

A STATISTICAL ANALYSIS OF ARIZONA
GRAPEFRUIT PRICES

by
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ABSTRACT

Per capita consumption of fresh and processed grapefruit has shown a steady decline over the past two decades. Prices for grapefruit accordingly have not been particularly favorable. Since grapefruit is and is expected to continue to be the largest volume citrus crop produced in Arizona, an understanding of the factors influencing grapefruit prices would be of importance to the industry. The purpose of this thesis is to develop statistical estimates of the relationships associating the price of Arizona grapefruit with the factors hypothesized to influence that price.

An investigation of the marketing and pricing of grapefruit suggested the following variables as important factors influencing the price of Arizona grapefruit: quantity of grapefruit produced for fresh and processed markets in Arizona and elsewhere in the United States, the general level of economic activity, quantity produced of a substitute product (oranges), population and trend.

Using the single-equation method of least-squares multiple regression, demand equations for free-on-board and on-tree prices are developed. Of the various explanatory variables included in the regression model, the variable representing non-Arizona fresh grapefruit production was shown to be the most significant factor affecting Arizona grapefruit prices.

Two applications of the resulting equations are illustrated. The first illustration is the forecasting of grapefruit prices for a

future period and the second is to the determination of the optimum diversion of the crop between fresh and processed outlets.

CHAPTER I.

INTRODUCTION

The agricultural producing and marketing firm exists and operates in an environment of uncertainty and change. Product and input prices, consumer preferences, technology, government policy actions, and weather are but a few of the changing factors which influence the firm's profitability and, at times, its very survival. The typical agricultural firm can control few if any of such factors, so that its success depends on adjustments to these changing external conditions. Decisions made in response to external changes can be most effective if there is reliable knowledge concerning the future behavior of these key variables and of the relationships connecting them. The future price of the commodity and the relationship among price and other factors influencing it are of particular importance since price is the primary variable to which the firm adjusts, as changes in the other factors are eventually recorded on the commodity's price.

The need for knowledge concerning such relationships is especially critical in the case of orchard crops, where it is characteristic that planting decisions are made many years before any produce can be marketed. It is the purpose of this thesis to develop statistical estimates of the relationships important in determining the price of grapefruit in Arizona and to illustrate the application of such knowledge to two specific decision problems. One illustration will be the application

of the estimated relationships to a model for determining the optimum allocation of grapefruit between the fresh and processing markets, and the second will be the development of a forecast for grapefruit prices for a period in the future.

A. Background on Grapefruit Production in Arizona

The principal citrus growing areas in Arizona are: (1) the Salt River Valley area located near Phoenix in Maricopa County, and (2) the Yuma area located near the city of Yuma in Yuma County.

The first commercial citrus in Arizona consisted of about 500 acres of oranges established in the Salt River Valley in the 1890's. A severe freeze in 1913 devastated most of this acreage but it was later replanted. By 1925, there were about 2,000 acres of commercial citrus in the Salt River area, of which white grapefruit comprised approximately half. The first commercial citrus groves in Yuma County, consisting mainly of Marsh seedless grapefruit, were planted in the late 1920's.

By 1935, Arizona grapefruit acreage had increased to about 14,000 acres, most of which was located in the Salt River Valley area. Little increase in acreage occurred through the rest of that decade as low grapefruit prices during this period discouraged new plantings and some acreage was taken out of citrus. The Arizona grapefruit acreage decreased from about 15,000 acres in 1940 to about 6,000 acres in 1958. Since that date, grapefruit acreage has remained relatively stable as new plantings nearly equalled grove removals.

Income--The average annual revenue to Arizona grapefruit producers (based on on-tree returns to farmers) for the seasons 1946-47 through 1962-63 exceeded one and one-half million dollars. Over 92 percent of this income was derived from sales of fresh grapefruit. (Although the volume of grapefruit processed is a substantial portion of total production, the low returns received in this market account for its lack of importance in the total income picture.)

Production and Marketing Firms--The Census of Agriculture in 1959 reported 675 farms producing grapefruit in Arizona. This compares with 2,736 farms reporting in 1945, 1,545 in 1950, and 821 in 1954. The declining number of farms reflects both a decrease in total grapefruit acreage and an increase in acres per farm.

Eighteen organizations are involved in the packing and shipping of fresh grapefruit in the state. Two firms with plants within the state purchase grapefruit for processing, primarily for a soft drink concentrate or for grapefruit juice. At times, some of the cull fruit is shipped to processing plants in nearby California.

B. Previous Research

The literature relating to marketing and price behavior for grapefruit is not extensive. The report by Seltzer and Rowell in 1950 is one of the few to consider demand relationships explicitly.¹ Also appearing in 1950 was Seltzer's report on Desert Grapefruit (published

1. Seltzer, R. E., and J. D. Rowell, Prices and Markets for Desert Grapefruit, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, 1950.

in conjunction with the California Agricultural Experiment Station), which dealt with marketing institutions in the desert grapefruit industry.² Work in the Agricultural Economics Department in the University of Arizona has resulted in a statistical handbook on the Arizona grapefruit industry³ and a more extensive analysis of economic aspects of the citrus industry (including grapefruit) in Arizona.⁴

Turning elsewhere, requests to agricultural economics departments in universities in other citrus producing states (Florida, Texas, and California) concerning previous or current research on grapefruit prices produced little additional research results. Of interest was the report by Godwin and Lloyd at the Department of Agricultural Economics at the University of Florida which examined substitution relationships among various citrus and other fruit products,⁵ and Foytik's paper on intraseasonal demand shifts for various fruits and vegetables, including grapefruit.⁶ In the United States Department of Agriculture,

2. Seltzer, R. E., et al., Desert Grapefruit Goes to Market, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, 1950.

3. Hill, James S., Desert Grapefruit Industry, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, 1964.

4. Hill, J. S., J. S. Hillman, and P. L. Henderson, Some Economic Aspects of the Arizona Citrus Industry, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, 1965.

5. Godwin, M. R., and B. S. Lloyd, Substitution Relationships Between Fresh Oranges and Related Citrus and Noncitrus Products, Department of Agricultural Economics, University of Florida, Gainesville, Florida, 1963.

6. Foytik, Jerry, "Intraseasonal Demand Shifts for Fruits and Vegetables," Proceedings, Annual Meeting of the Western Farm Economics Association, San Luis Obispo, California, July 15-17, 1964.

Frederick Waugh's bulletin presents a brief comment on a relatively successful attempt to explain the behavior of U. S. grapefruit prices at the retail level with two variables: per capita production and income.⁷ Also to be noted is the report by Podany, et al.,⁸ concerning pricing and marketing of grapefruit in the Rio Grande Valley of Texas.

C. Procedure

The remainder of this thesis will be organized as follows: In Chapter II, a brief description of the production, marketing, and pricing processes relevant to Arizona grapefruit will be presented. Chapter III, the concluding chapter, will describe the data, methods, and results of the statistical analysis of Arizona grapefruit prices; discuss the statistical data, its uses and applicability; and conclude with a summary of the thesis and point out the areas for further study.

7. Waugh, Frederick V., Demand and Price Analyses, Technical Bulletin 1316, United States Department of Agriculture, Washington, D. C., 1964, p. 32.

8. Podany, Joseph C., Raymond O. P. Farrish, and Robert Bohall, "Citrus Prices and Market Structure in the Lower Rio Grande Valley," United States Department of Agriculture. (Manuscript in process)

CHAPTER II.

PRODUCTION, MARKETING, AND PRICING OF ARIZONA GRAPEFRUIT

The purpose of this chapter is to present a discussion of the economic, institutional, organizational, and technical conditions under which Arizona grapefruit are produced and marketed and to describe the factors which appear to be important influences on the price of Arizona grapefruit.

A. Grapefruit Production in Arizona and the United States

Trends in Acreage and Production

Nearly all of the grapefruit and other citrus grown commercially in Arizona is found either in the Salt River Valley near Phoenix or in the irrigated areas surrounding Yuma in the southwestern part of the state. Grapefruit is the largest volume citrus crop grown in the state. The production of grapefruit has remained relatively stable, especially since the 1958-59 season. The twenty-third annual report of the Desert Grapefruit Administrative Committee shows that in the 1963-64 production season production of fresh grapefruit in Arizona was about 2.1 million packed boxes. (See Table I.) The average fresh grapefruit production, as determined by these reports, from the 1946-47 season through the 1963-64 season was 1.5 million packed boxes. Total grapefruit production in Arizona for the 1963-64 production season, as reported by the

Table I. Arizona Fresh Grapefruit Production by Producing Areas,
1941-42 through 1964-65

Year	Salt River Valley	Yuma	Total
(Thousand packed boxes) ^a			
1941-42	1,617	338	1,955
1942-43	919	272	1,191
1943-44	1,883	233	2,116
1944-45	1,915	410	2,325
1945-46	1,804	381	2,185
1946-47	1,305	309	1,614
1947-48	774	421	1,195
1948-49	360	483	843
1949-50	329	388	717
1950-51	1,331	435	1,766
1951-52	1,015	335	1,350
1952-53	1,296	357	1,653
1953-54	1,123	354	1,477
1954-55	1,048	367	1,415
1955-56	1,141	303	1,444
1956-57	1,086	231	1,317
1957-58	1,661	439	2,100
1958-59	1,163	337	1,500
1959-60	1,692	416	2,108
1960-61	1,156	299	1,455
1961-62	975	300	1,275
1962-63	624	260	884
1963-64	1,702	422	2,124
1964-65	1,450	324	1,774

Source: Desert Grapefruit Administrative Committee, Annual Reports,
1942-43 through 1964-65 editions.

a. Arizona packed box equals 64 pounds.

Statistical Reporting Service, was 3.2 million packed boxes. The average total grapefruit production in Arizona from the 1946-47 production season through the 1963-64 production season was 2.7 million packed boxes. Total grapefruit production during this period ranged from 1.9 million to a high of 4.1 million packed boxes, as shown by Table II. Acreage of Arizona grapefruit has also been quite stable in recent years. In 1965, the total grapefruit acreage was estimated to be 6,706 acres.

White Marsh seedless grapefruit is the principal grapefruit type grown in the state. The total acreage of white grapefruit within the state was 5,396 acres in 1962, of which 243 acres were nonbearing. Four thousand ninety-three acres of the white grapefruit in that year, all bearing, were in the Salt River Valley. The balance, including all the nonbearing acreage, was located in Yuma County.

Small acreages of the pink grapefruit varieties are grown in the state. The total bearing acreage of Ruby Red or Redblush grapefruit in Arizona in 1962 was 852 acres, of which 576 acres were in Yuma County. Nonbearing acreage of Ruby Red grapefruit in the state totaled 366 acres, of which the Salt River Valley contained 351 acres.¹

In the 1961-62 producing season, 83 percent of interstate shipments of Arizona grapefruit went to the eleven Western markets.² The primary destination was the state of California, which absorbs annually approximately 20 percent of all interstate shipments from Arizona. The

1. "Arizona Citrus," Arizona Agricultural Extension Service, 1962, 1965. (Processed)

2. Desert Grapefruit Administrative Committee, Annual Report, 1962.

Table II. United States Grapefruit Production by States, 1925-64

Year	Arizona ^a	California ^a	Florida ^b	Texas ^b	United States
(Thousand packed boxes)					
1925-26	150	600	7,600	200	8,550
1926-27	120	672	8,600	361	9,753
1927-28	176	720	7,500	524	8,920
1928-29	211	972	11,300	753	13,236
1929-30	365	1,000	8,300	1,550	11,215
1930-31	400	1,290	15,800	1,200	18,690
1931-32	450	1,431	10,700	2,600	15,181
1932-33	614	1,350	11,600	1,440	15,004
1933-34	800	1,772	10,900	1,200	14,672
1934-35	1,240	2,167	15,200	2,740	21,347
1935-36	1,800	2,267	11,500	2,780	18,347
1936-37	1,400	1,540	18,100	9,630	30,670
1937-38	2,750	1,943	14,600	11,840	31,133
1938-39	2,700	1,924	23,300	15,670	43,594
1939-40	2,900	1,992	15,900	14,400	35,192
1940-41	2,650	1,983	24,600	13,650	42,883
1941-42	3,380	3,181	19,200	14,500	40,261
1942-43	2,600	3,071	27,300	17,510	50,481
1943-44	4,080	3,300	31,000	17,710	56,090
1944-45	3,750	3,830	22,300	22,300	52,180
1945-46	4,100	3,350	32,000	24,000	63,450
1946-47	4,100	3,120	29,000	23,300	59,520
1947-48	3,000	2,430	33,000	23,200	61,630
1948-49	1,880	2,150	30,200	11,300	45,530
1949-50	3,400	2,500	24,200	6,400	36,500
1950-51	3,150	2,730	33,200	7,500	46,580
1951-52	2,140	2,160	36,000	200	40,500
1952-53	3,000	2,460	32,500	400	38,360
1953-54	2,670	2,500	42,000	1,200	48,370
1954-55	2,470	2,420	34,800	2,500	42,190
1955-56	2,370	2,510	38,300	2,200	45,380
1956-57	2,180	2,410	37,400	2,800	44,790
1957-58	2,780	2,400	31,100	3,500	39,780
1958-59	1,870	2,530	35,200	4,200	43,800
1959-60	3,220	2,700	30,500	5,200	41,620
1960-61	2,260	2,640	31,600	6,800	43,300
1961-62	2,270	2,940	35,000	2,700	42,910
1962-63	2,170	2,500	30,000	70	34,740
1963-64	3,210	3,900	26,300	500	33,910

Source: Agricultural Statistics, USDA, U. S. Government Printing Office, Washington, D. C., various annual issues.

- a. Arizona-California packed box equals 64 pounds.
- b. Florida-Texas packed box equals 80 pounds.

California production of desert³ and other grapefruit is utilized almost exclusively within that state, as the percentage of California's production that is shipped interstate has never exceeded 15 percent since 1942.⁴

Relative Importance of Arizona Grapefruit Industry

Arizona grapefruit production has comprised an average of 5.4 percent of national production of fresh grapefruit for the period beginning with the 1946-47 production season up to and including the 1963-64 season. The comparative figures for Florida, Texas, and California are 72.1 percent, 16.0 percent, and 6.5 percent, respectively.⁵

In the 1963-64 production season, Arizona fresh grapefruit production comprised 9.1 percent of the national fresh grapefruit production, while Florida comprised 77.4 percent, California 11.2 percent, and Texas 2.2 percent. (The low Texas proportion is not typical due to a severe freeze in that year.)

In absolute numbers, Arizona fresh grapefruit production has averaged 1.5 million packed boxes per year since the 1946-47 season up to and including the 1963-64 season. Comparable figures for California, Florida, and Texas during this same time period are 1.8, 15.7, and 3.5 million packed boxes, respectively.

3. The Desert Citrus area is defined to include all of the Arizona citrus production, plus the Coachella and Imperial Valleys in southern California.

4. Desert Grapefruit Administrative Committee, Annual Report, 1942-64 editions.

5. Hill, James S., Desert Grapefruit Industry, Agricultural Experiment Station, University of Arizona, Tucson, 1964, pp. 5, 9.

The amount of Arizona grapefruit production processed each season from the 1946-47 season up to and including the 1963-64 season has averaged 1.1 million packed boxes. Comparable figures for California, Florida, and Texas are .8, 20.5, and 2.7 million packed boxes, respectively. (See Table III.)

From the above it is evident that Arizona grapefruit production represents only a minor portion of the total United States fresh grapefruit production. Since the Arizona grapefruit must compete on a national market with grapefruit from other producing areas, any product distinctions or atypical production characteristics might prove helpful in developing explanations for variations in Arizona grapefruit prices.

Seasonal Production Patterns

An examination of monthly shipments of Arizona grapefruit (Table IV) reveals a seasonal increase in shipments for the first three months of the production season (November, December, and January). Production remains fairly steady during the months of February, March, and April. Shipments are normally heaviest near the end of the production season in May and June, a time at which higher grapefruit prices prevail. Shipments decline in July as the production season for grapefruit in Arizona ends, and because deterioration of the fruit begins to occur at this time.

Production of Grapefruit for Processing

Utilization of the Arizona grapefruit has consistently been mostly in the fresh form. The percentage of desert grapefruit production that has been processed has averaged 39.8 percent, as compared with 46.2

Table III. Fresh Grapefruit Production by States, 1925-26 through 1963-64

Year	Arizona	California	Florida	Texas	United States
(Thousand packed boxes) ^a					
1925-26	148	578	7,188	194	8,108
1926-27	118	650	7,909	353	9,030
1927-28	174	698	6,901	515	8,288
1928-29	208	950	10,179	739	12,076
1929-30	361	978	6,596	1,512	9,447
1930-31	396	1,268	12,815	1,128	15,607
1931-32	446	1,409	9,698	2,477	14,030
1932-33	593	1,328	8,989	1,387	12,286
1933-34	762	1,686	8,443	1,105	11,996
1934-35	1,052	1,823	9,550	2,328	14,753
1935-36	1,658	2,111	7,762	2,130	13,661
1936-37	947	1,162	11,233	7,026	20,368
1937-38	2,104	1,832	8,349	6,589	18,874
1938-39	1,968	1,840	12,226	8,366	24,400
1939-40	2,003	1,904	6,998	7,444	18,349
1940-41	1,931	1,809	10,624	7,371	21,735
1941-42	2,144	2,679	8,956	8,330	22,109
1942-43	1,254	2,649	9,603	9,582	23,088
1943-44	2,163	2,665	10,436	9,336	24,600
1944-45	2,365	3,031	7,059	12,686	25,141
1945-46	2,255	2,443	9,724	13,378	27,800
1946-47	1,634	2,354	10,414	13,815	28,217
1947-48	1,254	1,755	9,709	12,174	24,892
1948-49	872	1,541	13,754	5,956	22,123
1949-50	750	1,558	10,571	3,825	16,704
1950-51	1,851	1,819	15,197	2,825	21,692
1951-52	1,334	1,395	19,172	172	22,073
1952-53	1,702	1,707	17,305	300	21,014
1953-54	1,525	1,686	20,451	850	24,512
1954-55	1,470	1,705	18,996	1,840	24,011
1955-56	1,459	1,726	19,482	1,625	24,292
1956-57	1,334	1,671	18,187	1,645	22,837
1957-58	2,100	1,775	14,544	2,503	20,922
1958-59	1,455	1,787	16,479	2,965	22,686
1959-60	2,107	1,803	16,032	3,881	23,823
1960-61	1,398	1,720	15,726	5,444	24,288
1961-62	1,275	1,790	17,811	2,294	23,170
1962-63	890	1,601	13,913	45	16,449
1963-64	2,124	2,637	14,539	430	19,735

Source: Citrus Fruits--By States--Production, Use, Value, USDA, U. S. Government Printing Office, Washington, D. C., various annual issues.

a. Packed box equals 64 pounds.

Table IV. Arizona Fresh Grapefruit Shipments (Intrastate and Interstate) by Months, 1948-1964

Year	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Total for Season
(Thousand packed boxes)										
1948-49	86	149	55	64	153	101	129	94	NA	831 ^a
1949-50	121	154	69	37	83	74	100	24	NA	662 ^a
1950-51	161	146	147	172	215	187	191	303	234	1,758
1951-52	65	196	160	170	194	150	198	127	32	1,294
1952-53	87	123	183	133	154	133	306	373	129	1,622
1953-54	108	153	189	136	132	120	230	222	175	1,465
1954-55	196	158	265	176	143	177	136	112	29	1,392
1955-56	44	198	188	159	180	136	196	284	44	1,429
1956-57	68	178	133	130	155	127	140	241	105	1,277
1957-58	179	180	206	204	316	241	566	145	6	2,043
1958-59	183	167	227	169	165	142	209	158	45	1,465
1959-60	160	153	224	182	131	241	396	357	233	2,077
1960-61	115	179	166	135	170	182	128	150	171	1,396
1961-62	124	151	138	160	207	109	139	180	41	1,249
1962-63	101	176	132	114	127	71	93	56	1	871
1963-64	242	180	248	320	257	211	313	195	89	2,055
Average	127.50	165.06	170.62	153.81	173.88	150.12	216.88	188.81	94.57	

Source: Desert Grapefruit Administrative Committee, Annual Reports, 1949-64.

NA Not available (not clear in source if July shipments were zero or not reported)

a. Excluding July shipments, if any.

percent for the United States during the time period 1946-47 through 1963-64. The average percentage of Arizona production processed during this time period has been slightly above the desert figure at 40.8 percent as shown by Table V. The percentage of Texas production that has been processed during this same time period has averaged 29.5 percent, and the percentage of Florida production processed during this same time period has averaged 50.2 percent.

B. Trends and Factors in Consumption

Characteristics of Arizona Grapefruit

Arizona grapefruit have unique characteristics which differentiate this product from the nondesert fruit. It typically has a thicker peel, a higher acid content, and a comparatively lower juice content than fruit from other regions. Many consumers therefore prefer grapefruit from other areas to the Arizona product. These quality characteristics vary greatly from year to year and are a major influence on the price received for the commodity.

Trends in Consumption of Grapefruit and Competing Products

Per capita consumption of fresh grapefruit in the aggregate has declined from the fourteen-pound figure in 1946 (as shown by Table VI) to less than nine pounds in recent years. At the same time, no appreciable increase in consumption of other citrus or other fresh fruit products has occurred. In fact, per capita consumption of fresh fruits in the aggregate has been declining (mostly from substitution of canned or frozen forms). Per capita consumption figures give an indication of

Table V. Grapefruit Produced for Processing, United States, by States, 1930-31 through 1963-64.

Year	Arizona ^a	California ^a	Florida ^b	Texas ^b	United States
(Thousand packed boxes)					
1930-31	NA	NA	2,893	56	2,949
1931-32	NA	NA	993	103	1,036
1932-33	15	NA	2,526	46	2,587
1933-34	31	39	2,369	86	2,525
1934-35	180	140	5,545	383	6,248
1935-36	134	99	3,646	619	4,498
1936-37	445	258	6,759	2,563	10,025
1937-38	634	61	6,157	5,203	12,055
1938-39	399	39	9,212	5,531	15,181
1939-40	544	62	8,812	6,900	16,318
1940-41	706	150	13,876	6,223	20,955
1941-42	1,222	478	10,143	6,118	17,961
1942-43	1,334	400	17,584	7,876	27,194
1943-44	1,905	613	20,446	8,322	31,286
1944-45	1,373	776	15,135	9,554	26,839
1945-46	1,833	885	22,136	10,562	35,416
1946-47	1,531	733	15,866	8,920	27,050
1947-48	790	639	19,451	8,661	29,541
1948-49	956	581	16,306	5,270	23,113
1949-50	2,638	921	13,489	2,510	19,558
1950-51	1,287	878	17,853	4,610	24,628
1951-52	794	745	13,678	8	15,225
1952-53	1,283	731	15,035	75	17,124
1953-54	1,130	794	20,089	325	22,338
1954-55	988	689	15,644	600	17,921
1955-56	896	761	18,658	500	20,815
1956-57	831	716	19,053	1,080	21,680
1957-58	665	602	16,396	922	18,585
1958-59	400	720	18,561	1,160	20,841
1959-60	1,093	846	14,308	1,244	17,491
1960-61	842	888	15,714	1,281	18,725
1961-62	875	1,008	16,809	356	19,048
1962-63	1,260	875	15,962	0	18,097
1963-64	1,061	1,238	11,581	25	13,905

Source: Citrus Fruits--By States--Production, Use, Value, USDA, SRS, U. S. Government Printing Office, Washington, D. C., various annual issues.

NA Not available

a. Arizona-California packed box equals 64 pounds.

b. Florida-Texas packed box equals 80 pounds.

Table VI. Consumption of Ten Major Fresh Fruits and Total Fresh Fruits, Pounds per Capita, United States, 1936-63

Year	'Oranges, 'Tangerines'	'Grape- 'fruit'	'Lemons'	'Total' ^a 'Citrus'	'Apples'	'Bananas'	'Peaches'	'Grapes'	'Pears'	'Prunes, 'Plums'	'Straw- 'berries'	'Total Fresh Fruit'
1936	31.6	10.2	4.3	46.2	27.6	23.6	10.9	6.3	6.0	2.7	2.9	129.1
1937	28.7	12.3	3.4	44.5	33.6	26.9	14.2	7.4	6.6	2.6	3.4	142.5
1938	35.1	9.6	4.3	49.1	28.2	24.1	13.1	5.6	6.4	2.7	2.9	135.3
1939	43.4	13.7	4.2	61.4	30.7	22.1	15.3	6.0	6.5	2.7	3.3	151.5
1940	41.0	11.1	4.5	56.7	29.7	20.3	13.1	6.3	7.1	2.5	3.3	142.1
1941	40.7	12.2	4.7	57.7	31.7	19.5	18.6	6.2	6.4	2.4	3.1	148.9
1942	41.2	12.1	4.3	57.7	28.1	9.4	14.6	6.2	6.7	2.4	3.4	131.4
1943	42.6	12.5	5.0	60.3	24.9	8.2	8.4	5.6	5.4	2.2	1.8	119.7
1944	50.1	13.0	4.9	68.2	25.5	10.6	17.9	4.9	7.1	2.7	1.2	141.7
1945	47.8	13.5	5.1	66.6	22.9	14.2	18.2	5.6	7.3	2.3	1.3	142.0
1946	40.3	14.0	4.7	59.1	23.0	17.3	16.6	5.7	6.8	2.7	1.6	136.5
1947	43.4	13.9	4.8	62.2	25.4	20.1	14.8	6.6	5.9	2.3	1.9	142.3
1948	37.5	12.3	4.5	54.4	26.3	21.9	11.3	5.8	4.4	2.1	1.8	131.1
1949	32.8	10.9	4.1	47.9	24.7	20.5	11.6	5.2	5.5	2.4	1.6	122.8
1950	28.9	8.2	4.0	41.3	22.7	19.1	7.8	5.4	4.1	1.8	1.6	106.8
1951	30.7	10.3	4.0	45.1	25.7	18.3	9.4	5.9	4.0	2.3	1.8	115.2
1952	29.9	10.5	3.9	44.4	21.6	18.9	10.7	6.0	4.4	1.7	1.6	112.1
1953	29.8	9.7	3.7	43.4	20.9	21.7	10.3	4.8	3.9	2.1	1.4	111.1
1954	26.5	11.0	3.6	41.2	20.0	20.2	10.0	5.1	3.7	1.4	1.2	105.7
1955	26.9	10.7	3.4	41.2	19.6	19.5	6.1	5.0	3.4	1.8	1.2	100.6
1956	24.5	10.5	3.2	38.5	18.9	20.3	9.0	4.7	3.7	1.9	1.5	100.7
1957	23.4	9.5	3.3	36.5	19.3	20.2	8.6	3.9	3.7	1.6	1.7	98.4
1958	18.5	8.7	3.0	30.5	22.6	20.6	10.5	4.1	3.5	1.2	1.5	97.1
1959	21.2	9.1	2.9	33.4	23.0	22.0	9.7	3.9	3.2	1.7	1.3	100.9
1960	20.5	9.6	2.9	33.3	20.1	23.2	9.5	3.9	2.6	1.2	1.4	97.5
1961	17.9	9.4	2.8	30.4	18.6	21.9	9.5	3.4	2.6	1.4	1.6	92.0
1962	17.1	8.7	2.8	29.0	19.5	20.1	8.2	4.0	2.7	1.4	1.6	88.9
1963 ^b	12.9	6.0	2.6	21.9	18.7	20.8	7.6	3.7	2.0	1.5	1.6	80.4

Source: Florida Citrus Manual, Florida Citrus Commission, 1963-64 season, p. 103; and Agricultural Statistics, USDA, U. S. Government Printing Office, Washington, D. C., various annual issues.

a. Includes a small quantity of limes and tangelos, which explains why the figures in the Total Citrus column are not the exact sum for oranges, grapefruit and lemons.

b. Preliminary.

the change in demand over time in response to changes in income, prices, and consumer preferences. If per capita consumption of fresh grapefruit had declined as per capita consumption of other possible competing fruits had increased, this might suggest a substitution because of changing relative prices between fresh grapefruit and the competing fresh product concerned. However, as there has been no increase in consumption of related fresh fruits, this explanation for the decline in fresh grapefruit consumption is not supported by the evidence.

C. Marketing Patterns for Arizona Grapefruit

Marketing Procedures

The marketing patterns for Arizona grapefruit are similar in most respects to the marketing patterns for all other areas, the exception possibly being the proportion of fruit diverted to the processed market. Prices paid for grapefruit for processing are relatively low; hence, a smaller proportion of the fruit is processed as compared with other grapefruit producing states. In order to facilitate understanding of the grapefruit industry, a simple flow chart which excludes foreign outlets has been presented below. Figure 1 shows the movement of grapefruit from the producer to the consumer. Under normal circumstances (when no freeze or other situation which results in the fruit being unsuitable for fresh market having occurred) the producer will sell his grapefruit to the packinghouse. The packer will transport, clean, grade, size, wax, cull, and package the fruit. The "culled"⁶ fruit is then sold to

6. "Culled" fruit is the grapefruit discarded by the packinghouse which, because of various external and internal defects, is unsuitable for sale as fresh fruit.

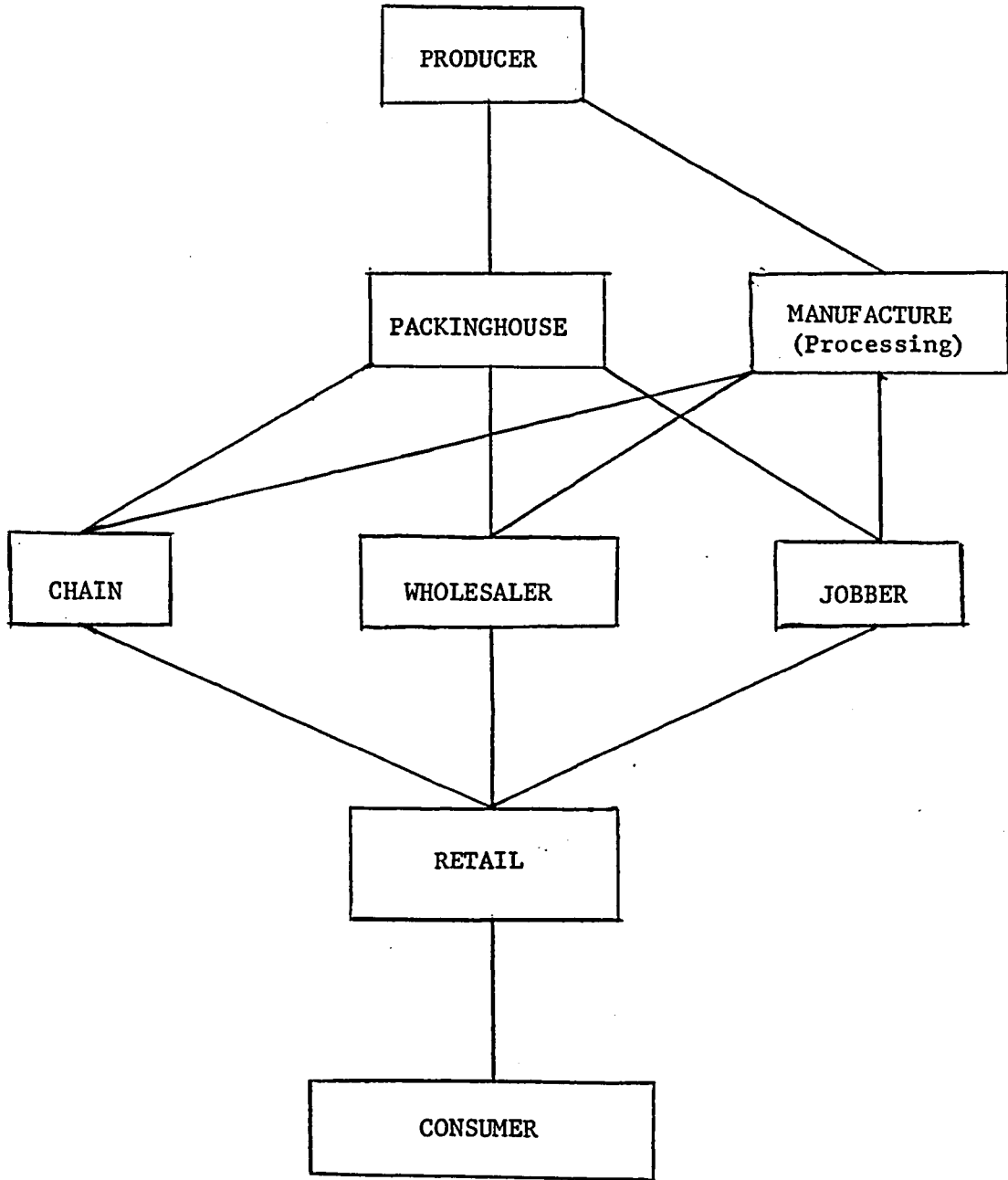


Figure 1. Movement of Desert Grapefruit

the processor. The producer or grower who participates in cooperative selling will not receive any return on his produce until the fruit is sold by the packinghouse and the costs of the packinghouse services and operations have been paid. The grower may also sell directly to the processor, should the fruit not merit consideration for the fresh market.

As stated earlier, the packinghouse sells the grapefruit to the processor or to more advanced middlemen such as the wholesaler, chain operation, or the jobber. The cost of transportation between these points is borne by the buyer in each case.

The wholesaler, chain operation, or jobber sells to the retailer, the cost of transport being borne by the retailer. From the retailer the fruit goes to its intended destination, the consumer.

Grapefruit produced in Arizona is marketed under an arrangement by which the packinghouse serves as the central coordinating agency, performing a number of operations and services for producers. In the cooperative marketing of grapefruit, the growers voluntarily form "lots." When the packinghouse sells a particular lot, the proceeds (after deducting packinghouse and other expenses) are distributed to the members of the lot according to their percentage contribution to the total produce sold in that lot.

The marketing of Arizona grapefruit revolves around the packinghouse which serves as a central agency to the grapefruit producers. There are eighteen grapefruit packinghouses in Arizona (all in Yuma and Maricopa Counties) which handle all of the commercial Arizona fruit. In a recent survey, to which sixteen of these eighteen packers responded,

various organizational forms were found.⁷ Of the sixteen, five were cooperative packers, two were grower-packers, five were custom packers, and the other four were various combinations of the above.

For grapefruit producers and packers in the Salt River Valley area, a plant processing grapefruit for a soft drink concentrate located at Glendale represents an economic outlet for the culled fruit. There is one packinghouse in Yuma County which operates its own cannery for single-strength grapefruit juice. As some packinghouses are affiliated with large citrus chains, the culls are sometimes shipped directly to the home plant with which they are associated (usually in nearby California).

Population Centers and Transport Cost as Demand Factors

Since the population of the United States is concentrated mainly east of the Mississippi River, Arizona grapefruit must overcome a disadvantage in freight rates to the Eastern and Midwestern markets when compared with Texas and Florida. Due to their geographical location, Florida and Texas are able to participate economically in the Eastern and Midwestern markets almost at all times during the production season, while Arizona and California often find it unprofitable to do so.

A look at existing freight rates for fresh grapefruit shows that freight rates are a substantial portion of the cost of the fruit at terminal markets. This issue will be discussed in more detail later in this chapter. Florida has an absolute and relative rail-cost advantage

7. Unpublished figures provided through the courtesy of James Hill, Department of Agricultural Economics, University of Arizona.

over the other major grapefruit producing areas with respect to the Eastern market. Texas has an absolute and relative rail-cost advantage over the other major grapefruit producing regions with respect to the Midwestern markets. Likewise, Arizona and California have an absolute and relative rail-cost advantage over Florida and Texas with respect to the Western market. The term "rail-cost advantage" is used because rail charges are less in total amount for markets close to the point of origin. For distant points, however, a blanket rate is charged, which means that rail charges are not an exact function of miles traveled. Charges for mechanical refrigeration of the fruit while in transit do, however, increase with all significant mileage changes.

Although a definite advantage in terms of freight rates to certain destinations exists for all producing regions, the variation in producing seasons between areas makes it possible for different areas to compete in all markets when the price is favorable. The availability of markets for Arizona grapefruit, both within and without the immediate home area, is dependent in large part upon Florida and Texas grapefruit production. The degree of competition from Texas and Florida grapefruit has a substantial effect on Arizona grapefruit prices. When Florida and Texas are at the height of their production season, it does not usually prove profitable for Arizona and California grapefruit producers to ship fruit to Midwestern and Eastern markets. When Florida and Texas are shipping small quantities of fruit, the markets for Arizona grapefruit normally expand to the Midwestern and Eastern areas. In most years, the Midwestern and Eastern markets become profitable to Arizona grapefruit

producers during the latter part of May--the time at which the production season for Florida and Texas has normally ended.

Marketing Agreements

Arizona and California desert fresh grapefruit is marketed under a marketing agreement allowable under the provisions of the Agricultural Marketing Agreement Act of 1937. The purpose of programs under this Act is to bring about orderly marketing and, hence, improve prices to producers. Provisions of a marketing order are mandatory, but participation in a marketing agreement is voluntary. A marketing agreement is a contract between handlers of a commodity and the Secretary of Agriculture. The agreement is to regulate marketing in interstate commerce. The reason for the Agricultural Marketing Agreement for Arizona grapefruit is to insure producers of fresh grapefruit a reasonable price for their produce through the restriction of supply of grapefruit to only the better quality fruit.

A marketing order is mandatory and is issued by the Secretary of Agriculture. It may only be issued for a commodity if two-thirds of the producers of a commodity in a specific area, or two-thirds by volume, approve the order. If the Secretary of Agriculture feels that the provisions of the Act can be accomplished without the order, the consent of one-half of the handlers (in addition to a two-thirds majority of producers) of the commodity by volume is necessary to implement the order. If the Secretary feels that an order is the only practical way to accomplish the provisions of the Act, the consent of one-half of the handlers by volume is not necessary.

In order for marketing agreements and orders to be successful, production of the commodity must be centrally located, and available markets for the commodity must be existent and separable.⁸ The reason that Arizona grapefruit is marketed under the Act is that it is produced by "batches" and must be marketed when it has matured. Markets for Arizona grapefruit are distant from the producing areas (with the exception of California). Marketing costs are usually fixed and, hence, inflexible; weather changes affect the crop and, therefore, the supply of fruit to various outlets. Due to the variation in the conditions affecting supply, prices fluctuate greatly throughout the production season and make the marketing order and agreement desirable to grapefruit producers and handlers.

Within the marketing order or agreement, provision is made for the selection of an agency among the participants to carry out the terms of the program. These terms include (1) ways and means for handlers to pay for the administrative expenses of the agency in conducting the program, (2) regulatory provisions to assure compliance of participants, (3) regular reports to be made to handlers, and (4) the feasible time for termination of the program. The administrative agency for the desert grapefruit industry is the Desert Grapefruit Administrative Committee, which is composed of desert area growers and packers from both California and Arizona. This agency was formed in 1941 and makes annual reports to producers and handlers, in addition to its function of supply regulation. Serving in conjunction with the Grapefruit Administrative

8. Yearbook of Agriculture, 1954, "Marketing Agreements," pp. 357-363.

Committee is the Grapefruit Advisory Board, which operates in an advisory capacity to the committee. The purpose of the committee is

. . . to improve seasonal average prices by marketing fruit not only of the highest quality, but of sizes acceptable to the consumer. It is the intention of the program and its sponsors to so direct the movement of grapefruit into fresh fruit channels by grade and size regulations so as to provide safeguards against destructive price decline as caused by the normal uncontrolled marketing of fruit of undesirable grades or sizes in excessive quantities.⁹

The Grapefruit Administrative Committee has thus conducted its program by regulating grades and sizes, and, through this process, indirectly regulating volume. Controls such as these are used when the nature of demand or supply is such that supply allocations to different markets will result in increased returns to producers. This, of course, presupposes that the markets are separated by either form, time, or place. In the case of grapefruit, form utility is the main market separating factor. The alternate market for fresh grapefruit is processed grapefruit juice, which is not always a profitable economic outlet for Arizona producers.¹⁰

D. Prices

Free-on-Board Price and On-Tree Returns to Fresh Grapefruit

"On-tree returns" to grapefruit producers is the effective price per unit of product which the farmer receives. The packer computes the on-tree return to a particular lot by subtracting the cost of picking,

9. Desert Grapefruit Administrative Committee, Annual Report, 1951-52, p. 1.

10. On-tree returns to Arizona producers for processed grapefruit are sometimes zero or negative.

hauling, packing, selling and advertising, and marketing program assessments from the F.O.B. price. There is a close but not an invariant relationship between F.O.B. and on-tree prices. Table VII shows that the average differential between F.O.B. and on-tree prices for the seasons beginning 1946 through 1962 is \$1.50, while the differential during this same time period ranged from \$1.30 to \$1.77. Although there has been considerable year-to-year variation in prices of fresh grapefruit, an almost direct functional relationship was found between F.O.B. and on-tree prices. The scatter diagram relating the two variables indicates that a fixed minimum unit marketing charge does exist, and beyond this minimum value a functional relationship can be observed. The slope of the approximate freehand line expressing this relationship is positively sloped and suggests the possibility that the F.O.B. price can be expressed as a constant markup plus a constant percentage of the on-tree price.

Since grapefruit prices in Arizona have been quite variable, a weighted average of some one of these prices might enable us to obtain a clearer indication of what a representative price would be in any average month. A distinct price pattern is observed when the Arizona monthly F.O.B. prices for 1946-47 to 1963-64 seasons are weighted by the quantity shipped in the corresponding months.

Seasonal Price Movements

Arizona fresh grapefruit prices show a distinct seasonal trend which is inversely related to fresh grapefruit shipments. Prices for Arizona grapefruit decrease as the production season progresses, reaching

Table VII. Prices for Arizona Grapefruit, 1938-39 through 1964-65.

Year	F.O.B. Fresh	Packinghouse-door Fresh	On-tree Fresh	On-tree Processed
(Dollars per packed box) ^a				
1938-39	1.12	.27	.17	.01
1939-40	1.19	.34	.24	.11
1940-41	1.03	.36	.26	.04
1941-42	1.42	.74	.62	.19
1942-43	2.24	1.48	1.32	.64
1943-44	2.52	1.66	1.48	.87
1944-45	2.93	2.06	1.88	.68
1945-46	2.20	1.32	1.13	.50
1946-47	1.68	.64	.38	-.10
1947-48	1.88	.68	.48	-.04
1948-49	2.37	1.00	.85	.05
1949-50	2.35	1.24	1.05	.16
1950-51	2.03	.13	.64	.27
1951-52	2.37	1.19	1.00	.07
1952-53	2.29	1.06	.84	.19
1953-54	2.44	1.16	.94	.18
1954-55	2.28	1.00	.78	.11
1955-56	2.49	1.20	.98	.12
1956-57	2.84	1.56	1.34	.11
1957-58	3.00	1.73	1.51	.32
1958-59	3.14	1.80	1.55	.14
1959-60	2.85	1.50	1.27	.14
1960-61	2.80	1.45	1.22	.23
1961-62	2.60	1.13	.83	.03
1962-63	3.25	1.93	1.58	-.03
1963-64	3.70	2.40	2.05	NA
1964-65	3.15	1.80	1.45	NA

Source: Agricultural Prices, SRS, USDA, U. S. Government Printing Office, Washington, D. C., various annual issues.

a. Arizona packed box equals 64 pounds.

NA Not available.

the low point in March and increasing thereafter until the end of the marketing season in July. Average monthly prices for the period are shown in Table VIII. The high F.O.B. price is normally attained at the beginning of the production season in November, which averaged \$2.68 (per 64-pound packed box), and the low price, which is usually attained in March, averaged \$2.32. The season ending price (in July) averaged slightly below the season opening price at \$2.65. As shown by Table VIII, the season average price is \$2.49, which is equivalent in amount to the May weighted price.

Year-to-Year Price Movements

The intensity of the yearly variability of price gives an indication of the price uncertainty with which grapefruit producers must cope. If the yearly price changes can be accurately estimated, the grapefruit price outlook can be somewhat determined. Reliable price projections also provide the grapefruit producers with information on the probable future profitability and the need for expansion or contraction of present grapefruit acreage or production.

Comparisons with Other Regions

Prices received by Arizona grapefruit producers (on-tree returns) have been comparable with other grapefruit producing areas as shown by Table IX. There is a distinct seasonality of price variation which is due mainly to the overlapping production seasons with respect to the other major grapefruit producing areas. Prices are usually highest at the beginning and ending of the production season for Arizona producers and lowest in the middle of the production season (Table VIII).

Table VIII. Weighted Average Arizona F.O.B. Monthly Prices^a
for Fresh Grapefruit.

Month	Weighted ^b F.O.B. Price	Percentage of Season Average Price
	(Dollars)	(Percent)
November	2.68	108
December	2.56	103
January	2.41	97
February	2.37	95
March	2.32	93
April	2.36	95
May	2.49	100
June	2.56	103
July	2.65	106
Season	2.49	

a. Weighted by quantity.

b. Production data taken from Desert Grapefruit Administrative Committee Annual Reports. Includes interstate and intrastate shipments only. Prices taken from data obtained from the Statistical Reporting Service, 1946-63.

Table IX. On-tree Returns for Selected States, 1930-63.

Year	Arizona	California	Florida	Texas
(Dollars per packed box) ^a				
1930-31	1.44	1.50	.42	.94
1931-32	.85	.84	.57	.54
1932-33	.75	.75	.34	.71
1933-34	.74	.74	.57	.58
1934-35	.68	.71	.34	.50
1935-36	.75	.67	.68	.63
1936-37	.76	1.15	.46	.31
1937-38	.33	.46	.62	.38
1938-39	.17	.37	.24	.20
1939-40	.24	.32	.50	.25
1940-41	.26	.32	.34	.28
1941-42	.62	.67	.58	.46
1942-43	1.32	1.26	.86	.86
1943-44	1.48	1.58	1.07	1.12
1944-45	1.88	1.68	1.38	1.10
1945-46	1.13	1.46	1.20	1.01
1946-47	.38	.93	.75	.81
1947-48	.48	1.32	.42	.42
1948-49	.85	1.81	.76	.58
1949-50	1.05	2.27	1.59	1.56
1950-51	.64	1.37	.98	1.14
1951-52	1.00	1.66	.65	2.63
1952-53	.84	2.24	.86	1.97
1953-54	.94	2.33	.69	1.36
1954-55	.78	2.19	.76	1.02
1955-56	.98	2.52	.74	.98
1956-57	1.34	2.76	1.09	.92
1957-58	1.51	3.05	1.10	1.02
1958-59	1.55	2.71	1.09	1.15
1959-60	1.27	1.92	1.05	.95
1960-61	1.22	1.60	.99	.86
1961-62	.83	1.40	.86	.86
1962-63	1.58	2.73	1.62	3.23
1963-64	2.05	2.30	2.14	2.57
1964-65	1.45	1.13	1.67	1.70

Source: Agricultural Prices, SRS, USDA, U. S. Government Printing Office, Washington, D. C., various annual issues.

a. Per 64-pound equivalent packed box.

Price Comparisons Among Desert Producing Areas

Within the desert area a considerable price differential existed between producing areas until 1957. Since 1957 this price differential has steadily decreased. The Coachella Valley grapefruit has consistently received a premium for its production, while the Yuma County grapefruit has received the lowest average price of all the desert areas for its production. The Salt River and Imperial Valleys have received about the same average price for their production.

After 1940, the Coachella Valley developed a reputation for production of quality fruit. This was due mainly to the fact that growing conditions in the Coachella Valley area permits growers to produce grapefruit with a thinner peel and with a lower acidity. The Sunkist organization, with their intensive promotion work, developed considerable consumer acceptance for the Coachella fruit. This was possible since it does have a thinner, smoother skin than the other desert fruit and its physical appearance and internal composition is preferred by consumers.

Relatively high grapefruit prices during the latter part of the 1950's enticed Coachella grapefruit growers to plant more acreage.¹¹ From 1957 to 1962 the bearing acreage of grapefruit in the Coachella Valley increased from 2,400 acres to 6,000 acres, or an increase in acreage of 150 percent over the 1957 figure. These younger trees did not, however, produce the type and quality fruit as did the older trees. In addition, the fruit from the older trees began to lose its size

11. Hill, Hillman and Henderson, Some Economic Aspects of the Arizona Citrus Industry, Arizona Agricultural Experiment Station, 1965.

advantage. Since 1957, with the loss of the advantages in quality; prices for Coachella grapefruit have declined considerably.

The price difference that exists for Yuma County grapefruit is not the result of inferior quality fruit but of unfortunate timing of harvest. The Yuma fruit is the first desert fruit to mature and, hence, shipments begin early. Due to this early maturity the Yuma fruit is usually shipped in largest volume during the winter and early spring when prices are at their seasonal low. (This is a time when the Florida and Texas production is being shipped in rather large volume.) During the months of May, June, and July, when Florida and Texas have practically ceased shipments, prices are exceptionally high but Yuma is also out of the market. The Salt River, Imperial and Coachella Valleys are still producing grapefruit at this time and are able to take advantage of the favorable price levels.

Interregional Price Comparison

Unadjusted price data for on-tree returns for fresh grapefruit to Arizona producers (prices are given in terms of per packed-box quantities) have averaged \$1.01 from the 1946-47 production season up to and including the 1962-63 production season. This is the lowest average return per packed box for any of the major grapefruit producing states. On-tree returns for Florida, Texas, and California producers during this same time period are \$1.17, \$1.57, and \$2.13, respectively. However, since the standard packed box in Florida and Texas weighs 80 pounds as compared to 64 pounds in Arizona and California, adjustment for an equivalent packed box was necessary. By multiplying the Florida and Texas

returns per packed box by .80, an equivalent 64-pound packed box figure is obtained. (See Table IX.) After the adjustment, average Florida and Texas on-tree returns per packed box become \$.94 and \$1.26, respectively, while the Arizona and California figures of course remain unchanged.

E. Factors Determining Prices for Arizona Grapefruit

Prices for grapefruit are determined by the interaction of demand and supply forces. Supply of Arizona grapefruit has remained fairly stable in absolute quantities and in terms of proportion of national fresh grapefruit production. The supply of fruit produced outside the Western areas has a substantial influence on Arizona and California prices. Changes in production in other states are quickly reflected in Arizona price quotations. (Since Arizona fresh grapefruit production constitutes such a small percentage of the total national production, damage to the Arizona crop has very little effect on prices received by producers in other areas.) Since the production of grapefruit in other areas substantially affects the price of Arizona grapefruit, outside production must be taken into consideration as an important price determining variable.

On the demand side, as was earlier indicated, U. S. per capita consumption of fresh grapefruit has been declining. The effect of declining demand has been reflected on relative prices. Although the price series used in this study were not deflated, on-tree returns have shown no significant upward trend since World War II.

Per capita disposable income has been increasing, but, as grapefruit is not considered as a luxury item, the income elasticity of demand

is expected to be low. The statistical analysis in Chapter III shows this to be the case with respect to Arizona grapefruit.

The Effect of Transportation Costs in Price Received for Arizona Fresh Grapefruit

Transportation costs have an important effect on prices received by Arizona packers and producers. Buyers at the points of destination will offer less for Arizona fruit than for fruit from producing points enjoying a lesser rate to the destination, since the buyer usually pays for the transportation charges. This becomes a significant difference with respect to Midwestern and Eastern markets where transportation costs for Texas and Florida grapefruit are much less than those for Arizona grapefruit.

Rail freight rates for fresh grapefruit shipments to various destinations were obtained from two railroad companies. In addition to the freight cost, a charge is also made for mechanical refrigeration. Tables X, XI, and XII present rail transportation charges for fresh grapefruit between various shipping points and destinations in the U. S. Freight charges for Arizona grapefruit in a standard carload ranged up to \$1.58 per packed box for Eastern destinations such as New York and were nearly that high (\$1.53) for Midwestern destinations such as Chicago or Saint Louis. In comparison, transportation charges from Florida producing points were \$1.10, \$1.07, \$1.18 and \$1.13 to New York, Philadelphia, Chicago and Saint Louis, respectively.

To illustrate the relative importance of transportation in the delivered cost of fresh grapefruit, some examples might be shown. For the average price in the 1961-62 producing season, transportation costs

Table X. Grapefruit Freight Rates from Phoenix and Yuma, Arizona, 1965.

To	Rate per Hundred- weight	Rate per Hundredweight, Times Minimum Weight ^a	Mechanical, Refriger- ation Charges	Total Cost per Car	Cost per Packed Box	Cost per Pound
(Dollars)						
Atlanta	2.03	712.53	152.09	864.62	1.58	.025
Chicago	2.03	712.53	124.70	837.23	1.53	.024
Dallas-Ft.Worth	1.33	466.83	NA	NA	NA	NA
Denver	1.18	414.18	98.85	513.03	.94	.015
Des Moines	1.83	642.33	NA	NA	NA	NA
Detroit	2.03	712.53	139.16	851.69	1.55	.024
Fargo, N. Dak.	1.83	642.33	NA	NA	NA	NA
Houston	1.33	466.83	121.67	588.50	1.07	.017
Kansas City	1.53	537.03	NA	NA	NA	NA
Little Rock	1.83	642.33	NA	NA	NA	NA
Minneapolis	1.83	642.33	124.70	767.03	1.40	.022
New Orleans	1.83	642.33	NA	NA	NA	NA
New York	2.03	712.53	152.09	864.62	1.58	.025
Oklahoma City	1.33	466.83	NA	NA	NA	NA
Omaha	1.53	537.03	114.07	651.10	1.19	.019
Philadelphia	2.03	712.53	NA	NA	NA	NA
Pittsburgh	2.03	712.53	NA	NA	NA	NA
Portland, Ore.	1.08	378.00 ^b	98.85	476.85	.87	.014
San Antonio	1.33	466.83	106.45	573.28	1.05	.016
St. Louis	2.03	712.53	124.70	837.23	1.53	.024
Seattle	1.18	413.00 ^b	98.85	511.89	.94	.015
Spokane, Wash.	1.28	448.00 ^b	98.85	546.85	1.00	.016

Source: Atchison, Topeka, and Santa Fe Railway System.

NA Not Available

a. 35,100 pounds minimum weight, except as where otherwise noted.

b. 35,000 pounds minimum weight.

Table XI. Grapefruit Freight Rates from San Fernando, California, 1965.

To	Rate per Hundred- weight	Rate per Hundredweight, Times Minimum Weight ^a	Mechanical Refriger- ation Charges	Total Cost per Car	Cost per Packed Box	Cost per Pound
(Dollars)						
Atlanta	2.03	712.53	152.09	864.62	1.58	.025
Chicago	2.03	712.53	124.70	837.23	1.53	.024
Dallas-Ft. Worth	1.33	466.83	114.07	580.90	1.06	.017
Denver	1.18	414.18	98.85	513.03	.94	.015
Des Moines	1.83	642.33	114.07	756.40	1.38	.022
Detroit	2.03	712.53	139.16	851.69	1.55	.024
Fargo, N. Dak.	1.83	642.33	124.70	767.03	1.40	.022
Houston	1.33	466.83	121.67	588.50	1.07	.017
Kansas City	1.53	537.03	114.07	651.10	1.19	.019
Little Rock	1.83	642.33	124.70	767.03	1.40	.022
Minneapolis	1.83	642.33	124.70	767.03	1.40	.022
New Orleans	1.83	642.33	129.27	771.60	1.41	.022
New York	2.03	712.53	152.09	864.62	1.58	.025
Oklahoma City	1.33	466.83	114.07	580.90	1.06	.017
Omaha	1.53	537.03	114.07	651.10	1.19	.019
Philadelphia	2.03	712.53	152.09	864.62	1.58	.025
Pittsburgh	2.03	712.53	139.16	851.69	1.55	.024
Portland, Ore.	.81	284.31 ^b	83.65	367.96	.58	.009
San Antonio	1.33	466.83	106.45	573.28	1.04	.016
St. Louis	2.03	712.53	124.70	837.23	1.53	.024
Spokane, Wash.	1.14	354.51 ^b	91.25	445.76	.71	.011

Source: Atchison, Topeka, and Santa Fe Railway System.

a. Minimum weight is 35,100 pounds, except as where otherwise noted.

b. Minimum weight is 40,000 pounds.

Table XII. Grapefruit Freight Rates from Belleview, Florida, 1965.

To	'Rate per 'Hundred- 'weight	Rate per Hundredweight, Times Minimum, Weight ^a	Mechanical, Refriger- ation Charges	Total Cost per Car	Cost per ,Packed Box	Cost per Pound
(Dollars)						
Atlanta	.36	101.79 ^b	73.00	174.79	.40	.006
Chicago	1.56	561.60	104.19	665.79	1.18	.018
Dallas-Ft.Worth	1.67	601.20	106.47	707.67	1.26	.020
Denver	2.21	795.60	129.27	924.87	1.64	.026
Des Moines	1.67	601.20	114.07	715.27	1.27	.020
Detroit	1.54	554.40	104.19	658.59	1.17	.018
Fargo, N. Dak.	1.99	716.40	129.27	845.67	1.50	.023
Houston	1.66	597.60	106.47	704.07	1.25	.020
Kansas City	1.65	594.00	114.07	708.07	1.26	.020
Little Rock	1.55	558.00	104.19	662.19	1.18	.018
Minneapolis	1.76	633.60	117.10	750.70	1.33	.021
New Orleans	.67	186.85 ^b	91.25	278.10	.64	.010
New York	1.51	543.60	73.00	616.60	1.10	.017
Oklahoma City	1.73	622.80	114.07	736.87	1.31	.020
Omaha	1.72	619.20	114.04	733.24	1.30	.020
Philadelphia	1.47	529.20	73.00	602.20	1.07	.017
Pittsburgh	1.52	547.20	104.19	651.39	1.16	.018
Portland, Ore.	2.21	795.60	159.69	955.29	1.70	.027
San Antonio	1.74	626.40	114.07	740.47	1.32	.021
St. Louis	1.48	532.80	104.19	636.99	1.13	.018
Spokane, Wash.	2.21	795.60	159.69	955.29	1.70	.027

Source: Seaboard Air Line Railroad Company

a. Minimum weight is 36,000 pounds, except as where otherwise noted.

b. Minimum weight is 27,888 pounds.

for Arizona fresh grapefruit (calculated on a minimum load for standard car rates as in Table X) ranged from 25 percent of delivered cost in Portland, Oregon, up to 38 percent of delivered cost in Atlanta, Georgia (among the destinations noted in Table X).

For short distances, truck transport is the most economical as well as the most rapid and convenient mode of transportation for grapefruit. The rates are usually lower per packed box for trucks as opposed to rail transport for less than carload lots and also for short distances. Arizona grapefruit is shipped almost exclusively by truck to California because of the lower rates and rapid service.

CHAPTER III.

THE STATISTICAL ANALYSIS

The primary purpose of this thesis is to develop measurements of the relationships associating the price of grapefruit in Arizona with factors which influence that price. The statistical technique of regression analysis will be employed to estimate these relationships. In this chapter, the procedure and results of the statistical analysis are discussed and the results summarized.

A. Considerations in the Formulation of the Statistical Analyses

Isolation of Important Variables

The description presented in the previous chapter of the production, marketing, and pricing of grapefruit, together with considerations derived from economic theory, suggest a number of variables which might be hypothesized to be important influences on the price of grapefruit. The first step in the analysis was to assemble the data series for the variables which were judged to be of interest. The series were then plotted on graphs against time, and on scatter diagrams against price and against one another where important relationships were hypothesized to exist. This procedure served to eliminate some variables and relationships from consideration and to gain insight into the nature of the relationships which were found to exist. Among the variables which were selected on this basis included, in addition to price, production of

grapefruit in Arizona and elsewhere in the United States, production of substitute fruit, consumer disposable income, population, quality of the fruit, and policies taken under the operation of the marketing agreement.

Considerations in the Formulation of the Statistical Model

Statistical analysis of demand and price relationships may be made either for the purpose of estimating the "true" demand curves of economic theory (i.e., the structural coefficients of a system of equations) or for the purpose of forecasting expected prices. Elmer Working¹ and others have shown why (because of what is called the "identification problem") single equations estimates obtained by least squares regression techniques may not result in the "true" demand curves. Various statistical methods have been developed, particularly through efforts at the Cowles Commission, which solve this problem. For forecasting purposes, it has been shown that single equation estimates obtained by least squares regression techniques should give the best unbiased forecasts,² providing the basic structure of demand remains unchanged. Fox³ found that for many agricultural products the results obtained with least squares estimates were practically identical to those obtained from the more elaborate methods developed to estimate structural equations. He

1. Working, Elmer, "What Do Statistical Demand Curves Show?" AEA Readings in Price Theory, Richard D. Irwin, Inc., Chicago, Illinois, 1952, pp. 97-119.

2. Marshak, Jacob, "Economic Measurements for Policy and Prediction," Studies in Econometric Method, N. D. Hood and T. C. Koopmans, editors, John Wiley and Sons, Inc., New York, 1953.

3. Fox, Karl, The Analysis of Demand for Farm Products, Technical Bulletin 1081, United States Department of Agriculture, Washington, D. C., 1953.

concluded that where the independent variables in a demand equation are predetermined, the least squares technique is also an appropriate method for estimating the true demand relations.

This study will apply the least squares technique to estimate demand relations for grapefruit, on the grounds that forecasting is the primary goal of the investigation, as well as on grounds of resource limitations. (However, the independent variables selected in the analysis appear to be predetermined, so the results may also be a satisfactory approximation to the true demand curves.) Price is used as the dependent variable, since production of grapefruit, as is the case for most agricultural commodities, can be regarded as predetermined within the production season (i.e., production is largely independent of price within a given production season).

Sources and Reliability of Data--The time series data used in the regression analysis are shown in the Appendix tables, together with the sources from which the various series were obtained.

Price and production series were obtained from publications of the Statistical Reporting Service of the United States Department of Agriculture. This source is used with some reservations. There are some (often sizeable) discrepancies observed between the production estimates of the Statistical Reporting Service and those published in the annual reports of the Grapefruit Administrative Committee. Persons close to the industry regard the production estimates of the Administrative Committee as being somewhat the more reliable of the two sources. However, since the Committee does not publish a price series, data for all production and price series were taken from SRS in order to have a consistent source.

Time Period of the Analysis--The production seasons 1946-47 through 1961-62 were selected for analysis. It was judged that no major structural changes or abnormal fluctuations were present during this period, but that this might not hold true if years prior to 1946 were included.

Deflation--The price and income series used were not deflated because the process assumes a constant relationship between the original series and the deflator. This assumption may not be valid since prices for agricultural commodities are known to fluctuate much more widely during a business cycle than will the general price level.⁴ Furthermore, a relatively small change in the general price level has been observed during the postwar period covered by the analysis.

Other Adjustments--The production and consumer disposable income series were all converted to a per capita basis by dividing them by United States population. Since the production season for Arizona grapefruit is from November to July, the population estimate for the year in which the major portion of the marketing season occurs was used. For example, the 1960-61 season would be divided by the 1961 population estimate. The consumer disposable income series was treated in a similar manner; i.e., the per capita income estimate for the year in which the largest portion of the production season falls was associated with season price in the demand equations.

4. Shepherd, Geoffrey, Agricultural Price Analysis, Fifth Edition, Ames, Iowa, Iowa State University Press, 1963.

B. Results of the Statistical Analysis

Estimation of the Parameters of the Equation

The single equation method of least squares regression⁵ was used to estimate the parameters of the model. Both F.O.B. price and on-tree returns were used as dependent variables. In order to find the best fitting relationship, the equations were estimated with the variables in logarithms, in first differences, and in logarithms of first differences as well as in the standard linear form. (The computations were performed on the computer facilities of the Numerical Analysis Laboratory, University of Arizona, using a standard regression program.)

The results of the regression analyses are displayed in Tables XIII, XIV, and XV, together with the usual reliability indicators: the standard error of estimate, the coefficient of multiple determination, and the standard errors of the regression coefficients.⁶ Definitions of variables used are included in each table.

Tables XIII, XIV, and XV show the sequence of changing formulations of the demand relationships which was followed. The initial formulation included a rather large number of independent variables (Table XIII). The coefficients of multiple determination and the standard errors of estimate were quite satisfactory (particularly in the F.O.B. price equations). However, few if any variables had coefficients which were significantly different from zero (at the five percent level of

5. Ezekiel and Fox, Methods of Correlation and Regression Analysis, Third Edition, John Wiley and Sons, Inc., New York, 1959, pp. 61-63.

6. Ezekiel and Fox, op. cit.

Table XIII. Results of the Regression Analysis, Part 1.

Code	Dep. Var.	Constant Term	X ₁	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₁₄	R ²	S.E.
0	X ₁₂	-2.7544	-.0050 (.0028) ^a	-.0191* ^b (.0083)	.0035 (.0551)	-52.2539 (43.5955)	-14.0660 (7.6060)	17.1635 (87.3756)	-11.5228 (6.0860)	.3033 (.1839)	.89	.20
0	X ₁₃	-1.5288	-.0041 (.0035)	-.0164 (.0105)	-.0037 (.0693)	-34.3612 (54.8474)	-13.6119 (9.5691)	16.1091 (109.9269)	-11.7986 (7.6568)	.2226 (.2314)	.75	.25
2	X ₁₂	2.6571	-.2278 (.6638)	-.1186 (.1184)	-.4948 (.4204)	-.0339 (.1667)	-.0014 (.0440)	-.3951 (.4490)	.0204 (.2215)		.84	.09
2	X ₁₃	4.0225	-.8977 (1.9280)	-.1311 (.3439)	-1.0944 (1.2210)	.1070 (.4841)	-.0394 (.1275)	-1.4158 (1.3041)	-.1838 (.6435)		.74	.27
1	X ₁₂	.0431	-1.1651 (1.1680)	-.0438 (.0921)	-.2268 (.3524)	-.0917 (.1036)	-.0150 (.0360)	-.2598 (.3255)	.0183 (.1784)		.63	.09
1	X ₁₃	.0525	-2.3951 (3.2903)	.0415 (.2595)	-.7313 (.9926)	-.1643 (.2917)	-.0613 (.1013)	-.8611 (.9169)	-.1825 (.5024)		.64	.25

a. Numbers in parentheses refer to standard errors of the regression coefficients.

b. Coefficients marked by an asterisk were found to be significantly different from zero at the 5 percent level ("t" test).

Definition of Independent Variables

X₁ = U. S. per capita disposable income (in actual dollars).

X₃ = Percentage Arizona production processed.

X₄ = U. S. per capita orange consumption (in pounds).

X₅ = U. S. per capita Arizona fresh grapefruit production (per 64-pound packed box).

X₆ = U. S. per capita Texas fresh grapefruit production (per 64-pound packed box).

X₇ = U. S. per capita California fresh grapefruit production (per 64-pound packed box).

X₈ = U. S. per capita Florida fresh grapefruit production (per 64-pound packed box).

X₁₄ = Trend Variable

Definition of Dependent Variables

X₉ = Arizona on-tree price for processed grapefruit (per 64-pound packed box).

X₁₂ = Arizona F.O.B. price for fresh grapefruit (per 64-pound packed box).

X₁₃ = Arizona on-tree price for fresh grapefruit (per 64-pound packed box).

Code

0 - No data transformations; 1 - First differences of logarithms to the base "E";

2 - Logarithms to the base "e"

Table XIV. Results of the Regression Analysis, Part 2.

Code	Dep. Var.	Constant Term	X ₁	X ₃	X ₄	X ₅	X ₁₄	X ₁₅	R ²	S.E.
0	X ₁₂	-1.0986	-.0042 (.0022) ^a	-.0162* ^b (.0063)	-.0073 (.0407)	-36.1394 (27.8531)	.2484 (.1406)	-10.7819 (5.4631)	.88	.18
0	X ₁₃	.6833	-.0036 (.0027)	-.0142 (.0078)	-.0079 (.0500)	-21.0476 (34.1988)	.1923 (.1726)	-11.3244 (6.7077)	.75	.22
0	X ₁₂	3.9028	.0005 (.0003)	-.0118 (.0067)		-42.9539 (29.7828)		-8.8130* (3.4929)	.81	.20
1	X ₁₂	.0824	-1.8267 (.9480)	-.1320 (.0892)		-.1816* (.0662)		-.2869 (.1990)	.56	.08
0	X ₁₂	3.9028	.0005 (.0003)	-.0118 (.0067)		-42.9539 (29.7828)		-8.8130* (3.4929)	.81	.20
2	X ₁₂	-3.8465	.4948* (.1880)	-.1574 (.0959)		-.1627 (.0984)		-.4806* (.2132)	.83	.08
0	X ₉	.7834	-.0001 (.0001)	-.0001 (.0025)		16.5041 (11.2505)		-3.9720 (1.3195)	.62	.08
3	X ₁₂	.2479	-.0040* (.0015)	-.0098 (.0049)		-51.8339* (16.3879)		-6.5634 (3.0350)	.64	.17
1	X ₁₂	.0824	-1.8267 (.9480)	-.1320 (.0892)		-.1816* (.0662)		-.2869 (.1990)	.56	.08

a. Numbers in parentheses refer to standard errors of the regression coefficients.

b. Coefficients marked by an asterisk were found to be significantly different from zero at the 5 percent level ("t" test).

Definition of Independent Variables

X₁ = U. S. per capita disposable income (in actual dollars).

X₃ = Percentage Arizona total grapefruit production processed.

X₄ = U. S. per capita orange consumption (in pounds).

X₅ = U. S. per capita Arizona fresh grapefruit production (per 64-pound packed box).

X₁₅ = U. S. per capita rest-of-the-U. S. fresh grapefruit production (per 64-pound packed box).

Definition of Dependent Variables

X₉ = Arizona on-tree price for processed grapefruit (per 64-pound packed box).

X₁₂ = Arizona F.O.B. price for fresh grapefruit (per 64-pound packed box).

X₁₃ = Arizona on-tree price for fresh grapefruit (per 64-pound packed box).

Code

0 - No data transformations; 1 - First differences of logarithms to the base "E";

2 - Logarithms to the base "e"; 3 - First differences.

Table XV. Results of the Regression Analysis, Part 3.

Code	Dep. Var.	Constant Term	X ₁	X ₅	X ₁₅	X ₁₆	X ₁₇	R ²	S.E.
0	X ₁₂	3.3292	.0005 (.0004) ^a	-18.7803 (26.7761)	-7.9178 (3.9358)	-36.2124 (23.3222)	.0266 (2.6046)	.81	.22
0	X ₁₃	2.4543	.0001 (.0004)	-4.2295 (29.7140)	-8.4363 (4.3676)	-28.8360 (25.8811)	.4624 (2.8904)	.66	.24
0	X ₉	1.0399	-.0002 (.0002)	15.9074 (9.5276)	-4.6816* ^b (1.4004)	-7.6956 (8.2986)	.2077 (.9268)	.65	.08
0	X ₁₂	3.3337	.0005 (.0004)	-18.7825 (25.5293)	-7.8984* (3.2866)	-36.2543 (21.8917)		.81	.20
2	X ₁₂	-3.5349	.3116 (.2024)	-.0822 (.0789)	-.5470* (.1962)	-.1430* (.0590)		.86	.07

a. Numbers in parentheses refer to standard errors of the regression coefficients.

b. Coefficients marked by an asterisk were found to be significantly different from zero at the 5 percent level ("t" test).

Definition of Independent Variables

X₁ = U. S. per capita disposable income (in actual dollars).

X₅ = U. S. per capita Arizona fresh grapefruit production (per 64-pound packed box).

X₁₅ = U. S. per capita rest-of-the-U. S. fresh grapefruit production (per 64-pound packed box).

X₁₆ = U. S. per capita Arizona processed grapefruit production (per 64-pound packed box).

X₁₇ = U. S. per capita rest-of-the-U. S. processed grapefruit production (per 64-pound packed box).

Definition of Dependent Variables

X₉ = Arizona on-tree price to processed grapefruit (per 64-pound box).

X₁₂ = Arizona F.O.B. price to fresh grapefruit (per 64-pound packed box).

X₁₃ = Arizona on-tree price to fresh grapefruit (per 64-pound packed box).

Code

0 - No data transformations.

2 - Logarithms to the base "e".

significance). This was due at least in part to the limited number of degrees of freedom available. The first difference form has a somewhat lower coefficient of multiple determination (R^2) than the linear and logarithmic equations. (In this case R^2 represents the proportion of variation about the trend explained by the equations, so the cases are not strictly comparable.) The "on-tree" price equation is in all cases less satisfactory than the F.O.B. price equation.

In order to add degrees of freedom, the non-Arizona production was lumped into one variable. (See Table XIV). Again, only one variable was significantly different from zero at the five percent level (none in the on-tree returns equation) although the standard errors of estimate and the coefficients of multiple determination remains satisfactory.

It was noted that the partial correlation between the income (X_1) and the trend (X_{14}) variables was .96, indicating the variables were practically identical for statistical purposes. One of these, the trend variable, was therefore dropped from most of the subsequent formulations. Furthermore, the variable representing orange production (X_4) was found to be practically unrelated to grapefruit prices (as determined by the partial correlation coefficient) and was not considered further.

As was discussed in the previous chapter, the Desert Grapefruit Administrative Committee tries to influence the price of grapefruit by regulating the quantity of the crop sold for fresh consumption. The proportion of the crop shipped to processing might then be expected to reflect the influence of the marketing agreement. This variable (denoted

X₃) was included in the analysis. The coefficient of the variable had the expected negative sign and was significantly different from zero (five percent level) in the linear formulation.

Several additional equations were developed to provide a basis for the diversion model (to be discussed below). In this case, the independent variables included income and production of grapefruit for fresh and processing consumption within and without Arizona, all on a per capita basis. (See Table XV.) In addition, quantity (rather than proportion) of the crop diverted to processing was included as an independent variable. This variable also had a negative coefficient and was significant in some formulations.

In the final estimating runs, the variable representing non-Arizona processing was dropped. The equations were estimated in both linear and logarithmic form, using F.O.B. price as the dependent variable. (See Table XV.) These equations are regarded as quite satisfactory in accounting for the observed variation in the dependent variable.

C. Price Forecasting: An Application of the Estimated Relationships

An important application of estimated relationships, such as were developed in this study, is to the forecasting of future states of the system under investigation. For illustrative purposes, some such forecasts on F.O.B. price for Arizona grapefruit are described below. Two demand equations were selected for making the forecast. The "best" of the logarithmic and of the linear formulations were chosen. (Table XVI shows the values of the independent variables used.)

Table XVI. Values of Independent Variables Used to Derive Price Forecasts.

Producing Season	X_1	X_5	X_{15}	X_{16}
	United States per Capita Disposable Income	United States per Capita Arizona Fresh Grapefruit Production	United States per Capita Rest-of-the-U.S. Fresh Grapefruit Production	United States per Capita Arizona Processed Grapefruit Production
	(Actual dollars)		(Per 64-pound box)	
1962-63	2,125	.0047	.1010	.0067
1962-63 ^a	7,661	-5.3600	-2.2930	-5.1050
1963-64	2,249	.0111	.1119	.0056
1963-64 ^a	7,715	-4.5010	-2.1900	-5.1850
1970-71	2,645	.0077	.1260	.0032
1970-71 ^a	7,880	-4.8670	-2.0720	-5.7450

a. All variables expressed as logarithms to the base "e."

Data for two seasons (1962-63 and 1963-64) which were not included in the statistical analysis were available. The appropriate observed values for those years for the independent variables were then simply "plugged in" to the equation to derive a price forecast in each case. The results are shown in Table XVII. Since the observed values of the prices are available in those years, the forecasts can be checked against the observation for accuracy. For the 1962-63 season, there is considerable difference between the forecasts achieved by the linear as opposed to the logarithmic formulation, although the prediction of the linear equation is remarkably close to the actually observed value. In the next year, the forecasts are much more consistent with each other but not nearly so close to the observed price. (The season was marked by a freeze in Texas, and the equation perhaps does not reflect the extent of the shift in demand which took place.)

A forecast was also made for a future season, 1970-71. In this case, with no observations available on the independent variables, rough predictions on these were necessary. The simplest possible technique for this was employed; a freehand trend line estimate was made on the scatter diagram of each variable plotted against time. The resulting values of the independent variables are shown in Table XVI and the resulting predictions are shown in Table XVII. The predictions suggest F.O.B. prices could be expected to be very little different than in recent years given the existing trends in population, income, and grapefruit production.

Table XVII. Forecasting F.O.B. Prices for Arizona Fresh Grapefruit.

Equation	Producing Season	Forecasted Value (Dollars)	Observed Value (Dollars)	Residual (Dollars)
1 ^a	1962-63	3.27	3.25	-.02
2 ^b	1962-63	3.58	3.25	.33
1	1963-64	3.30	3.70	.40
2	1963-64	3.25	3.70	.45
1	1970-71	3.40	--	--
2	1970-71	3.58	--	--

a. Linear equation

$$X_{12} = 3.3367 + .0005 X_1 - 18.7826 X_5 - 7.8984 X_{15} - 36.2543 X_{16}$$

b. Logarithmic equation

$$X_{12} = 3.5349 + .3116 X_1 - .0822 X_5 - .5470 X_{15} - .1430 X_{16}$$

(Variables are defined as in Table XVI.)

One independent estimate of Arizona supply for a future period is available which might be of interest to consider.⁷ This source estimates grapefruit production in 1967-68 to be 3.0 million boxes. (The prediction was achieved by applying typical yields to expected acreages of grapefruit in that season, given the age distribution and acreage presently in grapefruit orchards.) This estimate of Arizona production is about 15 percent higher than that projected on the basis of extrapolating the trend. However, due to the relatively small effect local production has on price, the effect on the projected prices is small (about two cents per packed box for the linear equation).

D. Optimum Diversion Between Fresh and Processing Markets

Another possible application of the demand relationships estimated in this study would be to the problem of determining the optimum allocation of the crop between the fresh and processing markets. Waugh⁸ has developed a general model for this problem and applied it to lemon products in California. The procedure followed in the present study is outlined below.

In order to determine the net returns from each market, demand equations for both fresh and processed grapefruit were necessary. In these two equations the effect of the quantity produced for the alternate

7. Hill, Hillman, and Henderson, Some Economic Aspects of the Arizona Citrus Industry, University of Arizona, Agricultural Experiment Station Technical Bulletin 168, October 1965.

8. Waugh, Frederick V., Demand and Price Analysis, Technical Bulletin 1316, U. S. Department of Agriculture, Washington, D. C., 1964, pp. 74-77.

outlet was considered. By using on-tree price of fresh and processed grapefruit as the dependent variables and quantity sold for fresh use and for processing in Arizona and the Rest-of-the-United States as the independent variables, holding the effects of all other variables constant (such as income, price of alternative products), estimating equations of on-tree prices of fresh and processed grapefruit were derived. (See Table XV.)

Returns to grapefruit producers in Arizona in any year, in any use, is a function of the quantity sold in each outlet. The net returns to producers in either market are thus a function of the quantities sold in both the fresh and the processing markets. By discovering these functional relationships between prices and quantities and by multiplying the quantities by their respective prices, a total returns function may be derived for each market. Then, by differentiating the total returns function with respect to the quantity sold in the fresh and processed market, respectively, marginal returns to producers in each market is obtained. A marginal return of zero in both markets would be the most desirable since it results in the maximum obtainable net income. Positive marginal returns in either market means that a larger income could have been derived by increasing the quantity sold. Negative marginal returns in either market means that a larger income could have been realized by marketing a smaller quantity.

For a given size crop, total revenue is maximized where the marginal returns in each outlet are equal. This point is found by the simultaneous solution of a system of linear equations formed from the

marginal returns equations and an identity asserting that total production equals fresh consumption plus processed consumption for a given season.

This procedure was followed in the present study with unsatisfactory results. The solution indicated a negative value for the quantity to be shipped to fresh markets. This conclusion is hardly consistent with the observable facts from the case, for the marginal returns from processing source (e.g., price for processed grapefruit) have never approached that for grapefruit for the fresh market over the postwar period. The reliability of the equation estimating on-tree returns for processed grapefruit was not very great, which could account for the inappropriate solution. (There of course remains the possibility of error in the mathematical reasoning used in finding the solution.)

E. Concluding Remarks

Implications

The previous analysis suggests that there are a number of factors which can be regarded as influencing or closely associated with the price of grapefruit in Arizona. These include production of grapefruit within the state and elsewhere, consumer preferences, quality of the product, marketing agreement policies, and the general level of economic activity.

The two variables which are the most important influences on grapefruit prices (as measured by the price flexibilities obtained in the statistical analysis) are grapefruit production outside of Arizona

and consumer disposable income. These two variables are for all practical purposes beyond the influence of the Arizona grapefruit industry.

Other of the factors influencing price can, in principle at least, be affected by the industry's individual and collective policies, although these variables are less important than those previously mentioned. In this case, the analysis throws some light on the effects of possible actions taken by the state's growers.

The most important of these influences is the changing consumer preferences for grapefruit, a change operating to the disadvantage of grapefruit producers. A substantial decline in per capita consumption of grapefruit has been witnessed over the past 15 years. The analysis does not indicate that this decline could be explained by either higher prices for grapefruit or larger supplies and lower prices for competing fresh or processed fruits. Nor does the alternative hypothesis of a negative income elasticity for grapefruit seem to be supported by the evidence. One is, therefore, left with the conclusion that the hypothesis of changing consumer preferences for grapefruit account best for the observed trends.

If grapefruit and grapefruit products are losing favor with U. S. consumers, a number of actions might be taken to stem or reverse the trend and increase the size of the market for grapefruit. On the consumption side of the equation, additional promotion might be undertaken. On the production side, it might be appropriate to consider changing the nature and quality of the product by variety changes, in order to accommodate consumer desires. This is of course not a short-term solution,

and it is not clear at present just what characteristics in grapefruit the consumer might prefer.

The results of the analysis suggested an association between quantity (and proportion) of the grapefruit crop processed and price. (The coefficients on these variables were significant and with expected sign.) This is taken to be a reflection of the activities of the Desert Grapefruit Administrative Committee in operating the federal marketing agreement. However, it should be noted that the direction of causation in the relationship is not clear. The importance of non-Arizona production on prices received for Arizona grapefruit suggests that the Committee's power to influence price is limited to some extent. The established association between quantity of the crop processed and price might be merely a measurement of the Committee's response to changing levels of non-Arizona supplies and, hence, prices received for Arizona products.

Suggestions for Further Research

A number of items can be pointed out as promising areas for further research.

Completion of a Complete Forecasting Model--A more adequate forecasting model might be obtained by an analysis of the factors influencing supply of grapefruit, in Arizona and particularly in the other producing states. Such a model would be particularly useful in obtaining reliable long-term estimates of price in order to help growers make planting decisions.

Consumer Preferences--More needs to be known concerning the reasons why consumer preferences are changing, and what factors might be done to change the trend.

Effectiveness of the Marketing Agreement--The effectiveness of the marketing agreement should be clearly established. It might well be that the market for Arizona grapefruit is not independent enough of other influences to make the operation of the agreement worthwhile.

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APPENDIX

Table I. Free-on-Board Prices for Fresh Grapefruit, by Producing States, 1930-65.

Season	Arizona	California ^a	Florida	Texas
(Dollars per packed box) ^b				
1930-31	2.21	2.36	1.26	1.82
1931-32	1.65	1.82	1.26	1.30
1932-33	1.53	1.58	1.06	1.42
1933-34	1.53	1.50	1.30	1.29
1934-35	1.49	1.54	1.05	1.22
1935-36	1.50	1.41	1.44	1.38
1936-37	1.68	2.02	1.18	.94
1937-38	1.15	1.19	1.23	.88
1938-39	1.12	1.10	.83	.72
1939-40	1.19	1.22	1.18	.88
1940-41	1.03	1.10	.91	.84
1941-42	1.42	1.45	1.23	1.20
1942-43	2.24	2.29	1.70	1.68
1943-44	2.52	2.66	1.95	1.96
1944-45	2.93	2.75	2.31	1.96
1945-46	2.20	2.52	2.12	1.88
1946-47	1.68	2.08	1.74	1.64
1947-48	1.88	2.60	1.47	1.25
1948-49	2.37	3.04	1.88	1.35
1949-50	2.35	3.60	2.74	2.52
1950-51	2.03	2.70	2.14	2.22
1951-52	2.37	3.10	1.86	5.18
1952-53	2.29	3.67	2.09	3.32
1953-54	2.44	3.85	1.88	2.64
1954-55	2.28	3.54	1.94	2.26
1955-56	2.49	4.18	1.94	2.14
1956-57	2.84	4.36	2.42	2.17
1957-58	3.00	4.78	2.55	2.32
1958-59	3.14	4.59	2.50	2.38
1959-60	2.85	3.55	2.42	2.29
1960-61	2.80	3.18	2.38	2.42
1961-62	2.63	3.10	2.26	2.46
1962-63 ^c	3.25	4.28	3.26	4.80
1963-64 ^c	3.70	4.74	3.74	4.08
1964-65 ^c	3.15	4.00	3.39	3.20

Source: Hill, James S., Desert Grapefruit Industry, Report 220, Agricultural Experiment Station, The University of Arizona, 1964.

- a. California desert valleys.
- b. Based on a 64-pound equivalent packed box.
- c. Agricultural Prices, Statistical Reporting Service, USDA, 1963-65 editions.

Table II. Total Revenue from Grapefruit in Arizona, 1946-47 through 1963-64 Seasons.

Season	Fresh (Dollars)	Processed (Dollars)	Total (Dollars)
1946-47	620,920	-153,800	467,120
1947-48	601,920	-31,600	570,320
1948-49	741,200	47,750	788,950
1949-50	787,500	421,440	1,208,940
1950-51	1,184,640	347,490	1,532,130
1951-52	1,334,000	56,630	1,390,630
1952-53	1,429,680	243,010	1,672,690
1953-54	1,433,500	203,580	1,637,080
1954-55	1,146,600	110,770	1,257,370
1955-56	1,429,820	107,880	1,537,700
1956-57	1,787,560	91,410	1,878,970
1957-58	3,171,000	211,840	3,382,840
1958-59	2,255,250	56,420	2,311,670
1959-60	2,675,890	153,020	2,828,910
1960-61	1,705,560	199,180	1,904,740
1961-62	1,058,250	26,220	1,084,470
1962-63	1,406,200	-37,740	1,368,460
1963-64	4,566,600	NA	4,566,600

Source: Hill, James S., Desert Grapefruit Industry, Report 220, Agricultural Experiment Station, The University of Arizona, 1964.

NA Not available.

Table III. Rest-of-the-United States Fresh Grapefruit Shipments (Carlot Shipments) by Months, 1946-64 Seasons.

Year	Jan.	Feb.	March	April	May	June	July	Nov.	Dec.
1946	5,392	5,109	5,407	5,654	3,253	1,728	859	4,482	3,926
1947	5,618	5,678	7,802	5,904	4,542	1,826	946	4,266	3,736
1948	4,763	5,419	6,008	5,781	4,255	2,098	1,267	4,230	4,254
1949	5,558	4,555	4,562	3,299	1,833	795	329	3,090	3,088
1950	3,820	3,441	3,619	2,815	2,426	930	693	3,261	3,357
1951	4,455	3,253	3,737	3,389	3,047	1,733	854	3,068	2,458
1952	4,152	3,959	4,477	4,292	3,818	1,698	1,109	3,322	3,093
1953	4,336	4,030	4,436	4,004	2,873	1,173	476	3,631	3,595
1954	5,101	4,518	5,664	4,468	3,806	1,767	1,112	3,478	3,473
1955	4,510	4,297	4,893	4,393	3,414	1,971	1,116	3,693	3,808
1956	4,874	4,818	5,299	4,447	3,868	1,375	790	3,864	3,461
1957	4,636	4,286	5,034	4,309	3,365	1,600	1,024	3,600	3,089
1958	4,376	4,097	4,079	2,714	1,565	621	540	3,294	3,244
1959	4,832	4,287	4,826	4,489	3,057	1,505	736	3,793	3,866
1960	5,088	4,543	4,882	3,403	2,019	550	385	3,839	3,540
1961	4,446	4,575	5,262	5,039	3,536	1,888	923	4,034	3,888
1962	4,904	4,142	5,028	3,800	2,943	1,570	710	3,642	2,745
1963	3,290	2,966	3,171	2,744	1,777	826	445	3,584	3,422
1964	4,371	3,802	3,507	2,575	1,704	837	480	3,674	3,349

Source: Fresh Fruit and Vegetable Shipments, Consumer and Marketing Service, Fruit and Vegetable Division, Market News Service, USDA, 1946-64 editions.

Table IV. Arizona Fresh Grapefruit Sales by Producing Areas.

Year	Salt River Valley	Yuma	Total
(Thousand packed boxes)			
1941-42	1,617	338	1,955
1942-43	919	272	1,191
1943-44	1,883	233	2,116
1944-45	1,915	410	2,325
1945-46	1,804	381	2,185
1946-47	1,305	309	1,614
1947-48	774	421	1,195
1948-49	360	483	843
1949-50	329	388	717
1950-51	1,331	435	1,766
1951-52	1,015	335	1,350
1952-53	1,296	357	1,653
1953-54	1,123	354	1,477
1954-55	1,048	367	1,415
1955-56	1,141	303	1,444
1956-57	1,086	231	1,317
1957-58	1,661	439	2,100
1958-59	1,163	337	1,500
1959-60	1,692	416	2,108
1960-61	1,156	299	1,455
1961-62	975	300	1,275
1962-63	624	260	884
1963-64	1,702	422	2,124

Source: Desert Grapefruit Administrative Committee, Annual Reports, 1942-65 editions.

Table V. Grapefruit Production, Continental United States and Selected Foreign Areas, 1930-64.

Year	United States	Puerto Rico	Cuba	Jamaica	Trinidad, Tobago	South Africa	Israel	World ^a Total
(Thousand boxes)								
1930-31	18,690	722	485	157	4	140	65	20,330
1931-32	15,181	776	485	218	30	158	100	16,772
1932-33	15,004	330	485	179	35	260	225	16,417
1933-34	14,672	637	485	251	45	296	350	16,024
1934-35	21,347	489	485	160	60	284	683	23,238
1935-36	18,347	677	375	270	75	327	844	21,166
1936-37	30,670	695	375	193	160	366	1,534	34,277
1937-38	31,133	417	375	207	175	447	1,794	34,791
1938-39	43,594	205	375	259	200	645	2,067	47,622
1939-40	35,192	248	375	140	260	628	988	38,340
1940-41	42,883	500	300	180	246	824	700	46,106
1941-42	40,261	500	300	200	144	846	550	43,222
1942-43	50,481	500	250	300	171	858	300	53,336
1943-44	56,090	500	160	250	114	968	800	59,433
1944-45	52,180	500	210	275	214	681	692	55,263
1945-46	63,450	500	90	266	260	636	800	66,558
1946-47	59,520	500	150	300	328	752	1,238	63,492
1947-48	61,630	525	130	290	587	614	1,500	66,125
1948-49	45,530	525	150	249	194	505	1,068	49,481
1949-50	36,500	525	170	405	552	557	1,100	40,896
1950-51	46,580	525	190	300	328	578	1,259	50,322
1951-52	40,500	525	230	257	337	358	1,136	43,938
1952-53	38,360	525	200	336	717	517	1,539	52,643
1953-54	48,370	220	240	351	361	566	1,539	52,643
1954-55	42,190	222	190	425	543	443	1,530	46,720
1955-56	45,380	243	200	490	467	402	1,450	49,963
1956-57	44,790	-	190	440	509	412	1,513	49,668
1957-58	39,780	-	200	375	910	399	1,603	45,546
1958-59	43,800	-	200	360	490	499	1,846	49,648
1959-60	41,620	-	200	388	1,000	581	1,934	48,182
1960-61	43,300	-	200	380	622	600	1,730	49,889
1961-62	42,910	-	200	607	800	900	1,892	50,165
1962-63	34,700	-	200	620	570	1,000	2,660	42,733
1963-64	32,500	-	50	600	500	1,100	2,900	40,340

Source: Statistical Abstract of the United States, various annual publications.

- a. World total is greater than production figures included in this table due to the exclusion of minor countries.

Table VI. Desert Grapefruit, Total Export by Producing Areas, 1941-62 Seasons.

Year	Salt River Valley	Yuma	Imperial	Coachella	Desert Total
(Packed boxes)					
1941-42	3,905	4,652	1,338	0	9,895
1942-43	15,479	2,805	667	16,247	35,198
1943-44	116,370	0	1,443	26,690	144,503
1944-45	80,305	6,000	589	27,220	114,114
1945-46	330,850	10,664	12,640	25,339	379,493
1946-47	262,691	31,764	1,858	13,486	309,799
1947-48	74,496	17,606	0	12,615	104,717
1948-49	20,807	44,169	0	2,736	67,712
1949-50	6,749	10,393	0	17,708	34,850
1950-51	46,971	8,221	0	3,160	58,352
1951-52	52,548	1,087	40	4,823	58,498
1952-53	67,767	17,202	0	3,382	88,351
1953-54	55,348	14,414	0	19,966	89,728
1954-55	40,208	25,772	2,339	28,066	96,385
1955-56	35,803	5,379	14,384	53,491	109,057
1956-57	62,082	3,307	11,524	52,775	129,688
1957-58	56,051	14,932	27,730	81,363	180,076
1958-59	50,550	7,028	12,994	29,751	100,323
1959-60	53,394	5,391	16,724	87,249	162,758
1960-61	108,845	21,963	31,505	113,980	276,293
1961-62	137,710	31,815	23,855	158,321	351,701
1962-63	68,316	43,228	22,083	239,927	373,554

Source: Desert Grapefruit Administrative Committee, Annual Reports, 1942-63 editions.

Table VII. Population and Income Estimates, United States, 1946-64.

Year	Population ^a (Thousands)	Per Capita ^b Disposable Income (Actual dollars)
1946	140,054	1,136
1947	143,446	1,181
1948	146,093	1,291
1949	148,665	1,271
1950	151,228	1,369
1951	153,383	1,474
1952	156,472	1,520
1953	159,035	1,582
1954	161,915	1,582
1955	165,064	1,660
1956	168,043	1,742
1957	171,108	1,803
1958	174,057	1,826
1959	177,131	1,904
1960	179,983	1,936
1961	183,043	1,984
1962	185,822	2,060
1963	188,616	2,125
1964	190,865	2,249

a. Statistical Abstract of the United States, 1954-65 editions.

b. Demand Analysis Section, Economic Research Service, USDA, "Working Data for Demand Analysis," October 1964 edition.