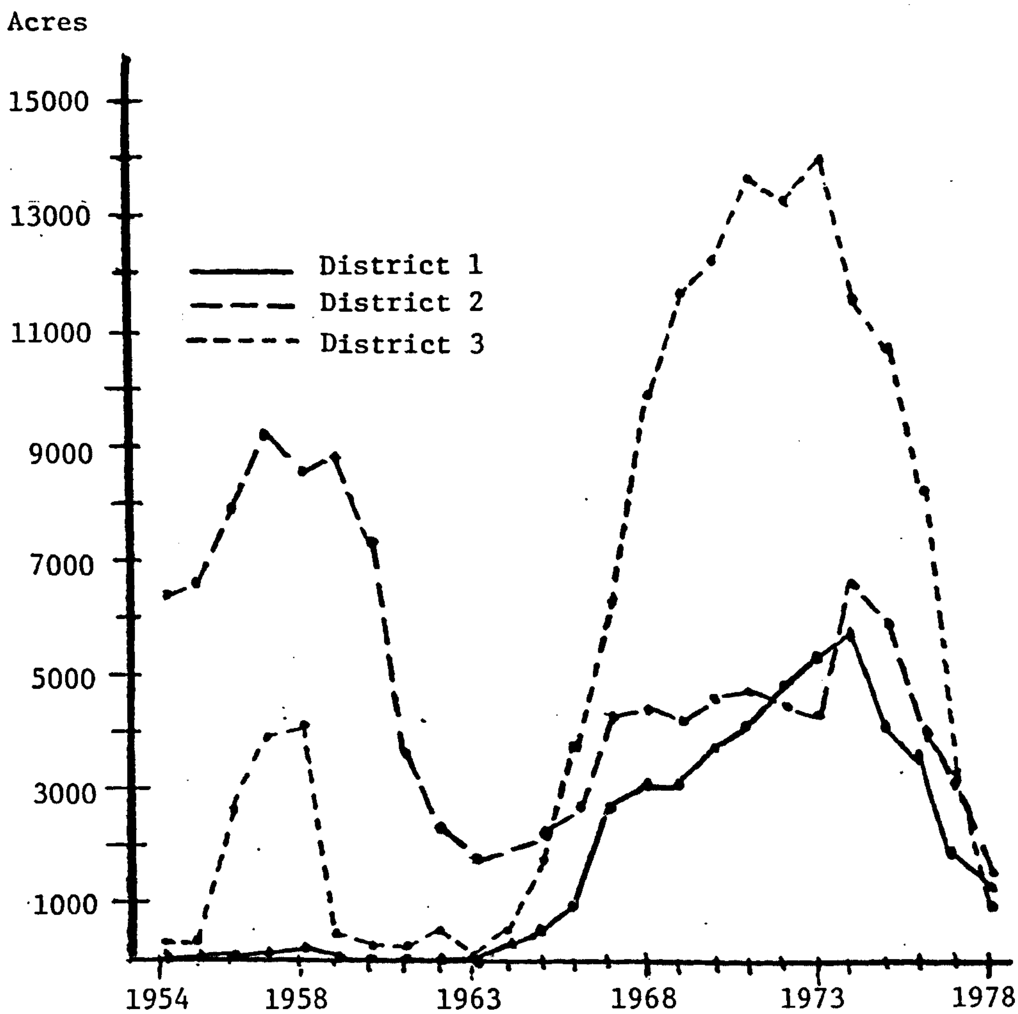

Figure 3. Nonbearing Average of California-Arizona Lemons by Districts, 1954-1978

Source: Table A-2, Appendix A.

low of 36,105 acres was reached in 1969. This was due in part to the rapid urban development occurring in the Los Angeles area and in part to poor returns. From 1966-1974, nonbearing acreage rose with a resulting rise in bearing acreage from 1970 to 1976. Since 1974, nonbearing acreage has dropped off due, at least in part, to the saturation of the export market to Japan. Acreage has been removed at more than normal rates since 1976 such that bearing acreage has declined more rapidly than would be expected from examining the figures for nonbearing acreage. This decline could reflect the resurgence of urban development in Southern California since the mid-seventies combined with the low prices since 1972.

The most dramatic increase in lemon acreage over the past 20 years has occurred in District 3. Commerical acreage was first planted in the mid-fifties. After a period of little planting, from 1959-1963, nonbearing acreage increased rapidly until 1973, when it reached a level of 14,033 acres. It has since fallen off and was very low (898 acres) in 1978. Bearing acreage increased after 1959 when it was 4,012 acres, 6.7 percent of the industry's bearing acreage. In the mid-sixties bearing acreage in District 3 leveled off at 7,500 acres, around 15 percent of total bearing acreage. Since the mid-sixties bearing acreage in District 3 has risen rapidly, reaching a high in 1978 of 29,092 acres, 38 percent of industry bearing acres.

Overall Districts 1 and 3 have risen from 2.2 percent and 1.5 percent of total bearing acreage in 1954, to 12.8 percent and 38.1 percent of total bearing acreage in 1978. This is due to the increased urbanization of District 2 accompanied by the strong demand due to increased exports to Japan. District 1 has been able to increase bearing acreage due to improved methods of freeze protection, while District 3 has benefitted from innovations both in freeze protection and irrigation.

Production

Production has trended upward from 1954 through 1978, but has not followed a smooth path (Figure 4). Because production may be expressed as bearing acreage times average yield, the variation in production will depend upon the variations in both yield and in bearing acreage. Causes of the variability in yield, and hence production, will be discussed in the section on yield.

Industry production has reached all-time high levels concurrent with the high levels of bearing acreage in the industry. With the low levels of industry nonbearing acres since 1976 it is expected that production will be constant or tend downward over the next 4-5 years, depending on removals.

In Districts 1 and 3 production has risen steadily since 1954. In both districts trend due to increased bearing acreage is emphasized as younger trees come into prime bearing age. In District 2 production has remained at the same level despite decreased bearing acreage. With accelerated removals of the older, less productive trees and little recent planting activity, most of the trees in this district are also in the maximum bearing-age group.

As late as 1963 District 2 accounted for 94 percent of total industry production with 84 percent of total bearing acreage. In 1978 District 2 accounted for only 58 percent of total production with 49

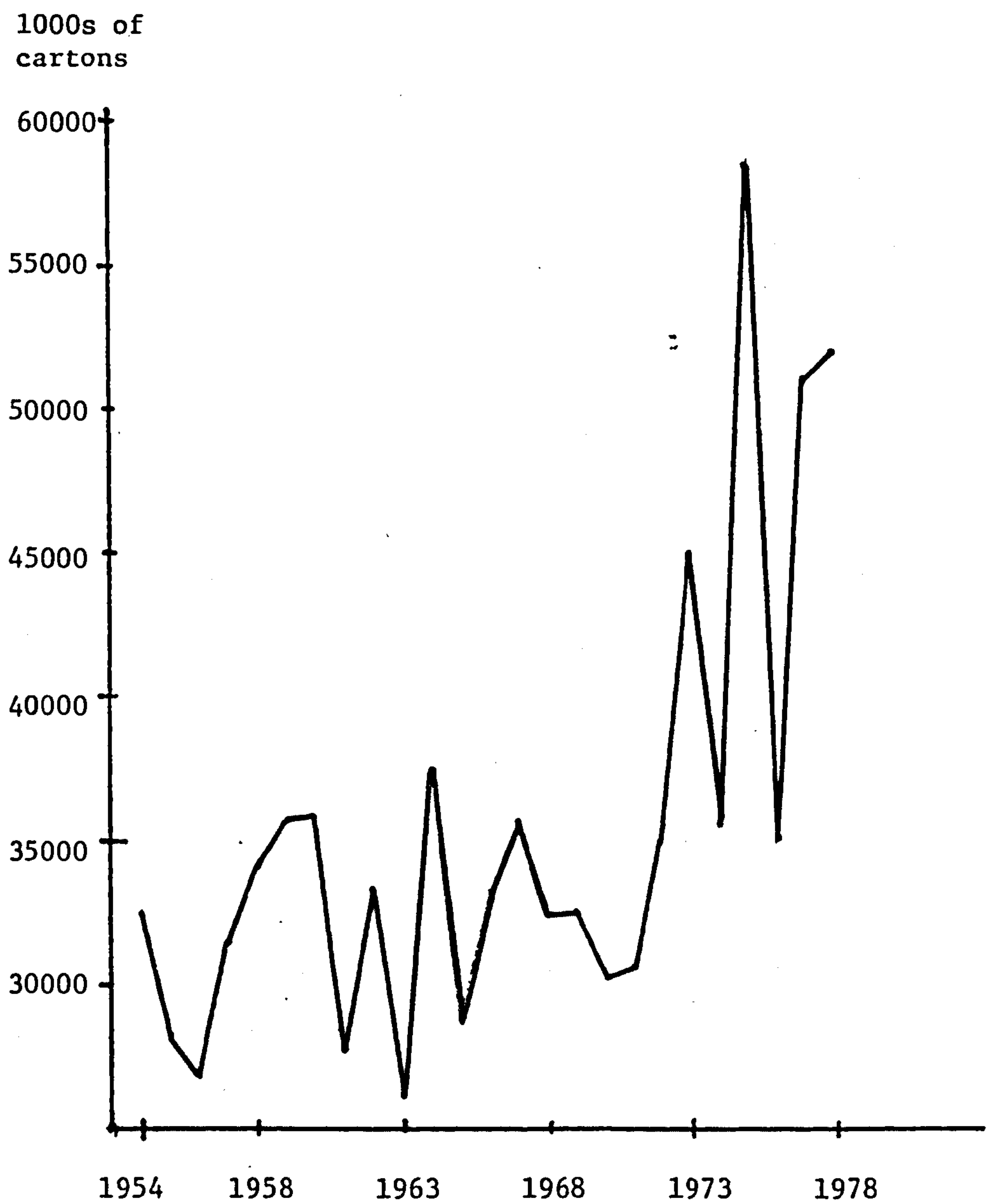

Figure 4. Production of California-Arizona Lemons by District, 1954-1978.

Source: Appendix A, Table A-3.

percent of total bearing acreage, while District 1 produced 11 percent of total production with 12 percent of the nonbearing acreage and District 3 reached 31 percent of production with 38 percent of bearing acreage.

Yield

Bearing acreage is characterized by rather smooth adjustments. Production, however, has not shown a propensity to follow the movements of bearing acreage. This discrepancy may be primarily attributed to two sorts of variation in yield at the district level.

The first determinant of yield is the age of the tree. In the aggregate, yield will be affected by the average age of the tree population. If few trees have been planted relative to the population of bearing trees, yield will be high while most of the trees are in the prime-bearing age and will begin to decline as the trees reach 20 years of age. Likewise, if there has been a very high level of planting the yield will be relatively low for the 5 to 10 years subsequent to planting.

The second set of determinants of yield are weather, disease, and a phenomenon of alternate-year bearing. These are primarily short run, usually affecting the season in which the phenomenon occurs. Some weather occurrences that may affect yield are extremely high temperatures occurring while the fruit is on the tree, which may result in sunburn; below freezing temperatures, especially if prolonged over several days causing a granulation and drying up of the pulp; heavy winds during the bloom, blowing the flowers from the trees; and insufficient moisture combined with high temperatures causing young fruit to drop during May, June, and July (known as "June drop"). Occasionally there will be periods during which a heavy crop and a light crop will alternate each season. Little is known, however, as to the causes, and there is no long-term regularity as to its occurrence. It is hypothesized by some to be biological and by others to be climatic.

At the industry level, shifts of bearing acreage from one district to another could cause changes in average yield in the long run. For instance, the shift in acreage from the prime growing District 2 to Districts 1 and 3 should cause the industry average yield to increase less quickly than the average yield for District 2. Since such shifts have become apparent in 1968, District 2 has had an annual rate increase in yield of 3 percent. During this same period (1968-1978) industry yield has shown no positive trend. Earlier (1955-1967) when most acreage was in District 2, industry yield increased at a rate of 2.4 percent per year, close to that of District 2, which was 2.7 percent per year. Conceivably, however, changes in average yield due to the different age distributions of the acreage in the three districts could account for the same results. Thus, the differential in the rates of increase in yield is a necessary, but not sufficient, condition for the proof of the effects of acreage shifts between districts.

In District 1, little acreage was planted during the early 1950s. Due to the maturation of the acreage planted in the early 1950s, it is expected that average yield would be higher from 1960 to 1968, after which the acreage planted from 1964 on would begin to lower the average. From 1960 to 1968 average yield in District 1 was 449 cartons per acre compared to 415 cartons per acre from 1969 through 1978. This is as expected despite an unusual number of extremely low yields due to inclement weather in the early 1960s.

In Distrct 2, nonbearing acreage has been very low since the period of heavy planting from 1955-1960. As the trees planted from 1955-60 reach maximum-bearing age from 1970 on, average yield is expected to be greater. Though obscured by the extreme variations in yield since 1971, the average yield in District 2 from 1970 to 1978, 749 cartons per acre, is higher than the yield for the nine previous years, 644 cartons per acre.

In District 3, where nonbearing acreage was low in the early to mid-sixties after heavy planting in the 1950s and where there was little acreage at all in the early 1950s yield is expected to be higher from 1963 to 1972 than before and after (when the high level of acreage planted from 1966 to 1972 began to bear). As expected the average yield per acre from 1963 to 1972, inclusive, was 538 cartons while that from 1973 to 1978 was 490 cartons, and that from 1955 to 1963 was 370 cartons.

In District 1 low average yields coincide quite closely with adverse weather conditions (Figure 5). It is especially noticeable in 1961, 1962, and 1963 when there were freeze conditions the first two years and a severe freeze the third year. Again in 1968 there were freeze conditions during the bloom. In 1969 the winter was cold and much damage was done by hail. In 1970 there was a freeze. In

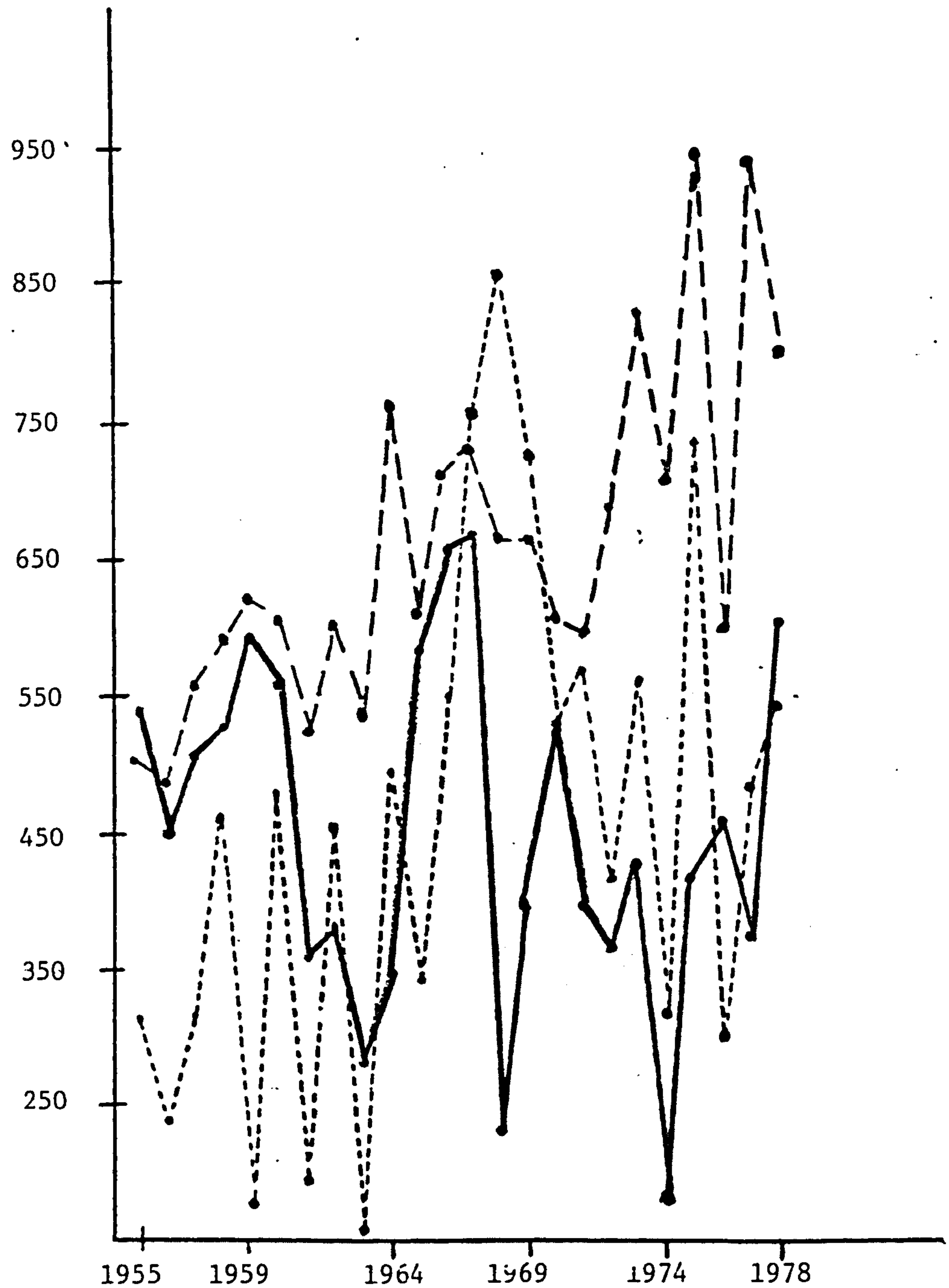

Figure 5. Average Yield per Acre of California-Arizona Lemons by District, 1955-1978

Source: Appendix A, Table A-4

1971 extremely high temperatures burned the fruit on the trees. In 1976 and 1977 District 1 again experienced freeze conditions.

In District 2 rainfall was low during critical periods of the 1956 season. There were freezes in the years 1961, 1962, 1963, 1968, 1969, and 1976. There were high winds in 1970 which caused a severe loss of blooms.

In District 3 the severe winters of 1961, 1962, and 1963 are evidenced by quite low average yields. A freeze occurred in 1965 and again in 1976.

Regarding the average yields for the three districts over the 24-year period District 2 consistently has a higher yield than the other two districts. The only exception is in 1968 when District 3 had an abnormally high yield and District 2 suffered from a freeze and adverse conditions during the bloom. Before 1968 District 3 had a lower level of yield than District 1. Since 1968 this relationship has reversed.

Variations in yield were compared by calculating the standard deviation of the percent deviation from trend in all three districts.[1] Trend, determined by regression analysis, was positive for Districts

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[1]The measure of comparison was σ_d where

$$d = \text{percent deviation from trend} = \frac{x_i - \hat{x}_i}{\hat{x}_i} \times 100$$

$$\sigma_d = \text{standard deviation of } d,$$

x_i is the actual value of x, and $\hat{x}$ = the estimated value of x. Where trend equals zero, $\hat{x}$ is equal to the mean of x and the formula is equivalent to that of the coefficient of variation.

2 and 3 and 0 for District 1. The standard deviations in yield are: 27.8 percent in District 1, 12.0 percent in District 2, and 36.3 percent in District 3. It seems likely that less favorable climatic conditions in Districts 1 and 3 would contribute greatly to such a pattern of variation in yield among districts.

Since output (Q) equals acreate (BA) times yield (Y), the percent change in output equals the percent change in acreage plus the percent change in yield. The percent change was calculated for both acreage and yield for the three districts and the industry, and the mean

$$(\%\ \Delta BA = \frac{BA_t - BA_{t-1}}{BA_{t-1}} \times 100) \qquad (\%\ \Delta Y = \frac{Y_t - Y_{t-1}}{Y_{t-1}} \times 100)$$

absolute percent change was calculated (Table 2). For all three districts and for the industry, the mean absolute percent change of yield is greater than the mean absolute percent change of bearing acreage. District 3 shows the greatest mean absolute percent change in both acreage and yield, while District 1, where weather conditions are more stable and acreage is at a higher level than in Districts 1 and 2, shows the lowest percent changes in both yield and acreage.

Table 2. Mean Absolute Percent Change in Acreage and Yields of Lemons, Districts 1, 2, 3, and Industry 1954-1978.

	Mean Absolute Percent	
	ΔBA	ΔY
District 1	11.4	31.4
District 2	3.3	16.4
District 3	18.9	59.4
Industry	3.3	17.1

It is seen that bearing acreage does not tend to oscillate greatly from year to year, and it is hypothesized that the variation in production may be ascribed primarily to yield. This hypothesis is tested by an analysis of the variance of output for the industry and the three districts. A technique discussed by Burt and Finley (1968) considers the proportions of the variance of a product directly associated with the component variables. Output (Q) may be defined by bearing acreate (BA) and yield (Y) in the identity $Q \equiv BA \times Y$. For this identity, the variance of Q is $\text{var}Q = A + B + C + D + F + G$

where

$$A = \overline{BA}^2 \text{ var } Y,$$

$$B = \overline{Y}^2 \text{ var } BA,$$

$$C = 2\overline{BA}\,\overline{Y} \text{ cov}(BA,Y),$$

$$D = E[(BA - \overline{BA})(Y-\overline{Y}) - \text{cov}(BA,Y)]^2,$$

$$F = 2\overline{BA}\, E[(BA - \overline{BA})(Y-\overline{Y})^2],$$

$$G = 2\overline{Y}\, E[(BA - \overline{BA})^2 (Y-\overline{Y})],$$

and

E is used to denote the expectation operator.

Burt and Finley (1968) asserted that the last three terms are unimportant and that consideration only need be given to the first three first-order terms. They propose that the proportionate influence of $Y(P_Y)$ be represented by $A/(A+B)$, the proportionate influence of $BA(P_{BA})$ be represented by $B/(A+B)$, and the interaction of acreage and yield ($P_{BA,Y}$) be represented by C/(A+B). Upon criticism from Goldberger (1970), Burt and Finley (1970) admitted that the higher order terms could have significant effects on the total variance of output and that it was advisable to make the complete computation of the variance for the product of two variables. However, A/(A+B) and B/(A+B) still give a means of comparing the direct effects of bearing acreage and yield on the variance of output.

Where trends are present in the data series, Burt and Finley (1968) recommended that the trends be removed before calculating the appropriate variances and covariances. Trends for lemons, as determined by regression analysis, were significant for all series except District 1 yield. The trends were eliminated by using the variance of the residuals of Y and BA. Because of the presence of trends in the data, $\overline{BA}$ and $\overline{Y}$ must be represented by a point on the trend line. In the course of the analyses, it was found that the variances of yield and bearing acreage are not constant, as is assumed by Burt and Finley (1968). To eliminate this problem, the data series were divided into two periods: 1954 to 1966 and 1967 to 1978. The values of the last year in each period were used in the calculations of the proportionate influences of bearing acreage and yield (Table 3). For the three districts and the industry, the proportionate influence of yield on the variance of output is much greater than the proportionate influence of bearing acreage. The importance of yield in determining the variance of output ranges from 24 to 99 times the importance of acreage in determining the variance of output.

Table 3. The Direct Effects and the Relative Importance of Lemon Acreage and Yield on the Variance of Output

	1954-1966			1967-1978		
	% Direct Effect		Relative Importance	% Direct Effect		Relative Importance
	P_Y	P_{BA}	$P_Y:P_{BA}$	P_Y	P_{BA}	$P_Y:P_{BA}$
District 1	97	3	32.3:1	99	1	99:1
District 2	97	3	32.3:1	96	4	24:1
District 3	97	3	32.3:1	99	1	99:1
Industry	96	4	24:1	97	3	32.3:1

Utilization

There are three general markets for California-Arizona lemons: products, fresh domestic, and fresh export (Figure 6 and Appendix Table A-5). The fresh domestic market comprises lemons sold fresh in the U.S. and Canadian markets. Since the early 1950s there has been a slight, though steady, decline both in actual quantities entering the fresh domestic market[1] and in quantities entering the market as a percentage of total production. The quantity marketed averaged 14,135 thousand cartons for the years 1955-1956, or an average of 45.4 percent of total output for those years. For the years 1967-78 an

[1]Least-squares regression analyses were run, with quantities entering the three markets as the regressands and time as the regressor, to test for trend. The quantity entering the fresh domestic market exhibited a negative trend. Trends for quantities entering both the export market and the products market were positive.

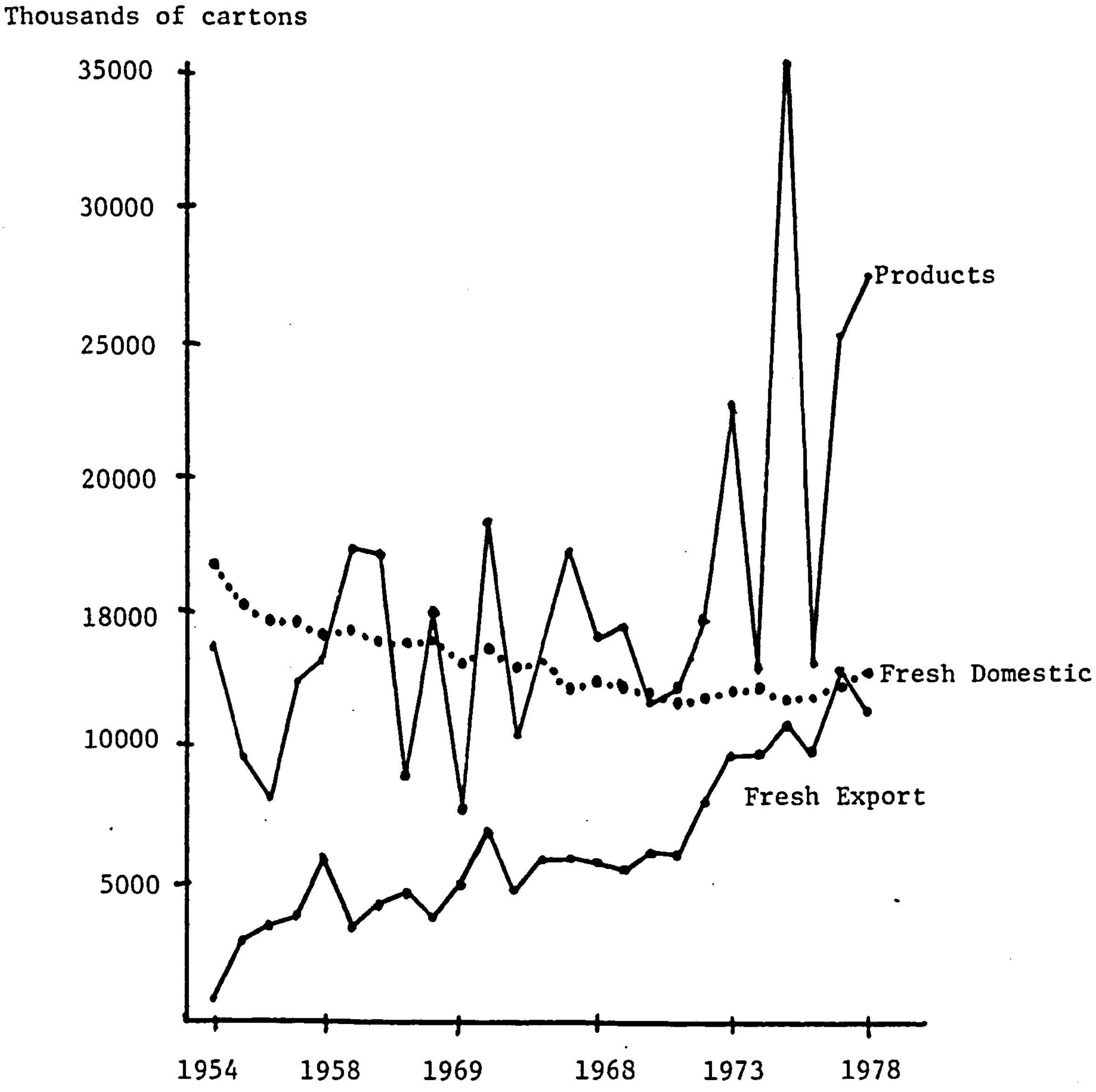

Figure 6. Quantity of California-Arizona Lemons Marketed as Products, Fresh Domestic, and Fresh Export, 1954-1978

Source: Appendix A, Table A-5.

average of 12,287 thousand cartons entered the fresh domestic market, 32.5 percent of total production. It is this quantity that is controlled by the LMO.

The quantity of lemons entering the export market remained fairly constant from 1955 to 1965, averaging 4,354 thousand cartons, or 14 percent of annual production for that period. From 1964 to 1974 exports to Japan increased at an annual rate of 19 percent, resulting in an annual rate of growth of 6.5 percent for all exports during that period. From 1974 to 1978 exports averaged 11,064 thousand cartons, 24.5 percent of the output for that period.

Fruit that does not meet the standards for the fresh domestic or export market are diverted to the products market. However, there are quite often quantities of fresh quality fruit that go to the products market along with the low-quality fruit. Profitability in the export and domestic markets appears to determine the quantity diverted to the products market. For example, despite the huge crop of the 1975 season, there was a slight decrease in fresh domestic shipments and only a modest increase in export sales. As a result, a large quantity of fruit was diverted to the processors (Figure 6).

The primary products derived from lemons are concentrated lemon juice, lemon oil, peel, pectin, and lemonade. Due to the residual nature of the products market, the quantity entering this market has tended to fluctuate more than the quantity entering either the fresh domestic or export markets. Overall, however, the quantities entering the products market have been increasing over time. The quantity of products as a percentage of total output has also been increasing.

There has been an exceptionally large increase in the percentage going to the products market in recent years. From 1955 to 1966 the quantity entering the products market was 12,779 thousand cartons, or 39.7 percent of the total output for these years. From 1967 to 1978 an average of 18,594 thousand cartons, or 45.7 percent of the total output for that period, entered the processing market. This may partially be explained by the increase in bearing acreage resulting from the plantings that were undertaken upon the liberalization of the Japanese market for lemons. The resulting increase in production has outstripped the capacity of the new market to absorb additional imports.

Costs and Prices

Cultural costs are the costs of labor, materials, fuel, and equipment used in producing the crop, especially in fertilization, irrigation, pest and disease control, weed control and cultivation, pruning, and frost protection. These costs tend to be high when output is low. Since low levels of production are often the result of harsh winters, dry seasons, or pest problems and these problems are expensive to counteract, the correlation is not unexpected.

However, prices tend to fluctuate much more than costs (Appendix A, Table A-6). For the years 1954-1973 the coefficient of variation for cultural costs is 14 percent. During the same period the percent deviation from trend of the price of lemons is 25 percent.

It is observed that growers experienced higher real net revenues in the early 1950s and late 1960s-early 1970s while the rel net revenues in the late 1950s and early 1960s were quite low. In fact, real net revenues for the years 1959 through 1962 were close to zero or negative.

CHAPTER 3

THEORETICAL MODELS OF SUPPLY RESPONSE

In attempting to model supply response for an agricultural activity, the researcher has the option of developing a model utilizing aggregate-level variables or micro-level variables (Tomek and Robinson, 1977, pp. 351-65; Jensen, 1977, p. 41). We shall refer to these options as the "aggregated approach" and the "disaggregated approach."

In the disaggregard approach, the set of decision variables must be specific for the supply function for each firm or group of similar firms. Thus $Q_{it} = F_i(X_{it})$ where Q_{it} is the quantity produced by firm i in time t and X_{it} is the vector of appropriate exogeneous and decision variables for firm i in time t. Once all firm supply functions have been specified, a value for total output for each firm at time t, Q_{it} may be determined by substituting actual values for the independent variables in the supply function. Summing the firm outputs at time t yields industry output at time t: $Q_t = \Sigma Q_{it}$. This method has the advantage of accounting for all the variations in decision-making affecting supply. However, there is a problem in specifying the decision variables for each firm. Data are not usually available in such detail, and the cost of determining the supply response function for each firm would be great, given that there are several thousand citrus producers in California and Arizona. For these reasons, the disaggregated approach will not be used in this study.

The aggregated approach develops a supply response function that deals with aggregate level variables. There are two possible theoretical foundations for a model developed by this approach: macro- and micro-foundations. In the macro-model, aggregate supply response is analyzed directly in light of the appropriate aggregate level variables; $Q_t = g(x_t)$ where Q_t is total supply in t and x_t is the set of appropriate aggregate-level variables in time t. In essence, this approach treats the industry as one large producer and attempts to determine factors to which the industry responds in determining aggregate supply. This approach is appealing in that it uses more readily available data and assumes that the industry will tend to have a more consistent response to economic variables than will a model attempting to represent each individual producer. This assumption is made in light of the multiplicity of motivation at the individual level, which may not be significant in the aggregate. One problem of this approach is that the influence of certain variables may be indeterminate at the aggregate level yet significant at the grower level. For example, several years of low prices may cause growers with small acreages to sell their groves or at least not to expand due to cash-flow problems. In the same situation outside investors might buy into the industry due to low grove values if they believe prices will rise again. This would create problems in using low prices to reflect cash flow at the aggregate level in that its influence may not be demonstrable due to the negligible net influences on acreage.

It is also possible to arrive at an aggregate level model through analysis of the micro-foundations of aggregate level supply response. This model draws heavily upon behavioral information common to the disaggregated approach. A form is chosen based on behavior assumed to be common to all producing firms:

$$Q_t = g(x_t)$$

where

$$Q_t = \Sigma Q_{it}$$

$$x_t = \Sigma x_{it}.$$

The values Q_{it} and x_{it} are only implicit and are not observable at the aggregate level. The validity of this approach depends on the degree to which the assumption of common decision variables among firms is justified. The problem of a discernible net influence of variables due to differing behavior among firms, as noted above, is also present in this approach.

In the following section several attempts to develop aggregate supply response models are reviewed. Then, models of aggregate supply response are developed according to each of the two possible foundations of the aggregated approach. First, an attempt is made to explain the behavior of producers as a group, starting with certain assumptions about individual producer behavior (the micro-foundation approach). Next, looking directly at aggregate level supply response, an attempt is made to isolate variables consistent with economic theory and significant at the aggregate level (the macro-foundations approach).

Previous Work

There is a vast literature on supply response (Tomek and Robinson, 1977; Dillon, 1977). However, much of this literature is concerned with annual crop response. The difference in supply response specification for annuals and perennials is important: (1) there is a gestation period for perennial crops which causes a lag from initial input to first output; (2) the initial investment decision for a perennial crop results in an extended period of output; and (3) eventually there is a gradual deterioration of the productive capacity of the perennial plant (French and Matthews, 1971). "The planting of a perennial is very much like the acquisition of a piece of capital" (Askari and Cummings, 1976, p. 219). Consequently, only work with perennials, primarily citrus, is examined in this section.

Within the context of the various approaches to supply response analysis described in the previous section, supply response may be examined in the short run or long run. That is, one may examine in-season supply response, where the stock of trees is fixed but where cultural practices may be adjusted, or one may examine the adjustment process where all inputs, including the stock of trees, are variable. The latter approach is the concern of this study.

All of the studies to be discussed used the aggregated approach. French and Bressler (1962) formulated hypotheses directly from the aggregate-level situation; Rausser (1971), French and Matthews (1971), and Matthews, Womack, and Huang (1974) used the micro-foundations approach beginning with a detailed analysis of grower response.

French and Bressler (1962) developed a model that illustrated the presence of cyclical variations in lemon production which could be examined by the cobweb theory. They used an identity for bearing acreage and equations for plantings and removals. Plantings, expressed as a percentage of bearing acres in the previous year, were specified as a function of expected long-run profitability of lemons, interpreted to be a 5-year average of past net returns per acre. Due to lack of data, removals were estimated at 4.5 percent of bearing acres per year. A trend for yield was determined in the model to obtain estimates of total production. Although the results closely followed past production figures, the projections of production proved to be extremely inaccurate. This study faced at least two major difficulties. First, data on removals, a major determinant of the age structure of the tree population and of bearing acreage, were not complete. Second, structural change occurred in the form of a rapid increase of exports to Japan in the 1960s due to changes in trade policy (Heimpel, 1977). The resulting surge of planting led to production levels far above the predictions of the French and Bressler (1962) model.

The present attempts to model supply response in the lemon industry will face problems similar to those faced by French and

Bressler. Data on removals, plantings, and age structure are not available.

Shifts in demand and supply due to technological and institutional change are generally unforeseeable, thus limiting the predictive capacility of most supply response models. Care must be taken to define the period under study such that structural changes are either excluded or accounted for by appropriate variables. Askari and Cummings (1976) suggest a limit of 25-30 years on supply-response time-series data to avoid these problems. Due to the unforeseeable nature of structural change, projections should be limited to 5 or at most 10 years.

French and Matthews (1971) developed a detailed model of perennial crop production response. A generalized model with five components considered plantings, removals, variation in yield, and various actual and expected economic relationships as determining a desired level of bearing acreage and total production. For any given crop, certain variables may be excluded as insignificant or for lack of data. The authors applied their model to asparagus. In the empirical model, expected profitability was approximated by a 2-year average of the ratio of grower prices to an index of farm wages. This measure was found superior to more complicated formulations including a variation of Nerlove's adaptive expectations model. The plantings variable was deleted, as was that for nonbearing acres, because of lack of data. Removals were estimated to be a constant proportion of the average of the five most recent years of bearing acreage. Expected profits for alternative crops were not included in the empirical model, although they were in the theoretical model. A reduced form equation explaining year-to-year changes in acreage was estimated with expected profits, harvested acreage, and a policy variable to reflect the availability of foreign labor under the Bracero law. The emphasis of the model was on the rational behavior or the grower and of the industry. Producers were assumed to have the same production function, to face similar risks, and to maximize profits.

Rausser (1971) developed a complete model of demand, supply, and allocation for the California-Arizona orange industry. Regional (the three prorate districts) and varietal (navel and valencia) dimensions were treated in his study. The supply model consisted of identities for both output and bearing acreage and behavioral equations for plantings, removals, and yield. The model was applied to navel and valencia oranges for each of the three districts. Navels and valencias were considered alternative crops for each other. Grapes were considered the only other alternative crop for District 1, while lemons and avocados were competitive with oranges in District 2. The two investment equations (plantings and removals) included a risk variable that jointly measured the influence of taxes, total revenues per acre for oranges and the alternative crop, and the variances of these total revenues. Expected profits were expressed as moving averages of past values of prices and yields and were included in the plantings and removal equations, as was a variable for trees over 25 years old. The removal equations also included a variable for freezes and urban development. Yield was explained by various weather and tree-age variables, as well as price variables.

The results of Rausser's (1971) study are interesting in that his was the only one of the studies examined to have most of the data required for estimation of the model. A major problem for Rausser was the lack of data for District 3, such that plantings, removals, and bearing acreage could not be estimated. The results of the removal equations for the other districts were poor. This was due perhaps to the dual role of revenue in influencing removals. High revenues could be associated with a decreased rate of removals if the grower attempts to maximize short-run income. Conversely, the higher revenues could be associated with increased rates of removal stimulated by the intention to replace the removed acreage if high revenues are expected to continue or if they create a favorable cash-flow situation for the grower.

The supply response portion of Rausser's model in combination with the demand and marketing order decision components allows for an industry-wide equilibrium solution, although an empirical solution was not attempted.

The study of the U.S. orange economy by Matthews, Womak, and Huang (1974) relied heavily on the French and Matthews (1971) model. Output was specified as an identity equal to the product of bearing acreage and yield, while bearing acreage was expressed as a behavioral equation. Yield values were estimated by computer dimulation.

Matthews et al. (1974) developed acreage equations for Florida and Central and Southern California. For Florida, the independent variables included a distributed lag of the ratio of the price of Florida oranges to grower's cost, a trend variable, a weather dummy, and another dummy which was left unexplained. The equation for Central California included the ratio of prices to cost lagged 7 years, the ratio of the land bank interst rate to the value of farm real estate lagged 7 years, and a variable measuring low temperature.

The Southern California acreage equation contains the price to cost ratio lagged 4 years and bearing acreage lagged 1 year. Initial trials of the model led to poor forecast results. Acreage was then fixed at 75,000 acres for the projection period to improve the forecasts. This assumption proved extremely unrealistic.

The supply equations estimated by Matthews et al. (1974) were combined sequentially with a set of demand equations to create a dynamic forecasting model of the orange industry. The authors justified the form of the model by the accuracy of the predictions for a verification period (1968-69 to 1972-73), and the high values of the coefficients of multiple determination (R^2) of the supply and demand equations. However, this author would feel more comfortable with the results of the supply model if the inclusion and exclusion of certain variables in the theoretical and empirical models were more carefully explained.

The relative virtues of the two forms of the aggregated approach seems to depend more on the availability of accurate data than on any virtue inherent in either form. Although the micro-foundation approach considers behavior of the individual it would be deceptive to believe that it represents the individual producer in any but an absolutely homogeneous industry. Its advantage over the macro-model is the extent to which it explicitly incorporates the researcher's knowledge into the model through the analysis of behavior. In the macro-model the researcher's behavioral assumptions are present only implicitly. The advantage of the macro-model is thus its flexibility, but it is only as successful as its empirical accuracy.

In view of the importance of expected values in the formulation of supply models, a discussion of expected values is appropriate at this point. Expected values, as estimates of future values, imply uncertainty. A brief discussion of risk will follow that of expected values.

Expected Values and Risk

In making decisions that will determine future production levels, the producer is assumed to form expectations as to future yield, prices, and structural stability within his economic environment. The formulation of these expectations is critical in modeling all supply response. However, whereas planning for the production of annual crops must take account of one year's price and yield, the producer of a perennial crop must anticipate prices and yields over a much longer period. There is a substantial investment incurred at the time of planting with returns foregone until the plant attains bearing age. The period during which the tree bears often surpasses 30 years. Alternative investments must also be considered for this time period.

Various formulations of expected value have been developed by researchers. Almost all assume that the producer will base his future expectations upon historical values of the parameter. Formulations generally differ in their assumptions concerning the length of the lag taken into account, the relative weights given to the near past and distant past, and the weight given to the variation in these values. For example, Behrman (1968) used a distributed lag model and incorporated a 3-year moving average of the standard deviation of price and yield to represent risk. Other studies (Just, 1974; Traill, 1976) have developed mathematically more sophisticated models of expectations, but the ultimate choice of measures seems to rest on the goodness of fit of their empirical estimation of the model to the facts. Given the varieties of information available to producers and the complicated decisions to be made, it is likely that most formulations of expected values will remain proxies used in an "as if" manner. If researchers are able to keep in mind the extent to which they are not describing actual behavior, this should not pose a problem to research.

Most agricultural production takes place under uncertainty; that is, production occurs while the prices to be received and environmental conditions, and hence output, are still unknown. The combination of these uncertainties with those parameters known with certainty will determine the grower's attempted level of production. While attitudes about risk have been examined through interviews, experimentation, and observation, it is the average risk that is of relevance to a model of aggregate supply response.

As explained by Young et al. (1979, p. 2), risk may be represented in two ways: "(1) measures of dispersion such as variance or standard deviation; and (2) "chance of loss" or the probability (α) that random net income (π) will fall below some critical or "disaster" level (d); formally, Pr ($\pi \leq d$) = α."

Measure (1) is derived from the expected utility maximization hypothesis. This measure has been widely used in modeling risk because it requires readily available data series and is able to be incorporated into aggregate level models.

Measure (2) is derived from the behavioral assumption that an individual attempts to avoid his perceived disaster level. Although more difficult to assess, the disaster level is individual specific and could be incorporated into a disaggregated model of supply response.

Aggregate Approach: Micro-foundations Model

Lemon output may be described by the identity

$$Q_t \equiv BA_t \bar{Y}_t \qquad (3\text{-}1)$$

where

Q_t is output in season t

$\bar{Y}_t$ is average yield in season t

BA_t is bearing acreage in season t.

Yield

As discussed in Chapter 2, yield has both short-run and long-run determinants. In the long run it is the age distribution of the trees and technology that determine yield. In the short run yield is affected by weather, disease, and other environmental factors. Thus, for a given season t,

$$\bar{Y}_t = f(a_t, T_t, W_t, C_t, D_t) \qquad (3\text{-}2)$$

where

A = age distribution of the tree population

T = level of technology employed

W = weather variable

C = set of cultural practices within the season

D = disease variable.

Some of these factors, such as weather or cultural practices, may have effects which carry over into the following season. It is assumed that in any one season the grower will be knowledgeable of the age distribution of his trees of bearing age and will have an expected value, $\bar{Y}_t$, for the average yield in that season given a fixed level of technology. It is assumed that it is possible for him to project his knowledge concerning age distribution into the future to determine an expected value of average yield, thus accounting for presently nonbearing acreage. From this an expected average yield $\bar{Y}_t$ may be inferred from which variations are determined exogenously by such factors as weather and disease.

Bearing Acreage

Bearing acreage may be explained by the investment activities that determine the changes in productive capacity over time. The identity representing this relationship is:

$$BA_t \equiv BA_{t-1} + P_{t-4} - R_{t-1} \tag{3-3}$$

where P_{t-4} are the acres planted in season t-4, which become bearing acreage in season t, assuming a gestation period of 4 years, and R_{t-1} are the removals of bearing acreage in the season t-1. It is assumed that no nonbearing acreage is removed.

Plantings. Acreage planted to lemons during season t will become bearing acreage in season t+4. The grower is faced with the decision to plant in season t-1 when he must prepare the ground and order trees for actual planting in season t. Any acreage planted in seasons t-4, t-3, t-2, t-1 will become bearing acreage as of seasons t, t+1, t+2, and t+3, respectively, and must be considered in anticipating the level of bearing acreage in season t+4. The plantings in these four seasons together make up the nonbearing acreage in season t-1.

Given the long productive life of the trees, the grower must be confident that his investment will be profitable over an acceptable portion of the life of the tree, that is, that the expected long-run profits will be high relative to alternative investment of capital. Alternative investments include financial investment and the cultivation of crops other than lemons. The most suitable alternative crops are other citrus because the costs, management skills, and infrastructure required are much the same for all citrus.

Government policy such as tax regulations may also serve to encourage or discourage planting. The Tax Reform Act of 1976 requires that growers must "capitalize the costs of planting, cultivating, maintaining, and developing a grove . . . which are incurred prior to the year the grove . . . becomes productive" whereas "growers of citrus . . . have previously been required to capitalize [only] their development expense incurred within 4 years of planting" (Sisson, 1976, p. 11). This change in legislation could lead to less plantings.

It is conceivable that an indicator such as the rate of inflation is taken into account by growers. If inflation is high, investment in land is generally very safe, and, in the United States, very profitable. Land speculation implies that there will be much transfer of land ownership. However, it is assumed here that this speculation will be distributed across other agricultural land as well. Thus, the level of activity in the lemon industry relative to other agricultural activities will not be due to the rate of inflation and the resulting desire to hold land but to its profitability relative to other activities.

Some planting may be for purposes of replacement. For instance, planting may be accelerated in one region to compensate for the loss of acreage due to urban expansion in another. District 3 has exhibited such a response to urban expansion within District 2. However, any plantings, whether new or replacement, should be captured by the economic variables, which will already reflect the situation resulting from removals.

Although all factors considered by the grower may indicate that he should plant new acreage, he will not do so unless he has the money to pay for the trees, leveling of fields, planting, and other related expenses. Any problems with cash flow are thus likely to adversely affect the level of plantings.

Since expected profits and interest rates cannot be known with certainty some measure of risk must be included. The equation for plantings in year t is:

$$P_t = f(p_t^1, pa_t^1, NA_{t-1}, D3_t, i_t, X_t, K_t, \qquad (3-4)$$

where

P_t = plantings, season t

P_t^1 = long-run expected profits of lemons

Pa_t^1 = long-run expected profit of oranges, the alternative citrus crop most extensively grown in this region

NA_{t-1} = the nonbearing acreage of the previous season

$D3_t$ = dummy representing the tax change of 1976 where 1954 through 1975 = 0 and 1976 through 1978 = 1

i_t = expected rate on possible investments throughout the expected production life of the trees planted

X_t = risk

K_t = cash flow

It is expected that p_t^1, and K_t will have positive coefficients while pa_t^1, NA_{t-1}, X_t, $D3_t$ and i_t will have negative coefficients.

Removals. The primary factors determining removals are the death of trees due to disease and freeze damage, a lower level of yield due to age of the trees, and economic factors. Urban expansion such as that occurring around Los Angeles since World War II and, to a lesser degree, around Phoenix in the last decade will increase removals. The effect of urban expansion upon removals is direct, unlike its effect upon plantings, and is included as an explanatory variable.

If alternate crops appear more profitable than lemons over a long enough period to warrant the loss of lemon production, removals will increase. It is assumed that short-run expected profits for other crops will not affect removals.

Removals will be reduced when short-run expected profits for lemons are high. Removals, with the intention of replacement, should increase when long-run expected profits are high. It is hypothesized that with the concurrence of high short-run and high long-run profits for lemons, new acreage will be brought into the industry and removals will be postponed.

As with the plantings equation, the deviation from expected values must be accounted for by some measure of risk. The equation for removals is:

$$R_t = f(D1_t, D2_t, A_t^0, U_t, X_t, p_t^1, p_1^s, pa_t^1) \qquad (3\text{-}5)$$

where

R_t = removals in season t

$D1_t$ = dummy representing severe freeze (1 = severe freeze, 0 = other years)

$D2_t$ = dummy, severe disease or insect infestation (1 = severe, 0 = other years)

A_t^0 = acreage 25 years or older

U_t = urban expansion

p_t^s = short-run expected profit of California-Arizona lemons

X_t = risk

p_t^1 = long-run expected profits of California-Arizona lemons

pa_t^1 = long-run expected profits of California-Arizona oranges.

It is expected that the coefficients for all variables except p_t^s will be positive.

The micro-foundation model can now be represented by Equations (3-1) through (3-5):

$$Q_t \equiv BA_t\bar{Y}_t$$

$$\bar{Y}_t = f(A_t, W_t, T_t, C_t, D_t)$$

$$BA_t \equiv BA_{t-1} + P_{t-4} - R_{t-1}$$

$$P_t = f(p_t^1, pa_t, NA_{t-1}, D3, i_t, K_t, X_t)$$

$$R_t = f(D1_t, D2_t, A_t^0, U_t, p_t^1, p_t^s, pa_t^1, X_t)$$

There are four expectation variables which are not observed: i, p^1, pa^1, p^s. Alternative hypotheses which relate the expectations to observable variables will be discussed in Chapter 4 when the empirical model is presented.

Variables such as i, p^1, pa^1, p^s, and Y_t have stochastic elements to them. That is, there is an element of risk, namely in expected prices and yields.

Aggregate Approach: Macro-model

As in the micro-foundation model, the macro-model begins with the identity:

$$Q_t \equiv BA_t \bar{Y}_t \tag{3-6}$$

where

Q_t = total output in season t

BA_t = bearing acreage in season t

$\bar{Y}_t$ = average yield in season t.

At the aggregate level, yield is a function of the age distribution of the tree population (A), the level of technology (T), and a variable representing adverse weather conditions and disease (W). It is assumed that there is an average level of inputs based on the current level of technology. This assumption is supported by Rausser (1971, pp. 106-123) for the case of California-Arizona oranges. Thus:

$$\bar{Y}_t = f(t, W_t) \tag{3-7}$$

where t is trend and is expected to capture some of the variation in yield due to the age distribution and the level of technology, and W is a variable representing adverse weather conditions and disease.

To allow for as great a statistical validity as possible the model must contain independent variables that together will attain a high degree of explanation of the variation in bearing acreage while not using up the limited degrees of freedom available. In the long run, the level of bearing acreage and hence the production of lemons will depend on the expected long-run profit of lemons relative to the expected long-run profits of alternative activities:

$$BA_t = f(p_t^1, pa_t^1) \qquad (3\text{-}8)$$

where

p_t^1 = expected long-run profits of California-Arizona lemons

pa_t^1 = expected long-run profits of alternative activities.

As both independent variables in this function are expected values, and hence unobservable, proxies must be chosen if the equation is to be estimated. As seen in previous studies, proxies for expected variables are often lagged. Given the stated objectives of predicting bearing acreage, variables lagged several years are highly desirable. A list of possible proxies will be presented along with the final estimated equation in Chapter 4.

CHAPTER 4

EMPIRICAL ESTIMATES AND PROJECTIONS

Two models of supply response were developed in Chapter 3. Estimates of both models were made using ordinary least-squares regression analysis. It was necessary to estimate the micro-model by a reduced-form equation. Even in this form, however, much of the required data was unavailable. The shortness of the period under study combined with the large number of variables in the reduced-form equation left few degrees of freedom and caused the results to be inconclusive.

The macro-model avoided the problems of the micro-model by limiting the number of variables in the estimated equations and by choosing variables for which data were known to be available.

The Data Set

The data for this study came primarily from the Citrus Fruit Industry Statistical Bulletin of Sunkist Growers, Inc., and the Annual Report of the LAC. Seasons are referred to by the year in which they terminate. Data series for the period 1954-1978 were complete for the following variables; production for the industry and the districts; quantities entering each of the three markets; on-tree prices for fresh fruit and processed fruit; the blend price received for the season; per capita consumption of lemons. All prices (Appendix A, Tables A-6 and A-7) were deflated by the implicit price deflator, 1972 = 100 (USDA, 1979). All quantities of lemons were converted to the standard 38-pound carton. Quantities of oranges (Appendix A, Table A-7) are expressed in 37.5-pound cartons. Data for orange acreage (Appendix A, Table A-7) came from the 1979 Annual Report of the Valencia Orange Administrative Committee and the 1978 Annual Report of the Navel Orange Administrative Committee.

The ability to estimate the coefficients of the micro-model was severely restricted by the lack of much necessary data. There were no series of data for plantings and removals that could be used for the California-Arizona lemon industry. California does publish data on plantings for each season as well as data on the number of trees that have survived from earlier plantings (California Crop and Livestock Reporting Service, 1954-1979). It was thought that an adequate series for age distribution, plantings, and removals could be derived for California from these data; however, the series was so inconsistent as to be unacceptable (Appendix B).

In attempting to denote urban expansion for the five-county Los Angeles area, several alternatives were considered: cropped acreage, population, and housing starts. Complete series for any one of the possible proxies were not available for the period under consideration.

No series was found for either disease or insect infestation.

For the weather variables, a series was spliced together (Appendix A, Table A-4) from several sources (Rock, 1970; Sunkist Growers, Inc., 1961-1978; Rausser, 1971; Lemon Administrative

Committee, 1955-1978). The decision to label a particular season as adverse or normal was based on the information gathered from the different sources.

Cultural costs per acre were incomplete for the period under study (Appendix A, Table A-6). The study was thus limited to the use of total revenues per acre where net revenue per acre may have been more desirable.

Estimation of the Micro-foundations Model

The basic micro-foundations model (Eqs. 3-1 and 3-3) is:

$$Q_t \equiv BA_t \bar{Y}_t$$

$$BA_t \equiv BA_{t-1} + P_{t-4} - R_{t-1}$$

where

Q = output

BA = bearing acreage

$\bar{Y}$ = yield

P = plantings

R = removals

The complete model, as specified in Chapter 3, requires separate equations for plantings (Eq. 3-4), removals (Eq. 3-5), and yield (Eq. 3-2).

<u>Acreage</u>

The lack of data on plantings and removals constrains estimation of the model to that of the reduced-form equation for bearing acreage. Bearing acreage (BA) is determined by the identity (Eq. 3-3):

$$BA_t \equiv BA_{t-1} + P_{t-4} + R_{t-1}$$

Plantings (P) and removals (R) are represented by the following Equations (3-4) and (3-5):

$$P_t = f(p^1_t, pa^1_t, NA_{t-1}, D3_t, i_t, K_t, X_t)$$

$$R_t = f(D1_t, D2_t, A^o_t, U_t, p^1_t, p^s_t, pa^1_t, X_t)$$

The functions representing plantings and removals are lagged appropriately and substituted into the bearing acreage identity. Shifting BA_{t-1} to the left side of the identity yields the reduced-form equation estimating the yearly change in bearing acreage:

$$BA - BA_{t-1} = f(p^1_{t-4}, pa^1_{t-4} NA_{t-5}, D3_{t-4}, i_{t-4}, K_{t-4}, X_{t-4}, D1_{t-1}, D2_{t-1}, A^o_{t-1}, U_{t-1}, p^1_{t-1}, p^s_{t-1} pa^1_{t-1}, X_{t-1}) \qquad (4\text{-}1)$$

where

p^1 = long-run expected profits of lemons

pa^1 = long-run expected profits of oranges

NA = nonbearing acreage

D3 = dummy representing the tax change

i = expected interest rate

X = risk

K = cash flow

D1 = dummy representing severe freeze

D2 = dummy representing severe disease or insect infestation

A^o = acreage 25 years or older

U = urban expansion

p^s = short-run expected profits of lemons

The coefficients for all variables except p^1_{t-4}, K_{t-4}, and p^s_{t-1} are expected to exhibit negative signs.

Due to lack of data, i, D2, A^o, and U were excluded from the estimated equation. A suitable proxy for risk was not formulated and risk was excluded from the estimated equation in favor of two more degrees of freedom. The tax change did not come into effect during the period under study due to the lag and it was not entered into the estimated equation. The equation to be estimated is:

$$BA_t - BA_{t-1} = f(p^1_{t-4}, pa^1_{t-4}, NA_{t-5}, K_{t-4}, D1_{t-1}, p^1_{t-1}, p^s_{t-1}, pa^1_{t-1}). \tag{4-2}$$

Of the eight variables not excluded, five are expected values: p^1_{t-4}, pa^1_{t-4}, p^1_{t-1}, p^s_{t-1}, and pa^1_{t-1}.

Several proxies were used for expected long-run profits of lemons lagged 4 years (p^1_{t-4}), alone and in combination:

1. A 3-year average of the all-uses on-tree price of California-Arizona lemons ($/carton) for the years just before the planting decision ($PL3_{t-7}$). This was chosen on the assumption that growers are most sensitive to recent experience at the time of a decision and that prices are seen as a measure of profitability.
2. A 3-year average of the total revenue per acre of California-Arizona lemons ($/acre) for the years just before the planting decision ($TRL3_{t-7}$). This adds the assumption that growers are sensitive to the level of yield as well as price in determining profitability. Often high prices may be associated with low yields, which would certainly make the crop seem less profitable than high prices with high yields.
3. Per capita U.S. consumption (pounds/capita) of California-Arizona lemons ($CONS_{t-5}$) for the year before the planting decision. If the grower observes a decline in the use of his product, it is hypothesized that he will respond by planting less than he might otherwise.
4. Since exports are a high-priced market for lemon growers, it is assumed that growers will be sensitive to activity in that market. Two alternative variables are proposed to capture this sensitivity to the export market (Appendix A, Table A-5). The grower may respond either to the quantity (1,000s of cartons) entering the export market to Japan the year before he plants ($EXJAP_{t-5}$), or to the total quantity

(1,000s of cartons) entering the export market the year before planting ($QELO_{t-5}$).

Expected long-run profits of California-Arizona lemons before the removal decision are proxied by the 3-year average of total revenues per acre ($TRL3_{t-2}$) for the reasons just discussed.

Expected long-run profits of California-Arizona oranges were represented by a 3-year average of the total revenue per acre ($/acre) of oranges (navels and valencias) for the years just before the planting decision ($TRO3_{t-7}$) and just before the removals decision ($TRO3_{t-2}$). Orange returns (Appendix A, Table A-8) are easily observed by the lemon grower and could be readily interpreted as the opportunity cost of producing lemons.

Due to the extreme variation in yield, it was thought that neither historical prices nor total revenues would accurately denote expected short-run profits. Lemon revenues derive primarily from the fruit sold to the fresh markets. It was hypothesized that the ratio of productive capacity to the demand in the fresh market would be indicative of over- or under-supply. The results would be greater or lesser rates of removal to take advantage of the market situation. Demand for fresh fruit was represented by the sum of the quantities entering the fresh export and fresh domestic markets. Productive capacity was represented first by bearing acreage (BA), and then by total acreage (TA) devoted to lemons. The measures were BA/fresh (acres/1,000s of cartons) and TA/fresh (acres/1,000 of cartons), both lagged one year.

Cash flow was denoted by one of two measures: a 3-year average of prices or a 3-year average of total revenue per acre before the planting decision ($PL3_{t-7}$ or $TRL3_{t-7}$).

Many alternative specifications of the reduced form equation (eq 4.2) of the micro-foundations model were attempted. The four variations in Table 4 were chosen as typical of the results obtained. The F statistic was used to test whether the independent variables as a whole significantly explain the variation of the dependent variable:

$$H_0: a_1 = a_2 = \ldots = a_9 = 0$$

$$H_1: a_1 = a_2 = \ldots = a_9 \neq 0$$

H_0 was accepted for estimates 2 and 4 (Table 4); that is, for a 5% level of acceptance of a type one error, it cannot be rejected that the independent variables have no influence on the dependent variable. H_0 was rejected for estimates 1 and 3; that is, there is a probablilty of .95 that the variation in the independent variables does explain the variation of the dependent variable.

Of the nine coefficients of the independent variables in estimates 1 and 3 (Table 4) only two are significantly different from zero at a 90% level or greater: TRL3 (-7) and NA (-5). Of these two variables, the 3-year average for the total revenue for the total revenue for lemons shows an illogical sign. Only nonbearing acreage is significant while exhibiting the expected sign.

Table 4. Least-squares Regression Estimates of Macro-model Equation (4-2), Yearly Change In Bearing Acreage of California-Arizona Lemons, 1962-1978

			Independent Variables													
Estimate	Dependent Variable	Constant Term	TRL_{t-7}	$PL3_{t-7}$	$CONS_{t-5}$	$QELO_{t-5}$	$EXJAP_{t-5}$	$TRO3_{t-7}$	NA_{t-5}	$D1_{t-1}$	$TRL3_{t-2}$	$PL3_{t-2}$	$TA/fresh_{t-1}$	$BA/fresh_{t-1}$	$TRO3_{t-2}$	Adjusted R^2	Standard Error
1	BA_t-BA_{t-1}	20830	-16.45		-3011	.12		12.25	.76	2774	4.17			-4898	-12.22	.71	1459
	(n=17)	(.78)	(-1.97)		(-.38)	(.11)		(.96)	(2.09)	(1.54)	(.37)			(-.71)	(-1.30)		[4.90]
2	BA_t-BA_{t-1}	10171		-1569	3345	-.35		7.17	.42	916		263		-5226	-15.34	.49	1959
	(n=17)	(.57)		(-.31)	(.42)	(-.25)		(.47)	(.96)	(.41)		(.05)		(-.52)	(-1.16)		[2.47]
3	BA_t-BA_{t-1}	22329	-15.37		-3568		-.43	10.77	.73	2666	4.35			-4360	-12.16	.72	1455
	(n=17)	(.84)	(1.62)		(-.45)		(-.20)	(.74)	(2.30)	(1.6)	(.40)			(-.84)	(-138)		[4.93]
4	BA_t-BA_{t-1}	16041	-17.00		-3827		-.45	7.01	.60	2602	6.52		-422		-12.45	.68	1553
	(n=17)	(.55)	(-1.70)		(-.44)		(-.19)	(.46)	(1.81)	(1.44)	(.58)		(-.11)		(-.94)		[4.14]

Notes:
Figures in parantheses are the t-statistic for the regression coefficients
Figures in brackets are the F statistics for the regression equations
t-K indicates a lag of K years
BA = bearing acreage of California-Arizona lemons (acres)
PL3 = three-year moving average of the real on-tree blend price per carton of lemons($/carton)
CONS = per capita U.S. consumption of lemons (pounds/person)
QELO = total exports of fresh lemons (1000 cartons)
EXJAP = fresh lemon exports to Japan (1000 cartons)
TFO3 = 3-year moving average of real, on-tree total revenues per acre of California-Arizona oranges ($/acre)
TRL3 = 3-year moving average of real, on-tree total revenues per acre of California-Arizona lemons ($/acre)
NA = non-bearing acreage of California-Arizona lemons (acrea)
D1 = dummy variable: severe freeze during season = 1, all other conditions = 0
TA/fresh = (NA+BA) : fresh fruit entering export and domestic market (acres/1000 cartons)
BA/fresh = BA ÷ fresh fruit entering export and domestic market (acres/1000 cartons)

Yield

Yield was denoted in the micro-model in Chapter 3 as:

$$\overline{Y}_t = f(A_t, T_t, W_t, C_t, D_t)$$

where:

A is the age distribution of the tree population,

T is the level of technology employed,

W is a weather variable,

C is the set of cultural practices within the season, and

D is a disease variable.

No data were available for D_t, C_t, T_t, and A_t. The only equation that could be estimated is $\overline{Y}_t = f(W_t\ t)$ where t is a trend variable intended to capture some effects of the other variables. This equation is estimated in the macro-model (pg. 69)

Production

Given the poor statistical properties of the estimated reduced-form equations for bearing acreage, it was decided not to rely upon the results to estimate production by the identity: $Q_t = BA_t\overline{Y}_t$ (Eq. 3.1).

Problems with the Model

The poor results of estimating acreage in the micro-foundations model may be attributed to the following difficulties:

1. Improper specification of the model due to the omission of variables included in the true relationship or the inclusion of a variable not in the true relationship. Under most

circumstances these errors of specification will result in the estimators being biased and inconsistent (Kelejian and Oates, 1974, p. 217). These specification errors may be due to:

a. Lack of data, as is the case for plantings, removals, costs and effects of disease, where data is either missing entirely or is incomplete for the period under study.

b. Lack of knowledge due to ignorance of the actual structural and behavioral components of the industry such that the estimated model does not correspond with the true model and to the extensive use of proxy variables, as was the case for the five expected values in the model, which only capture a part of a complicated process.

2. Too few degrees of freedom to make a reliable estimate of the equation. This may be caused by having too few observations with which to work or by having many parameters to estimate in the equation.

The necessity of estimating the reduced-form equation with several proxies and much missing data resulted in unreliable estimates of the parameters. It is thought that the model will perform better if some of the data problems are solved such that the model can be estimated as it was originally specified.

Estimation of the Macro-model

Acreage

In estimating the equation (3-8) $BA_t = f(p_t^1, pa_t^1)$, developed in Chapter 3, suitable proxies must be found for the values of the expected profits for both lemons (p_t^1) and oranges (pa_t^1). The expected profits for oranges are represented by a 3-year average of the total revenue per acre of California-Arizona navel and valencia oranges (TRO3).

To denote the expected profits of California-Arizona lemons several variables were considreed. Justification of the use of these proxies may be found in the discussion of the micro-model. The proxies are:

1. Exports of California-Arizona lemons to the Japan market, both the yearly quantities and a 2-year moving average (EXJAP, EXJAP2).
2. All exports of California-Arizona lemons, both the yearly quantities and a 2-year moving average lemons (QELO, QELO2).
3. Total revenue per acre of California-Arizona lemons, both 3 and 5-year moving averages (TRL3, TRL5).
4. Three-year moving average of the on-tree blend price per carton of California-Arizona lemons (PL3).
5. Per capita U.S. consumption of California-Arizona lemons (CONS).
6. Nonbearing acreage of California-Arizona lemons (NA). This indicates the potential additions to production capacity which the grower may influence by planting or by removing bearing acreage.

For each variable, various lags consistent with available knowledge of the industry were used in the estimated equations.

There were no prior reasons for choosing one functional form over another for the various specifications of the model. To examine the possibility of nonlinear relationships between the independent variables and the dependent variable in regression analysis, several alternative forms are commonly used. One is the log transformation in which all observations are converted to log form. Another is the semi-log transformation, in which the values of the independent variables are entered in log form, but not the dependent variable. The third alternative to the linear relationship is to put only the values of the dependent variable in log form.

All four forms were estimated for each set of variables and estimates were chosen which best approximated the dependent variable. For equations in which the dependent variable was in log form, a transformation was performed to allow comparison of the value of R^2 with those of other equations. The antilogs of the estimated values of the logs of bearing acreage were taken. These values were then regressed against the actual values of bearing acreage. The R^2 attained for this equation indicates the degree to which the log form estimates explain actual bearing acreage instead of the log of bearing acreage (Goldberger, 1964, p. 217).

The form of the estimates (Table 5) that best explain variation in bearing acreage are:

(5) $BA_t = f(TRL3_{t-7}, TRO3_{t-7}, QELO2_{t-6}, NA_{t-5})$ and

(6) $BA_t = f(TRL3_{t-7}, TRO3_{t-7}, EXJAP2_{t-6}, NA_{t-5}$

Estimate (5) uses the total quantity of exports while estimate (6) uses only the quantity entering the Japanese market as a regressor. Per

Table 5. Least Squares Regression Estimates of Macro-model Equation (3-8), Bearing Acreage of California-Arizona Lemons, 1962-1978

Estimate	Form of Variables dependent/ independent	Dependent Variable	Constant Term	$TRL3_{t-7}$	$TRO3_{t-7}$	$QELO2_{t-6}$	$EXJAP2_{t-6}$	NA_{t-5}	R^2 Corrected for log form	Standard Error Corrected for log form
5	log-log	BA_t	11.74	0.06	-0.33	0.06	----	0.06	.994	767
		(n=17)	(28.16)	(1.74)	(-12.29)	(2.28)		(6.49)		[495]
6	log-linear	BA_t	10.82	.00011	-.00014	------	.00003	.00001	.995	672
		(n=17)	(135)	(2.92)	(-2.03)		(4.07)	(7.33)		[629]

Notes:

Figures in parentheses are the t statistics for the regression coefficients.

Figures in brackets are the f statistics for the regression equations

BA = bearing acreage of California-Arizona lemons (acres)

$TRL3_{t-7}$ = 3-year moving average of real total revenue per acre of California-Arizona lemons at farm-level prices ($/acre)

$TRO3_{t-7}$ = 3-year moving average of real total revenue per acre of California-Arizona oranges at farm-level prices ($/acre)

$QULO2_{t-6}$ = 2-year moving average of total fresh exports of California-Arizona lemons, (1000's of cartons)

$EXJAP_{t-6}$ = 2-year moving average of fresh export of California-Arizona lemons to Japan (1000's of cartons)

NA_{t-5} = non bearing acres of California-Arizona lemons, (acres)

t-k = a lag of K years.

capita consumption and 3 and 5-year averages of the on-tree price of lemons were insignigicant in all equations in which they were entered. For both equations the F statistic was used to test the hypotheses:

$$H_0: b_1 = b_2 = b_3 = b_4 = 0$$

$$H_1: b_1 = b_2 = b_3 = b_4 \neq 0$$

The test rejected H_0 at the 99% level for both equations. The D-W statistic does not indicate problems of multicollinearity for either equation.

Bearing acreage should be positively associated with those variables acting as proxies for the expected profits of lemons and negatively associated with the proxy for the expected profit of oranges. The empirical results do not contradict these expectations. As there were expected signs to the coefficients, a one-tailed t-test was run on each coefficient in both estimates.

In estimate (5)(Table 5) the revenue variable for lemons ($TRL3_{t-7}$) is significant at a 90% level of confidence. While the remaining variables are significant at a 97.5% level of confidence. The R^2 corrected for the log form of the dependent variable, is .994, and the standard error of the estimate is 767.

In estimate (6) (Table 5) all variables are significant at the 99% level of significance. The R^2, corrected for the log form of the dependent variable, is .995 and the standard error of the estimate is 627.

These estimated equations, in which the independent variables are lagged at least 5 years and which have a small standard error with an extremely high R^2 are well-suited to make predictions. Predictions of bearing acreage are made from both equations and are discussed in the final section of this chapter.

Yield

The yield equation (Eq. 3-7) $\overline{Y}_t = f(t, W_t)$ was estimated, using ordinary least-squares regression analysis, for the period of 1954 to 1978. The estimate of equation (3-7) is:

$$\overline{Y}_t = \underset{(13.3)}{523} + \underset{(3.52)}{54.9t} - \underset{(-4.33)}{113W_t} \qquad (7)$$

where

t = trend in log form,

W = dummy variable where adverse weather conditions = 1, non-adverse conditions = 0.

$\overline{Y}_t$ = average yield in season t.

Figures in parentheses = 6 statistics.

All coefficients are significant at the 99% level. It was expected that the adverse weather variable would show a negative sign, and such is the case. Trend in yield is largely determined by long-run influences: level of technology and age distribution of the tree population. If the level of technology prevails in influencing the trend of yield, one would expect a positive coefficient. No expected sign is formulated for the age distribution of the tree population, nor is the magnitude of its effect known. Hence, no expectations were formulated concerning the sign of the coefficient of trend.

The R^2 for the yield equation is 0.54. Part of the reason for this low value is that the effects of exceptionally good weather conditions are not captured, being lumped with the ordinary years as a value of zero in the dummy variable. Neither is it possible to differentiate between more and less severe seasons. It is also difficult to judge what is a bad year for the industry, as most commentary is made at the district level.

For some purposes of projection, however, the degree to which yearly fluctuations are explained is not as important as an accurate representation of the trend in yield. This is because expectations will be based upon the general level of yield and not the effect of the stochastic weather variable, which is out of the control of the producers and other members of the industry. Examination of Figure 7 shows that the loss of explanatory power derives primarily from the inability to capture the large swings in yield, not from failure to track the trend.

Production

The estimates of both bearing acreage equations were combined with the estimates of yield (Appendix A, Table A.9) according to the identity $Q_t = BA_t\overline{Y}_t$. Regressions were run with actual production as the dependent variable and the estimates of production as the independent variable. The degree to which the model estimates explain actual

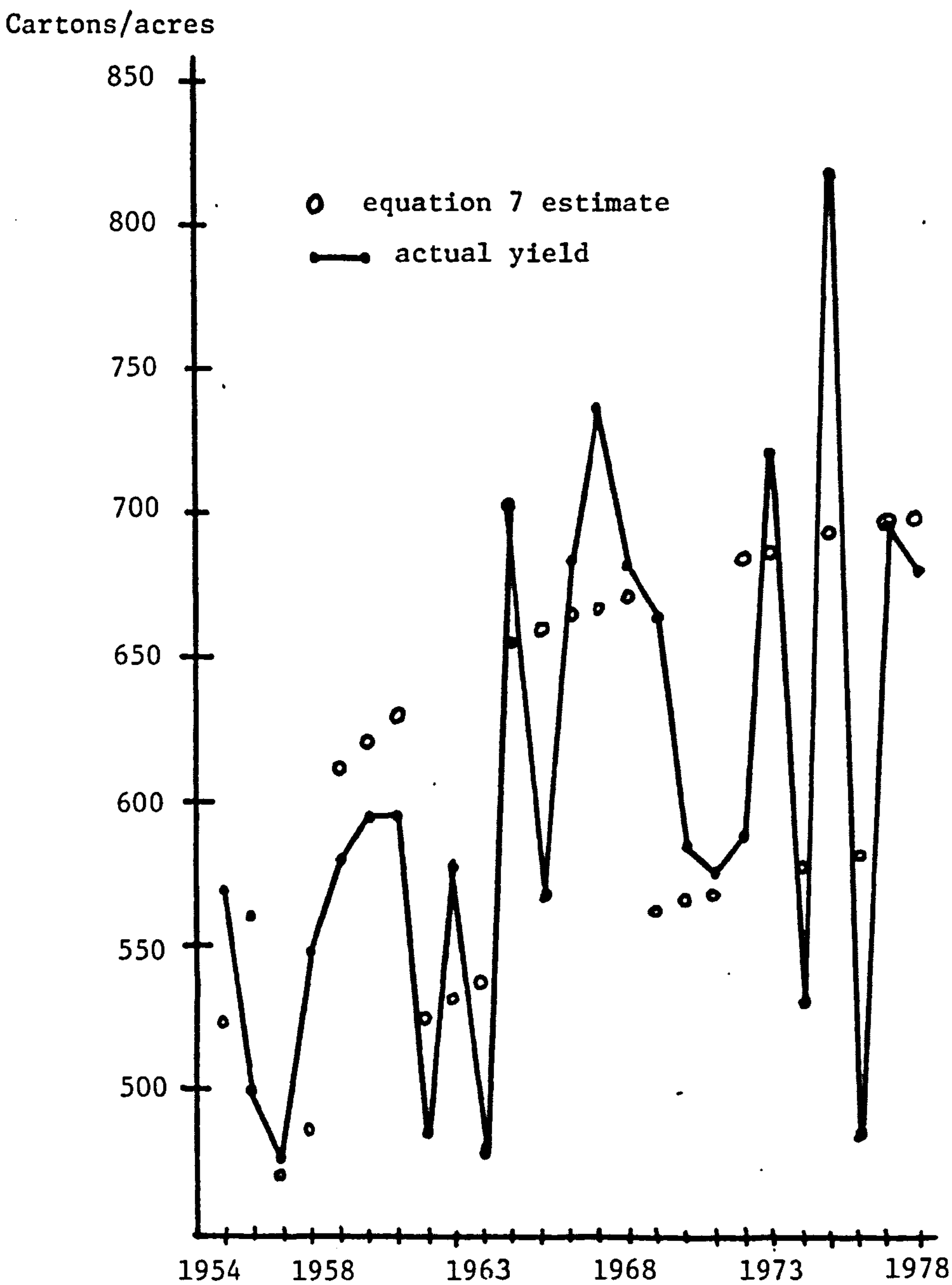

Figure 7. Yield per Acre of California-Arizona Lemons Macromodel Estimates, 1962-1978

Source: Tables A-4 and A-8, Appendix A

production (R^2) are .77 and .76 for estimates (5) and (6), respectively, combined with estimate (7).

Projections of Bearing Acreage, Yield, and Production Using the Macro-model

The estimated values of bearing acreage followed closely the locus of points, including the turning points, described by the actual values (Figure 8). As all variables in the estimates are lagged at least 5 years, it was possible to forecast bearing acreage for 5 years using available data. This was done and the results are shown in Table 6.

Table 6. Macro-model Projections of Bearing Acreage, Yield, and Production of California-Arizona Lemons, 1979-1983.

	Bearing Acreage (acres)		Yield (1000s car/acre)	Production (1000s cartons)	
Season	Estimate (5) (1)	Estimate (6) (2)	Estimate (7) (3)	(1)x(3)	(2 x(3)
1979	76,001	77,979	0.702	53,353	54,741
1980	75,531	75,766	0.704	53,174	53,339
1981	72,853	70,095	0.706	51,434	49,487
1982	71,582	64,505	0.708	50,680	45,670
1983	68,180	61,359	0.710	48,408	43,565

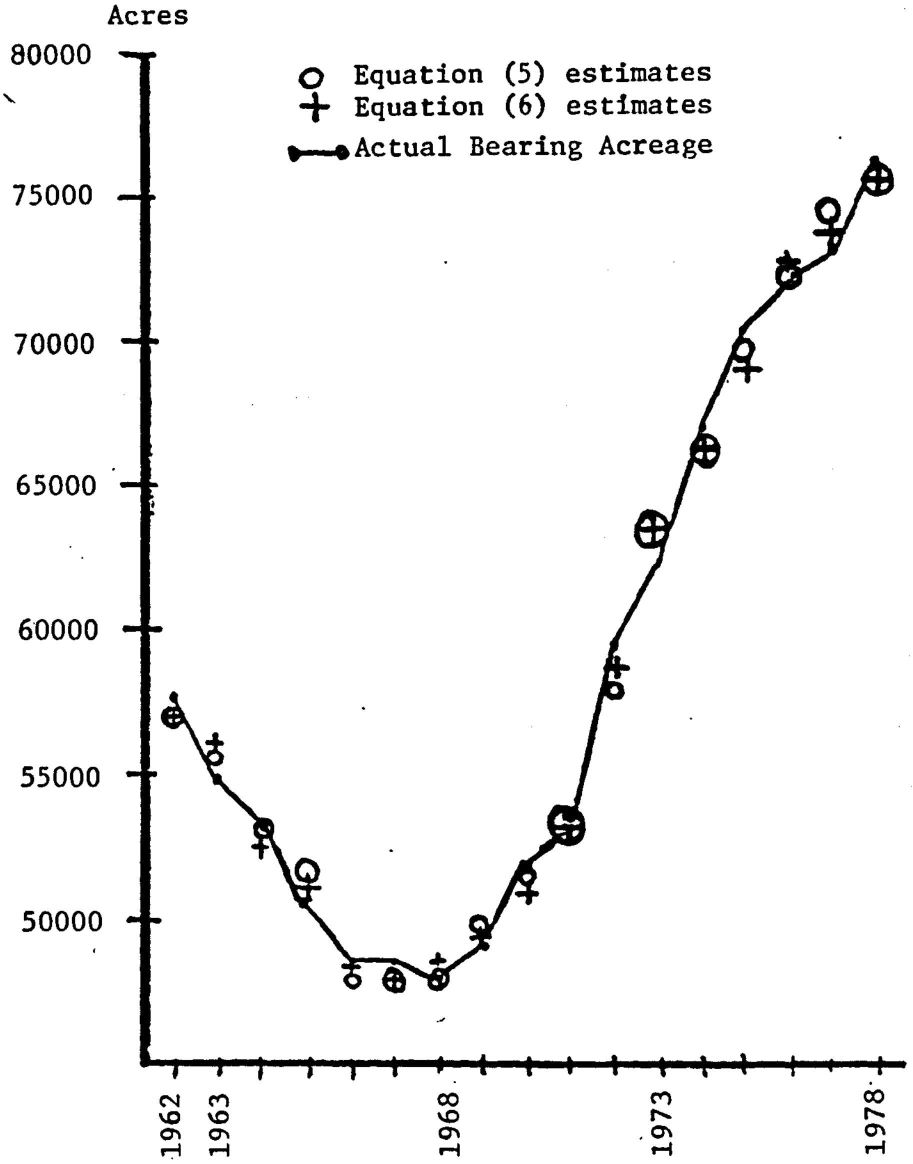

Figure 8. Bearing Acreage of California-Arizona Lemons and Macro-model Estimates, 1962-1978

Source: Appendix A, Tables A-1 and A-8.

Estimate (5), which uses total exports as an independent variable, predicts a downward trend from the 76,423 bearing acres in 1978 to 68,180 acres in 1983. Estimate (6), which contains the quantity of exports to Japan as an independent variable, predicts bearing acreage as rising to 77,979 acres in 1979. However, by 1983, estimate (6) predicts bearing acreage as falling far below that predicted by estimate (5). The difference in the two forecasts is believed to reflect the changing structure in the export market. Growers seem to be most responsive to the most active export market. The market for exporting lemons to Japan is beginning to stabilize, but total exports have been increasing due to activity in other markets such as Eastern Europe.

Whereas estimate (6) may explain past values of bearing acreage more completely, as illustrated by comparing the values of the standard error and R^2, its value in forecasting depends on a stable structure of the export market. This has not been the case, and it is believed that estimate (5) will be more valuable to planners.

Projections were made for yield (Table 6) as explained in Chapter 4 and were combined with the bearing acreage forecasts according to the model. The resulting forecasts of production are shown in Table 6. Projections of production, assuming non-adverse conditions in the yield equation, follow the same trend using either estimate (5) or estimate (6). For 1979, the forecasts rise above the 1978 figure of 55,027 thousand cartons. Subsequently, production is predicted to trend downward through 1983.

Comparison of Model Projections with Actual Values

To illustrate the possible utility of the macro-model equations to planners and forecasters, the form of estimates (5) and (6) were estimated using data only through 1970 and projections were made for the years 1971 through 1975. Subsequently, one year of data was added, another estimation of each form was made using the additional data, and projections were made for the forthcoming 5 years. This was repeated until the estimates were based on data from 1954 through 1978. The projections were grouped by the number of years beyond the range of the regression, and the mean absolute percentage error from the actual values was calculated for each group and each estimate. The results are shown in Tables 7 and 8. The projections made with estimates (5)

Table 7. Comparison of Bearing Acreage of California-Arizona Lemons with the Macro-model Forecasts

Forecast Period (Years)	Number of Forecasts	Mean Absolute Percentage Error from Actual	
		Estimate (5)	Estimate (6)
1	9	1.9	2.3
2	8	2.0	2.0
3	7	2.7	2.7
4	6	3.3	3.6
5	5	4.9	4.7

Table 8. Percentage Errors in the Macro-model Forecasts of Bearing Acreage of California-Arizona Lemons

Error of Projections	Number of Projections	
	Estimate (5)	Estimate (6)
≤ - 1.0% (overestimated)	7	13
> - 1.0% and < 1.0%	12	8
≥ 1.0% (underestimated)	16	15

and (6) were within 1 percent of the actual bearing acreage for 12 (34%) and 8 (23%), respectively, of the 35 comparisons. Such accuracy should be of interest to those to whom knowledge of the California-Arizona lemon industry is of importance.

Comparison with California-Arizona Citrus League Projections

The California-Arizona Citrus League (CACL) sponsors a yearly meeting to make acreage and production projections for the season 5 years in the future. Projections are made on the basis of judgment and consensus of a group of individuals familiar with the industry. In addition to lemons, projections are made for navel and valencia oranges, winter and summer grapefruit and tangerine types. The estimates were first made for 1977, based on data through 1972 (CACL 1979). Table 9 lists the CACL lemon estimates for the years 1977 to 1983 and the projections made from estimates (5) and (6), using the same data base.[1]

[1] In recent years, three levels of production (high, low, and mid) are projected by CACL. Comparisons of production in Tables 9 and 10 are based on the "mid" level projections.

Table 9. Comparison of the 5-year Projections of Bearing Acreage and Production of Lemons by the Macro-model and CACL with Actuals, 1977-1983

Year (1)	Years of Data Base for Projections (2)	Bearing Acreage (acres): Equation (5) (3)	Bearing Acreage (acres): Equation (6) (4)	Bearing Acreage (acres): CACL (5)	Bearing Acreage (acres): Actual (6)	Projected Yield Cartons Per Acre (7)	Production (1000s of Cartons): (3) X (7) (8)	Production (1000s of Cartons): (4) X (7) (9)	Production (1000s of Cartons): CACL (10)	Production (1000s of Cartons): Actual (11)
1977	1954-1972	78,905 (-7.7)	75,425 (-3.0)	71,000 (3.1)	73,258	680	53,687 (-5.1)	51,319 (-0.4)	43,000 (15.8)	51,091
1978	1954-1973	74,124 (3.0)	74,273 (2.8)	78,000 (-2.1)	76,423	691	51,235 (1.5)	51,337 (1.3)	53,500 (-2.5)	52,027
1979	1954-1974	75,986 (0.4)	78,026 (-2.2)	83,500 (-9.4)	76,317	689	52,339 (-27.7)	53,744 (-31.1)	47,000 (-14.7)	40,984
1980	1954-1975	75,986	76,941	87,500	n.a.	714	54,239 (-38.3)	54,920 (-40.0)	53,250 (-35.8)	39,214
1981	1954-1976	72,962	70,849	82,000	n.a	709	51,730	50,232	52,000	n.a.
1982	1954-1977	71,104	64,441	71,000	n.a.	711	50,523	45,792	47,000	n.a.
1983	1954-1978	68,180	61,359	70,000	n.a.	710	48,387	43,546	45,900	n.a.

Notes:

1. Values in parentheses are percentage errors from actual values: $\frac{\text{Actual} - \text{Predicted}}{\text{Actual}} \times 100$
2. n.a. denotes figure is not available
3. 1980 figure for actual production is an estimate of the Lemon Administration Committee, 1979

The projections are compared with the actual bearing acreage for 1977-79 and with actual production 1977-80 (LAC 1955-1978; LAC 1979); as shown in Table 10. Both the model projections and the CACL projections compare closely with the actual values of bearing acreage. The mean errors of the production forecasts also are quite similar, although the annual estimates vary considerably. In the 1979 season the lemon crop was greatly effected by freeze, and the LAC has commented that such damage will carry over into the 1980 season. For predictive purposes, the macro-model appears to be a very successful model; however, its average performance is not much better than the more informal approach used by CACL. Nevertheless, the macro-model could provide a useful check on the CACL projections.

Table 10. Mean Absolute Percent Error of CACL and Macro-model 5-year Lemon Forecasts, 1977-1980

Source of Estimates	Mean Absolute Percent Error From Actual Values
<u>Bearing Acreage</u>	
Estimate (5)	3.7
Estimate (6)	2.7
CACL	4.9
<u>Production</u>	
Estimate (5)	18.2
Estimate (6)	18.2
CACL	17.3

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Two models of supply response for the California-Arizona lemon industry were estimated in Chapter 4. The estimation of the micro-foundations model gave poor statistical results due to the extensive use of expected variables for which proxies had to be devised and to major gaps in other required data series. It was necessary to estimate a reduced-form equation for changes in bearing acreage. Because of the poor results of this equation it was decided that little information was to be gained in combining the acreage estimates with estimates of yield, as demanded by the model. Hence no estimates of production were made.

The estimation of the macro-model gave excellent results. Several formulations of the macro-model were estimated for bearing acreage and two were chosen as best. The two equations had R^2 values of .99 and small standard errors with regression coefficients that were significant at acceptable levels.

Projections using the macro-model were made in Chapter 4 and compared with historical values and with projections of the California-Arizona Citrus League. The two sets of projections compare closely with each other and with the available historical data.

In attempting to place this study within a larger research context, several topics are mentioned in which research would be valuable in furthering our understanding of supply response. Finally, a model of supply allocation is formulated in which attempts to take acount for economic and physical environment in which the growers and handlers operate.

Future Research

As noted in Chapter 4, estimation of the macro-foundations model was hampered by the lack of data. Data series for cultural costs, plantings, removals, and acreage lost to urbanization are needed for complete estimation of the model.

Detailed knowledge at the micro level is also needed. Information relating to the grower's decision-making process could provide a basis for criticism and improvement of the model. Some basic and needed areas of inquiry include:

1. What does the grower consider in making the decision to invest (plant) and divest (remove)?
2. What are expected profits and risk composed of in the mind of the grower?
3. To what extent does the grower adjust inputs within the season in order to affect yield?
4. What is the extent and influence of nonowner operation of farms in the industry?
5. While ensuring a market to growers in the short run, how does the blend price affect supply in the long run? How would growers respond if they received payment directly from each market: that is, if they reacted to marginal, and not average, returns?

6. To what extent has the products market been oversupplied? Has the Marketing Order limitation of fresh fruit sales in the domestic market and the practice of Sunkist Growers, Inc. of assuring the sale of the entire crop produced by its members led to artificial advantage of products over fresh fruit?
7. Under what circumstances would greater allocation to the fresh market result in a welfare gain or loss to growers if products allocations were decreased? In other words, to what extent is the LMO concern for grower equity resulting in a suboptimal solution for the industry and individual growers?
8. Would economic abandonment be advisable under any conditions? Could a cooperative policy of prorating the abandonment of fruit at the farm be formulated such that the costs of picking and hauling must be covered (products price $\geq$ average variable cost) before fruit is to leave the farm? As it is now, if most fruit goes to the cooperative to be pooled, picking and hauling costs become part of fixed costs and the products price may be less than that required to elicit the same quantity of fruit while the fruit is on the tree.

Some of the above questions could be investigated if an allocation model of the industry was constructed. Supply response may be seen as one component of an allocation model of the industry. Rausser (1971) identified five areas of activity that altogether describe the California-Arizona orange industry. At this level of description, the California orange and lemon industries are similar;

the five areas as identified by Rausser are: grower behavior, administrative committee behavior, cooperative, handler and processor behavior, marketing group behavior, and consumer behavior.

All five components must be considered to construct a decision and predictive model of the system within which lemons are produced and marketed. In examining previous studies of production and marketing, Rausser notes that most often the scope is limited to one or two of these components. This section attempts to set the stage for a study of the allocative process in the California-Arizona lemon industry. A short review of several attempts at supply allocation models precedes an attempt to construct a basic model of supply allocation for the California-Arizona lemon industry.

Previous Studies

Typical of the partial equilibrium solutions of perennial crop allocation are the studies by Masud, O'Rourke and Harrington (1978) and Hallberg, Brewer and Steadman (1978). Both studies, the first on Pacific Coast bartlett pears and the second on Appalachian apples, are concerned with intraseasonal allocation of the harvest. Demand curves at the farm level for the products market and the fresh market are derived, and a given supply is allocated to these markets. Of the two commodities, only pears are covered by a marketing order. The order both controls the amount of fresh fruit and regulates the containers and packs entering the fresh domestic market. Masud et al., asserted that the demand for pears for processing at the grower level is inelastic (.3089) whereas the demand for fresh marketed pears is of almost unitary elasticity. The authors suggested that allocation over the years would have been optimal had allocations to the fresh market averaged 23.8% above actual allocations to that market. This would have involved an 8% decrease in allocation to the processing market.

Hallberg et al. calculated elastic demands for Appalachian apples at the farm, packer and retail levels, although retail level elasticity is much greater than farm level elasticity of demand. Apples face four seasons during each year. The amount allocated to the third and fourth periods (March through August) must be placed in controlled atmosphere storage after the harvest. The study suggested that the growers allocate more of the crop to fresh in the fourth season and less of the crop to the processing market, though only by an average of 3 percent. They suggested a cooperative marketing effort by apple growers or the establishment of a marketing order to "organize the market." Considerations of costs of production and handling at the grower and handler level were not attempted for either study.

Weisenborn's (1968) allocation model covered the entire Florida orange industry, including the processors. Thus he considered fresh fruit as one product marketed along with frozen concentrated orange juice, canned single-strength orange juice, and chilled orange juice. The markets considered were retail, institutional, and export, as well as the possibility of economic abandonment, which was considered as a residual market after optimization. The export market also included hot pack concentrated orange juice.

Only 8 of the 13 demand functions were estimated due to data problems or unacceptable results. All demands showed price elastic response. Total cost functions and total revenue functions were estimated. As the total cost functions were linear, the marginal costs were constant and equal to average costs. These constants were subtracted from the total revenue functions to form net revenue functions, which were maximized by setting the marginal net revenues equal among forms and markets. Weisenborn analyzed an average year using his model. Substituting in the actual allocation for this average year, net revenue, according to the model, was a negative 23.8 million dollars. Optimum allocation implied significant increases of canned single strength orange juice and fresh oranges to retail markets at the expense of concentrated orange juice to the same market. He also concluded that an increasing percentage of the crop should go to the export and institutional markets as the crop size increases. Given the many data and methodological problems Weisenborn acknowledged and given that the orange industry would not be in existence if it lost money at such magnitudes as the model estimated, the orange industry should be quite reluctant to accept the counter-intutitive empirical results of even a well-thought-out model. It may be, however, that enough information was uncovered while researching the model that knowledgeable industry decision-makers can better intuit the actual situation. If such be the case Weisenborn will have accomplished more than many other modelers.

Matthews et al. (1974) developed a model of allocation for the U.S. orange economy while developing a forecasting model for that industry. To the block of supply equations described in the literature review in Chapter 3, they added a block of equations describing price and usage determination. Included are equations for processed and for fresh oranges demanded by the consumer, packer, and processor. Allocation among markets is accomplished by setting net marginal revenues equal in both the fresh and products market for both California and Florida. Prices determined in the demand block of equations are fed into the supply block and influence investment decisions in the form of removals and plantings. None of the other models thus far examined has this recursive approach.

The final model to be examined is that of Rausser (1971), also mentioned in Chapter 3 in the review of supply response studies. Rausser (1971, p. 273) stated that the nature of the California-Arizona orange industry is one of multiple interrelated products produced in multiple regions and sold in multiple space, form and temporal markets. The industry involves both short- and long-run production considerations as well as intraseasonal marketing periods. The complexity of the system results from interlocking cause-effect pathways, in particular, subsystems as well as the interaction between subsystems of the industry.

Rausser's (1971) analysis of each subsystem resulted in the following econometric representation of the industry: Grower behavior is represented by investment, yield, and production relations; administrative committee behavior is represented by intraseasonal supply and tree storage relations; cooperative, handler, and processor behavior represented by intraseasonal handler supply and grower-shipping point price relations; and the marketing group and consumer behavior are represented by derived demand relations for each of the major markets.

Rausser's (1971) model consists of 111 equations with 38 identities, which are applied at the district level for both navels and valencias. Rausser (1971) noted that any attempt at supply allocation (which he did not attempt) must be organized differently for each behavioral subsystem. Each group will have its own objective function. For instance, Rausser (1971) found that processed prices are more inelastic at the grower level than at the shipping point level. Supply allocations that maximize total revenue at the shipping point level will not maximize revenue at the grower level. The level of concern of any study must be carefully specified so as to avoid misinterpretation of the resulting recommendations.

Allocation Model of California-Arizona Lemons

While recognizing the applicability of Rausser's industry model to the California-Arizona lemon industry, space and time do not allow the formulation of the model for the lemon industry in as great a detail. Presented here is a model which attempts to capture the salient features of the California-Arizona lemon industry. The model here described is illustrated in Figure 9. Although formulated at the industry level, it can, and should, be adapted to the district level. Total supply is determined by the supply model developed in Chapter 3. The allocation of that supply is determined by the following set of equations:

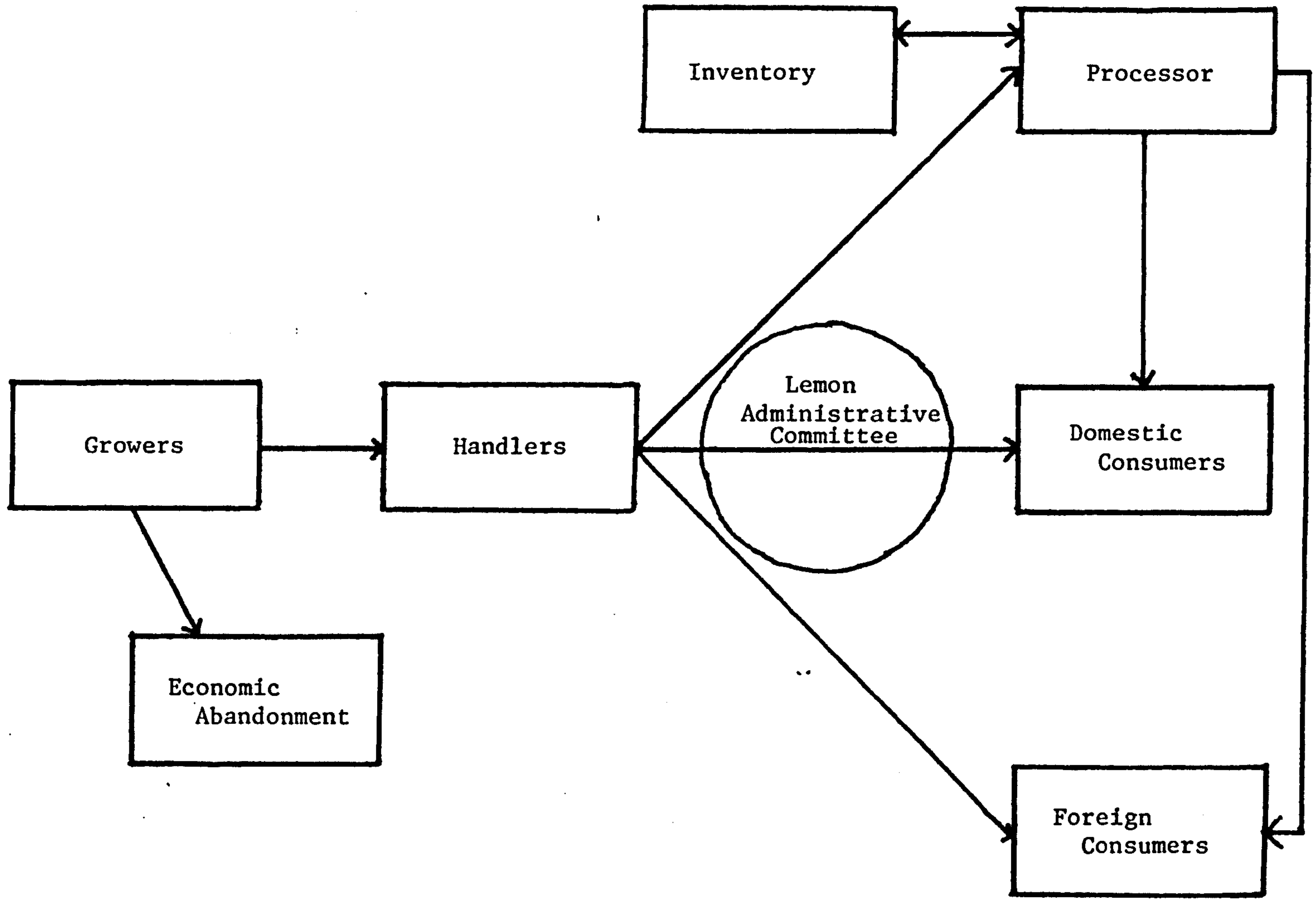

Figure 9. A Model of Supply Allocation of California-Arizona Lemons

fresh domestic demand:

$$Q_{fd} = f(P_{fd}, Y_{us}, P_{jd})$$

fresh export demand:

$$Q_{fe} = f(Z, P_{fe}, P_{1m}, Y_{n})$$

demand for fresh processors:

$$Q_{fr} = f(P_{je}, P_{jd}, Q_{i})$$

domestic demand for products:

$$Q_{jd} = f(P_{jd}, P_{fd}, Y_{us})$$

export demand for products:

$$Q_{je} = f(P_{je}, P_{fe}, Y_{n}, P_{fm}, P_{jm})$$

committee supply control:

$$Q_{fa} = f(Q_{fg}, Q_{fe}, Q_{fr}, Q_{fd}, Y_{us}, S_{us}, P_{fd:t-1}, P_{fi}, Q_{fd:t-1})$$

LAC control:

$$Q_{fd} = Q_{fa}$$

total demand:

$$Q_{fg} = Q_{fd} + Q_{fe} + Q_{fr}$$

clearing identity at grower level:

$$Q_{g} = Q_{h} + Q_{b}$$

$$Q_{g} = BA \cdot \bar{Y}$$

where:

Z = policies affecting exports

r = processor

h = handler

a = LAC

d = domestic

e = export

f = fresh lemons

j = lemon products

g = grower

l = lemons

us = United States

n = other consumer nations

m = competitive lemon-producing nations

b = economic abandonment

i = inventory

S = per capita consumption

$\bar{Y}$ = per capita income

P = price

Q = quantity

BA = bearing acreage

Y = yield

In applying this model, it must be kept in mind that allocation will vary according to the goals of each behavior group. Empirical verification of this model must contain an objective function for the group making the decisions subject to the demand and supply constraints represented by the ten equations of the model.

APPENDIX A

CALIFORNIA-ARIZONA LEMON AND ORANGE DATA AND MODEL ESTIMATES

Table A-1. Bearing Acreage of California-Arizona Lemons, 1954-1978

Season	Acres			
	Industry	District 1	District 2	District 3
1954	57,160	1,246	55,055	859
1955	56,575	1,322	54,421	832
1956	56,460	1,457	53,438	1,565
1957	57,358	1,457	54,113	1,788
1958	58,621	1,523	55,010	2,088
1959	59,983	1,657	54,314	4,012
1960	60,073	1,781	53,396	4,896
1961	57,431	1,713	50,148	5,570
1962	57,592	1,983	48,614	6,995
1963	54,872	1,883	46,123	6,866
1964	53,225	1,702	43,934	7,589
1965	50,538	1,764	41,242	7,532
1966	48,484	1,754	39,126	7,604
1967	48,535	2,014	38,770	7,751
1968	47,902	1,989	37,840	8,073
1969	49,067	2,517	36,105	10,445
1970	51,893	3,211	37,176	11,506
1971	53,119	3,617	37,339	12,163
1972	59,509	4,971	38,002	16,536
1973	62,322	5,127	39,165	18,030
1974	67,117	5,830	38,926	22,361
1975	70,495	7,193	39,616	23,686
1976	72,307	7,710	40,858	23,739
1977	73,258	9,442	36,072	27,744
1978	76,423	9,773	37,558	29,092

Source: Lemon Administrative Committee (1955-1978)

Table A-2. Nonbearing Average of California-Arizona Lemons, 1954-1978

	Acres			
Season	Industry	District 1	District 2	District 3
1954	6,679	20	6,403	256
1955	6,932	75	6,625	232
1956	10,589	118	7,871	2,600
1957	13,239	148	9,203	3,888
1958	12,846	200	8,558	4,088
1959	9,305	83	8,813	409
1960	7,615	88	7,291	236
1961	3,854	78	3,616	160
1962	2,856	10	2,276	570
1963	1,837	35	1,789	13
1964	2,691	350	1,852	489
1965	4,511	555	2,214	1,742
1966	7,409	1,001	2,678	3,730
1967	13,439	2,776	4,340	6,323
1968	17,498	3,135	4,427	9,936
1969	19,039	3,172	4,206	11,661
1970	20,647	3,757	4,661	12,229
1971	22,670	4,196	4,755	13,719
1972	22,647	4,824	4,522	13,301
1973	23,802	5,402	4,367	14,033
1974	23,964	5,809	6,594	11,561
1975	20,821	4,191	5,929	10,701
1976	15,912	3,683	4,045	8,184
1977	8,469	1,959	3,268	3,242
1978	3,811	1,407	1,506	898

Source: Lemon Administrative Committee (1955-1978).

Table A-3. Production of California-Arizona Lemons, 1954-1978

Season	1000s of Cartons			
	Industry	District 1	District 2	District 3
1954	32,500	NA	NA	NA
1955	28,186	713	27,388	260
1956	26,890	647	25,871	372
1957	31,485	734	30,187	565
1958	33,959	800	32,196	963
1959	35,667	987	33,961	720
1960	35,826	999	32,482	2,345
1961	27,864	610	26,126	1,127
1962	33,301	751	29,381	3,169
1963	26,148	523	24,557	1,069
1964	37,480	593	33,129	3,757
1965	28,585	1,009	25,039	2,537
1966	33,184	1,148	27,858	4,178
1967	35,783	1,347	28,584	5,852
1968	32,552	462	25,154	6,936
1969	32,645	1,010	24,052	7,583
1970	30,304	1,685	22,660	5,959
1971	30,603	1,425	22,253	6,925
1972	34,975	1,825	26,225	6,925
1973	44,981	2,190	32,608	10,183
1974	35,554	1,069	27,383	7,102
1975	58,470	3,013	38,062	17,395
1976	35,052	3,559	24,406	7,087
1977	51,091	3,532	34,164	13,395
1978	52,027	5,900	30,222	15,905

NA = Information not available.

Source: Lemon Administrative Committee (1955-1978).

Table A-4. Average Yield of California-Arizona Lemons, 1954-1978

	Cartons/Acre			
Season	Industry	District 1	District 2	District 3
1954	569	NA	NA	NA
1955	498	540	503	313
1956	476	444	484	238
1957	549	504	558	316
1958	579	525	585	461
1959	595	595	625	179
1960	596	561	608	479
1961	485	356	521	202
1962	578	378	604	453
1963	477	278	532	156
1964	704	349	754	495
1965	566	572	607	337
1966	684	655	712	549
1967	737	669	737	755
1968	680	232	665	859
1969	665	401	666	726
1970	584	525	610	518
1971	576	394	596	569
1972	588	367	690	419
1973	722	427	833	565
1974	530	183	703	318
1975	829	419	961	734
1976	485	462	597	299
1977	697	374	947	483
1978	681	604	805	547

NA = Not available

Sources: Tables A-1 and A-3

Table A-5. Utilization of California-Arizona Lemons, 1954-1978

	Total Fresh Export	Fresh Domestic	Processing	Food Export to Japan
	---1000s of cartons---			
1954	1,800	16,870	13,830	39
1955	2,973	15,378	9,607	46
1956	3,463	14,842	8,283	44
1957	3,920	14,860	12,453	161
1958	6,041	14,277	13,329	200
1959	3,420	14,506	17,467	150
1960	4,310	14,009	17,221	173
1961	4,840	13,973	9,051	188
1962	3,871	14,190	15,194	212
1963	5,042	13,347	7,758	253
1964	5,201	13,764	18,514	861
1965	4,815	13,100	10,671	1,009
1966	6,011	13,373	13,800	1,404
1967	6,093	12,350	17,340	1,670
1968	5,857	12,610	14,085	2,151
1969	5,554	12,464	14,627	2,270
1970	6,365	12,098	11,841	2,794
1971	6,285	11,875	12,443	3,496
1972	8,101	12,008	14,866	4,687
1973	9,885	12,206	22,890	5,298
1974	9,944	12,358	13,252	5,141
1975	11,011	11,931	35,528	4,517
1976	9,835	11,991	13,226	5,213
1977	13,149	12,529	25,413	6,167
1978	11,382	13,029	27,616	NA

Sources: Lemon Administrative Committee (1955-1978); U. S. Department of Commerce (1954-1977).

Table A-6. On-tree Prices, Cultural Costs and Net Revenues of California-Arizona Lemons, 1954-1978

Season	On-tree Price (1)	Cultural Costs (2)	Net Revenue (1)-(2)
	(dollars per carton)		
1954	1.68	0.87	0.81
1955	1.64	1.12	0.52
1956	1.88	1.26	0.62
1957	1.17	1.08	0.09
1958	1.09	0.98	0.11
1959	0.86	0.84	0.02
1960	0.87	0.92	-0.05
1961	1.21	1.23	-0.02
1962	0.98	1.11	-0.13
1963	2.19	1.45	0.74
1964	1.21	1.14	0.07
1965	1.48	1.37	0.11
1966	1.41	1.25	0.16
1967	1.39	1.08	0.31
1968	1.66	1.09	0.57
1969	1.80	1.28	0.52
1970	1.92	1.17	0.75
1971	1.93	1.14	0.79
1972	1.79	1.14	0.65
1973	1.42	0.91	0.51
1974	2.02	NA	NA
1975	0.87	NA	NA
1976	1.52	NA	NA
1977	0.59	NA	NA
1978	0.64	NA	NA

Note: NA indicates information not available
Prices, Costs and Revenues are in real terms (1972 = 100)

Sources: Sunkist Growers, Inc. (1961-1978); USDA (1979).

Table A-7. California-Arizona Valencia and Navel Orange Data, 1954-1978

	Navel			Valencia		
	On-tree Price	Yield	Bearing Acreage	On-tree Price	Yield	Bearing Acreage
	$/cart.	cartons/acre	acres	$/cart.	cartons/acre	acres
1954	1.05	399	72,524	1.29	316	117,197
1955	1.07	399	69,500	0.97	462	107,425
1956	1.34	459	65,686	1.16	484	99,109
1957	1.31	476	64,516	1.18	453	94,054
1958	2.18	290	62,092	2.13	327	90,310
1959	1.43	519	63,585	1.28	530	88,734
1960	1.64	406	65,352	1.65	418	87,247
1961	2.47	275	65,101	1.59	399	83,516
1962	2.71	229	66,817	1.55	336	82,174
1963	2.02	368	68,031	1.65	425	80,132
1964	1.61	436	70,475	1.88	417	85,099
1965	1.58	405	75,319	1.23	395	89,342
1966	1.07	478	80,327	1.23	415	92,873
1967	1.25	411	85,733	0.91	456	100,929
1968	1.89	218	88,057	1.83	260	95,130
1969	1.12	412	96,751	0.56	572	105,269
1970	1.03	425	108,440	0.97	402	107,775
1971	1.41	333	110,154	0.88	439	103,356
1972	1.07	406	115,271	0.71	492	103,256
1973	1.33	357	112,650	1.01	563	98,519
1974	1.44	383	117,572	1.15	443	97,231
1975	1.19	519	112,699	0.85	670	94,088
1976	1.01	549	106,460	0.76	616	86,815
1977	1.23	460	116,490	1.19	545	85,009
1978	2.42	365	115,283	2.20	634	81,147

Source: Navel Orange Administrative Committee, 1978; Valencia Orange Administrative Committee, 1979; Sunkist Growers, Inc., 1961-1978.

Table A-8. Macro-model Estimates of Industry Yield, 1954-1978

Season	Weather Variable* (1)	Yield Cartons/acre (2)
1954	0	523
1955	0	561
1956	1	470
1957	1	486
1958	0	611
1959	0	621
1960	0	630
1961	1	524
1962	1	531
1963	1	537
1964	0	655
1965	0	659
1966	0	664
1967	0	668
1968	0	672
1969	1	562
1970	1	566
1971	1	563
1972	0	684
1973	0	687
1974	1	577
1975	0	693
1976	1	582
1977	0	697
1978	0	700

*1 = adverse conditions
0 - non-adverse conditions

Source: Rock, 1970; Rausser, 1971; Sunkist 1961-1978; Lemon Administrative Committee, 1955-1978.

Table A-9. Macro-model Estimates of Bearing Acreage and Production of California-Arizona Lemons, 1962-1978

	Bearing Acreage		Production	
	(1)[a]	(2)[b]	(3)[c]	(4)[d]
	--------acres---------		---1000s of cartons----	
1962	57,095	57,084	30,317	30,316
1963	55,626	55,785	29,871	29,957
1964	53,337	52,774	34,936	34,567
1965	51,310	50,815	33,813	33,487
1966	47,996	48,364	31,869	32,114
1967	47,925	47,964	32,014	32,040
1968	47,992	48,113	32,251	32,332
1969	49,778	49,529	27,975	27,835
1970	51,511	51,243	29,155	29,004
1971	53,577	54,050	304,853	30,754
1972	58,016	58,724	39,741	40,226
1973	63,523	63,515	43,640	43,635
1974	66,499	66,566	38,370	38,409
1975	69,812	69,552	48,380	48,200
1976	72,473	72,340	42,179	42,102
1977	74,274	73,791	51,769	51.432
1978	75,834	76,386	53,084	53,470

a. Estimated with equation (5)

b. Estimated with equation (6)

c. (column (1), Table A-9 x column (2), Table A-8)/1000

d. (column (2), Table A-9 x column (2), Table A-8)/1000.

APPENDIX B

CALIFORNIA PLANTINGS DATA: A CRITIQUE

The California Crop and Livestock Reporting Service (CCALRS) has published California Fruit and Nut Acreage annually since 1954, in which are listed data on bearing and nonbearing acreage, new plantings, and acreage planted during previous years and still standing. All counties are surveyed at least once every 5 years by the CCALRS. For the intervening years the CCALRS relies upon information supplied by the County Agricultural Commissions.

For California-Arizona lemons,

$$TA_t = BA_t + NA_t \qquad \text{(B-1)}$$

where

TA = total acreage

BA = bearing acreage, and

NA = nonbearing acreage.

Bearing acreage may be described by the previous year's bearing acreage and the investment activities, planting (P) and removals (R). Acreage planted in years t-4 and acreage removed in year t-1 will, with bearing acreage in year t-1, determine bearing acreage in t:

$$BA_t = BA_{t-1} + P_{t-4} - R_{t-1} \qquad \text{(B-2)}$$

Nonbearing acreage in year t consists of the trees planted after year t-4 through year t (assuming no removals of nonbearing acreage):

$$NA_t = \sum_{n=t-3}^{t} P_n \qquad \text{(B-3)}$$

When plantings and bearing acreage are known

$$R_{t-1} = BA_{t-1} + P_{t-4} - BA_t \qquad \text{(B-4)}$$

and a series for removals could be derived.

However, when the plantings data were checked against nonbearing acreage data, using equation (B-3), the two series were found to be inconsistent with each other. Age cohorts are those trees reported as planted in the same season. Upon following the age cohorts over time, it was found in certain instances that their numbers were increasing. Such illogical relationships precluded the use of these data without further investigation and econometric manipulation to reconcile the data series.

REFERENCES

Askari, Hossein and John T. Cummings. Agricultural Supply Response. New York: Praeger Publishers, 1976.

Burt, Oscar R. and Robert M. Finley. "Statistical Analysis of Identities in Random Variables." Amer. J. Agr. Econ. 50(1968):734-744.

Burt, Oscar R. and Robert M. Finley. "On the Statistical Analysis of Identities: Reply." Amer. J. Agr. Econ. 52(1970):155-156.

California-Arizona Citrus League. Five Year Projections of Bearing Acreage Production Made During a Annual Meeting, P. O. Box 7888, Valley Annex, Van Nuys, California 91409, 1979.

California Crop and Livestock Reporting Service. California Fruit and Nut Acreage, P.O. Box 1258, Sacramento, California 95806, 1954-1979.

Dillon, J. L. The Analysis of Response in Crop and Livestock Production. Second Edition, Oxford: Pergamon Press, 1977.

Fox, Roger W., C. Curtis Cable, Jr., and William P. Gotsch. Data for the Desert Citrus Industry. Report No. 260, Agricultural Experiment Station and the Cooperative Extension Service, The University of Arizona, Tucson, October, 1970.

French, Ben C. and Raymond G. Bressler. "The Lemon Cycle." Farm Economics (1962):1021-1036.

French, Ben C. and Jim L. Matthews. "A Supply Response Model for Perennial Crops." Amer. J. of Agr. Econ. 53(1971):478-490.

Goldberger, Arthur S. Econometric Theory. New York: John Wiley & Sons, 1964.

Goldberger, Arthur S. "On the Statistical Analysis of Identities: Comment." Amer. J. of Agr. Econ. 52(1970):154-155.

Hallberg, M. C., T. A. Brewer, and D. F. Steadman. Economics of the Appalachian Apple Industry. Bulletin No. 817, The Pennsylvania State University, College of Agriculture Experiment Station, University Park, Pennsylvania, May 1978.

Heimpel, Gretchen. "An Economic Analysis of the Expansion of United States Lemon Exports." Master's Thesis, University of Arizona, 1977.

Henderson, James M. and Richard F. Quandt. Microeconomic Theory. New York, N.Y.: McGraw-Hill, Inc., 1971.

Hilgeman, R. H. and D. R. Rodney. Commercial Citrus Production in Arizona. Special Report No. 7. Agriculturalal Experiment Station and Cooperative Extension Service, The University of Arizona, February 1961.

Jamison, John A. "Marketing Orders and Public Policy for Fruit and Vegetable Industries." Food Research Institute Studies, vol. 10, (1971):223-392.

Jensen, Harald R. "Farm Management and Production Economics, 1946-70." A Survey of Agricultural Economics Literature, vol. 1, ed. Lee R. Martin, Minneapolis: University of Minnesota Press, 1977, 39-46.

Just, R. F. "An Investigation of the Importance of Risk in Farmer's Decisions." Amer. J. of Agr. Econ. 57(1975):836-843.

Kelejian, Henry H. and Wallace E. Oates. Introduction to Econometrics. New York: Harper & Row, 1974.

Lemon Administrative Committee. Annual Report, Los Angeles, California, 1955-1978.

Lemon Administrative Committee. Letter to Bob S. Bergland, Secretary of Agriculture, State of California, Los Angeles California, 31 July, 1979.

Masud, Sherif M., A. Desmond O'Rouke, and Albert H. Harrington. Demand and Optiumum Allocation for Pacific Coast Bartlett Pears. Bulletin No. 866, College of Agriculture Research Center, Washington State University, November 1978.

Matthews, J L., Abner W. Womack, and Ben W. Huang. "The U.S. Orange Economy: Demand and Supply Prospects, 1973-74 to 1984-85", Fruit Situation, February 1974, 39-52, USDA.

Naval Orange Administrative Committee. Annual Report, Los Angeles, California, 1978.

Nicolatus, Stephen J. "An Economic Analysis of the Marketing Order for Lemons and Its Impact on the Domestic Consumer, 1954-1975." Master's thesis, The University of Arizona, 1977.

Rausser, G. "A Dynamic Econometric Model of the California-Arizona Orange Industry." Ph.D. dissertation, The University of California, 1971.

Rock, Robert C. "Weather Conditions Affecting Citrus Production in the United States, 1895-1970, University of California Experiment Station, Riverside, 1970.

Samuelson, P. A. Economics: An Introductory Analysis. Seventh Edition New York: McGraw-Hill, Inc., 1967.

Sisson, Charles A. Provisions of Importance to Agriculture in the Tax Reform Act of 1976. Economics Research Service No. 645, USDA, November 1976, Washington, D.C.

Sunkist Growers, Inc. Annual Report, Sherman Oaks, California, 1976-77.

Sunkist Growers, Inc. Citrus Fruit Industry Statistical Bulletin, Van Nuys, California, 1961-1978.

Tomek, William G. and Kenneth L. Robinson. "Agricultural Price Analysis and Outlook." A Survey of Agricultural Economics Literature, vol. 1, ed. Lee R. Martin, Minneapolis: University of Minnesota Press, 1977, pp. 329-401.

Traill, Bruce. Incorporation of Risk Variables in Econometric Supply Response Analysis. Cornell Agricultural Economics Staff Paper No. 76-27, August 1976, Ithaca, New York.

U.S. Department of Agriculture, Consumer and Marketing Service. Part 910: Lemons Grown in California and Arizona. Reprinted from Federal Register of August 15, 1962 (27 F.R. 8101); May 21, 1964 (29 F.R. 6617); August 16, 1968 (33 F.R. 1163); May 19, 1971 (36 F.R. 9061).

U.S. Department of Agriculture. Working Data for Demand Analysis. Washington, D.C., March 1979.

U.S. Department of Commerce. Trade Statistics, Commodity by Country of Destination, 1954-1977.

Valencia Orange Administrative Committee. Annual Report, Los Angeles, California, 1979.

Weisenborn, David E. "Market Allocation of Florida Orange Production for Maximization of Net Revenue." Ph.D. dissertation, University of Florida, 1968.

Young, Douglas, William Lin, Runon Pope, Lindon Robison, and Roger Selley. "Risk Preferences of Agricultural Procedures: Their Measurement and Use." Risk Management in Agriculture: Behavioral, Managerial, and Policy Issues, AW-4478, Department of Agricultural Economics, University of Illinois at Urbana-Champaign, July 1979.