A MODEL FOR EVALUATING ALTERNATIVE POLICY DECISIONS FOR THE FLORIDA ORANGE SUBSECTOR OF THE FOOD INDUSTRY

By

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Abstract of Dissertation Presented to the Graduate Council
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A MODEL FOR EVALUATING ALTERNATIVE POLICY
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A third generation quantitative economic model of the Florida orange subsector was developed and then used to evaluate the effects on subsector performance of alternative inventory, pricing, advertising and supply control policies. The model was composed of ten interrelated sectors, extending from tree planting through consumer demand, and was written in the DYNAMO simulation language.

The internal consistency of the model was examined. The model was then validated on the basis of its ability, when given empirical estimates of weather conditions, to reproduce the behavior of the orange subsector over the 1961-71 period. Theil's inequality coefficients were used to measure the correspondence between simulated and empirical data. Calculated values of the coefficients ranged from .55 to .98 and indicated that predictions were better than those that would have been realized with the model $p_t = a_{t-1}$, where a_t and p_t represent actual and predicted values at time t.

After the model had been accepted as an adequate representation of the structure of the orange subsector, a set of simulations was made to establish a base with which to compare the ten policies considered in

the study. Comparable results for a variety of conditions were obtained by replicating each simulation with five randomly selected weather patterns. Simulations were started with initial values corresponding to conditions that existed at the beginning of the 1961-62 season and covered a twenty-five-year period. Results were examined from the viewpoints of three major groups of subsector participants: orange producers, processors and distributors, and consumers. It was assumed that the interests of these groups could be evaluated on the basis of the present value and variance of grower profits, crop size, and average FOB price, respectively. These values were computed from model output with the aid of a FORTRAN computer program and along with estimated storage costs provided the information used in policy evaluation.

Policies that reduced long-run supplies of orange products caused substantially higher grower profits, lower storage costs and higher retail prices. They also reduced risks for orange producers, but not for other subsector participants. Small gains from policies that failed to alter the long-run behavior of the subsector were partially or completely offset by increased storage costs associated with them.

Given the advertising response functions in the model, the alternative advertising proposal, which increased average advertising expenditures from $11.9 million to $19.8 million per season, did not prove to be profitable. However, the study did not confront the question of whether or not one method of collecting and expending advertising funds was superior to the other.

The characteristic which dominated policy analysis was the presence of conflicts of interests among subsector participants. In almost every instance, in order for one group of participants to gain, another was placed in a less desirable position. For the policies considered in the study, results provided insights into costs and returns and their distribution among subsector participants. With periodic updating, the model can provide an ex ante method of evaluating future decisions as policy questions develop in the Florida orange subsector.

CHAPTER I

INTRODUCTION

The Florida orange subsector[1] has been characterized by large variation in orange production and crop value. Production during the past fifteen years (1958-72) has ranged from a high of 142.3 million boxes during the 1970-71 crop season to a low of 54.9 million boxes during the 1963-64 season. The on-tree value of the orange crop was 208.2 million dollars in 1970-71 as compared to a value of 241.3 million dollars for the smaller 1963-64 crop. Much of the short-run variation in crop size and value can be attributed to freeze damage. Freezes during the 1957-58 and 1962-63 seasons reduced orange supplies and caused large profits for some growers. These large profits were followed by new investments in orange groves which after a few years increased production and caused a period of low aggregate grower profits. During periods of low profits, grove establishment decreases; however, since existing orange groves produce over a long period of time, short-run supplies do not readily respond to low prices.

The Problem

Participants within the orange subsector have been concerned with the large variations in orange prices and supplies. Individual producers

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[1]The "Florida orange subsector" is defined in a broad sense starting with the establishment of orange groves and extending through processing, marketing and final consumption of oranges and orange products.

have sometimes benefited from short supplies and high prices; however, high prices allow the introduction of competitive products such as synthetic orange beverages and induce the establishment of new orange groves which increase supplies and reduce profits in future periods [17, p. 1]. The instability of the orange subsector may be detrimental to the long-run interests of all subsector participants. Supply stabilization would allow processors to eliminate excess processing capacity and reduce costs. Consumer interests may also be best served by stable prices.

Little is known about the effects of alternative industry policies on the system as a whole and on various subsector participants. The dynamic and interdependent economic mechanisms operating within the Florida orange subsector may dampen or amplify the effectiveness of a policy more than static partial analysis and intuitive judgment would indicate. Computer simulation provides a method of studying the effectiveness of policy decisions within the dynamic environment of an abstract model without the risk of experimentation on the actual system.

Objectives

The objective of this study was to develop a third generation, multiproduct, multimarket model of the orange subsector and to test policies designed to improve the performance of the orange subsector. More specific objectives were to:

1. Identify the system structure underlying the orange subsector's dynamic behavior.
2. Construct a four-product, two-market model of the orange subsector.

3. Delineate and/or develop measures of performance which reflect the interest of all participants in the subsector.
4. Use the model to evaluate the effects of policies designed to improve the performance of the orange subsector. These policies include:
    a. changes in the end of year carry-over of orange products.
    b. changes in the Florida citrus industry's generic advertising budget.
    c. alternative pricing strategies.
    d. alternative supply control policies, including:
        (1) elimination of fully productive trees if grower profits fall below specified levels.
        (2) curtailment of new tree plantings when grower profits are above specified levels.

Previous Work

In 1962, under a grant from the Minute Maid Corporation, Jarmain [9] developed a first generation industrial dynamics model of the Florida frozen concentrated orange juice (FCOJ) industry. Jarmain's study indicated that a larger carry-over of FCOJ from one season to the next would reduce price variability and improve the grower's position. Raulerson [21] revised and expanded Jarmain's work in a second generation model in order to appraise the effectiveness of alternative supply control policies in stabilizing and raising grower profits. Emphasis was placed on the lack of knowledge in the area of supply response of oranges--particularly during the periods of low prices. Both Jarmain and Raulerson used average grower profits as a basis for evaluating the performance of the frozen concentrated orange juice subsector. These studies provided a basis for the current study.

Models of the type used in this study require large amounts of information and it is helpful when this information is summarized in relatively efficient forms. Information for this model was available from several sources--the following studies were particularly useful.

A study completed by Polopolus and Black [17] in 1966 concluded that shifts in the quality and supply of orange juice due to periodic freezes have fostered the entry and proliferation of synthetic and partially natural citrus flavored drinks.

The Polopolus and Black study was followed by a study in which Myers [14] empirically estimated cross elasticities of demand for major orange juice products, orange drinks and synthetic orange flavored beverages. Frozen concentrate and chilled orange juice were found to be strong substitutes. Chilled and canned single strength orange juice appeared to be weak substitutes. No significant substitution relationship was found between frozen concentrate and canned single strength orange juice.

Weisenborn [25] completed a study in 1968 in which he used time series data and least squares regression procedures to estimate price-quantity relationships for major Florida orange products at the FOB level of the marketing system. These estimates provided the information necessary for the construction of net marginal revenue functions which were used to optimally allocate oranges among product markets for various size crops. Results based upon the estimated relationships indicated that a 128 million box orange crop maximized industry net revenue at the processor level.

Priscott [19] carried Weisenborn's study of the export market a step further in a 1969 study of the European demand for processed citrus products. In general, the study indicated that the demand for citrus products in West Europe was elastic and showed development potential.

McClelland, Polopolus, and Myers [12] used time series data to estimate the response of consumer sales with respect to changes in generic advertising expenditures. These estimates were used in conjunction with a quadratic programming model to measure possible gains from allocating advertising funds more efficiently. Information from this study provided a basis for specifying the influence of advertising on product demand.

In a 1971 study, Hall [8] estimated consumer demand in retail grocery stores for frozen concentrated orange juice, chilled orange juice, canned single strength orange juice, and canned single strength grapefruit juice for ten geographic regions of the United States. The analysis indicated that consumer demand functions for these products differ by region. Regional price elasticity estimates for canned orange juice compared closely with Weisenborn's national estimates. Estimates were lower for chilled orange juice and higher for frozen concentrate than those reported by Weisenborn.

Parvin [16] used yield estimates and standard regression techniques to estimate weather effects on early-midseason and Valencia orange production for eighteen Florida counties. These estimates provided a basis for the construction of a weather index for total Florida orange production.

CHAPTER II

STRUCTURE OF THE FLORIDA ORANGE SUBSECTOR[1]

An understanding of the essential relationships which give rise to a dynamic system's behavior is a prerequisite to the construction of a simulation model. A verbal description of the system's structure helped establish this understanding and provided a basis for building a quantitative economic model.

General Description

The Florida orange subsector is composed of five major groups of participants: producers, processors and packers, wholesalers, retailers and consumers. Producers are those individuals and business organizations who are primarily concerned with the production and sale of whole oranges. Processors and packers are involved with the conversion of whole oranges into processed products or with the packaging and sale of fruit in fresh form. Wholesalers and retailers provide marketing services and are concerned with the movement of orange products from the producing and processing area into consumer markets. Consumers are those primarily involved in the consumption of orange products and are the most numerous subsector participants. For the purposes of this study, final purchasers of orange products have been classified into two general types: retail and institutional.

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[1] Some of the material used in this chapter also appears in an article by the author [18].

Institutional purchasers are nontax-supported institutions such as restaurants and drugstore fountains and tax-supported institutions such as military establishments, hospitals, and school lunch programs. Retail purchasers are those who buy orange products through retail grocery outlets.

Production

The production of oranges in a given season depends on the acreage, variety, age distribution and physical environment of bearing orange trees plus the cultural and weather conditions that exist prior to harvest [16]. Weather is the most erratic factor affecting orange production. Rainfall, low temperatures, and hurrican winds can cause extensive damage to fruit and trees. Freezes have historically been the factor most feared by Florida orange producers.

In addition to the short-term effects of weather on orange production, freezes affect tree condition and productivity over long periods. Freeze damage to orange trees can be roughly divided into two general types: (1) damage to secondary branches requiring extensive pruning (hatracking) or (2) damage so severe that the tree dies. Secondary damage to the tree affects productivity for only a few crop seasons. More extensive damage requires that the tree be replaced.

Florida orange production is geographically distributed over the south and central portion of the Florida peninsula. However, following the 1962 freeze, there was some indication that the producing area was gradually moving farther south. As of December 1969, two-thirds of the nonbearing acreage was located in eight south Florida counties. In each of these counties, the ratio of nonbearing to bearing groves was in excess of one to five (Table 1). These plantings occurred before the enactment of the Holland Amendment which was incorporated into The Tax Reform Bill of 1969 [23]. This amendment requires the capitalization of all citrus grove development costs and exempts from capitalization requirements any citrus grove (or part thereof) "replanted after having been lost or damaged (while in the hands of the taxpayer), by reason of freeze, disease, drought, pest or casualty . . ." [23, p. 574]. Thus, it provides an incentive for citrus producers to concentrate on the improvement and maintenance of established groves rather than on new grove development.

The location of the orange producing area is important from the standpoint of a model which estimates crop size. If the location of the production area is rapidly shifting over time, historical data cannot be used as an estimate of future weather effects on orange production unless adjustments are made. Since the enactment of the Holland Amendment, locational movement within the producing area seems to be abridged. Whether or not this is an effect of the amendment is unknown.

Dynamics of the Florida Orange Subsector

A simplified flow diagram of the subsector is presented in Figure 1. Whole oranges move from the growing activity into the processing-packing sector where they are converted into processed orange products.[2] From processed inventory, orange products move into wholesale or institutional inventories and eventually consumption. Dotted lines in the diagram represent information flows between various system

[2]Processed products include fresh fruit ready for shipment.

Table 1. Acreage of bearing and nonbearing orange groves by Florida counties as of December 1969.[a]

County	Acreage		Nonbearing as percentage of bearing
	Bearing	Nonbearing	
	(acres)		(percent)
Brevard	6,930	755	10.9
Broward	3,327	125	3.8
Charlotte	3,109	645	20.7
Collier	1,817	637	35.1
Desota	10,763	2,407	22.4
Hardee	18,221	432	2.4
Hendry	8,094	1,765	21.8
Hernando	2,887	34	1.2
Highlands	20,456	613	3.0
Hillsboro	19,342	483	2.5
Indian River	12,436	2,237	18.0
Lake	48,638	685	1.4
Lee	3,539	2,666	75.3
Manatee	5,994	167	2.7
Marion	1,652	5	.3
Martin	18,714	6,778	36.2
Okeechobee	1,465	500	29.3
Orange	21,933	299	1.4
Osceola	6,746	93	1.4
Palm Beach	3,972	1,781	44.8
Pasco	16,560	463	2.8
Pinellas	1,980	87	4.4
Polk	59,527	1,232	2.1
St. Lucie	24,123	2,574	10.7
Seminole	2,536	18	.1
Volusia	3,412	19	.1
Total	328,173	27,500	

Source: [5].

[a]Counties with less than one thousand acres are excluded.

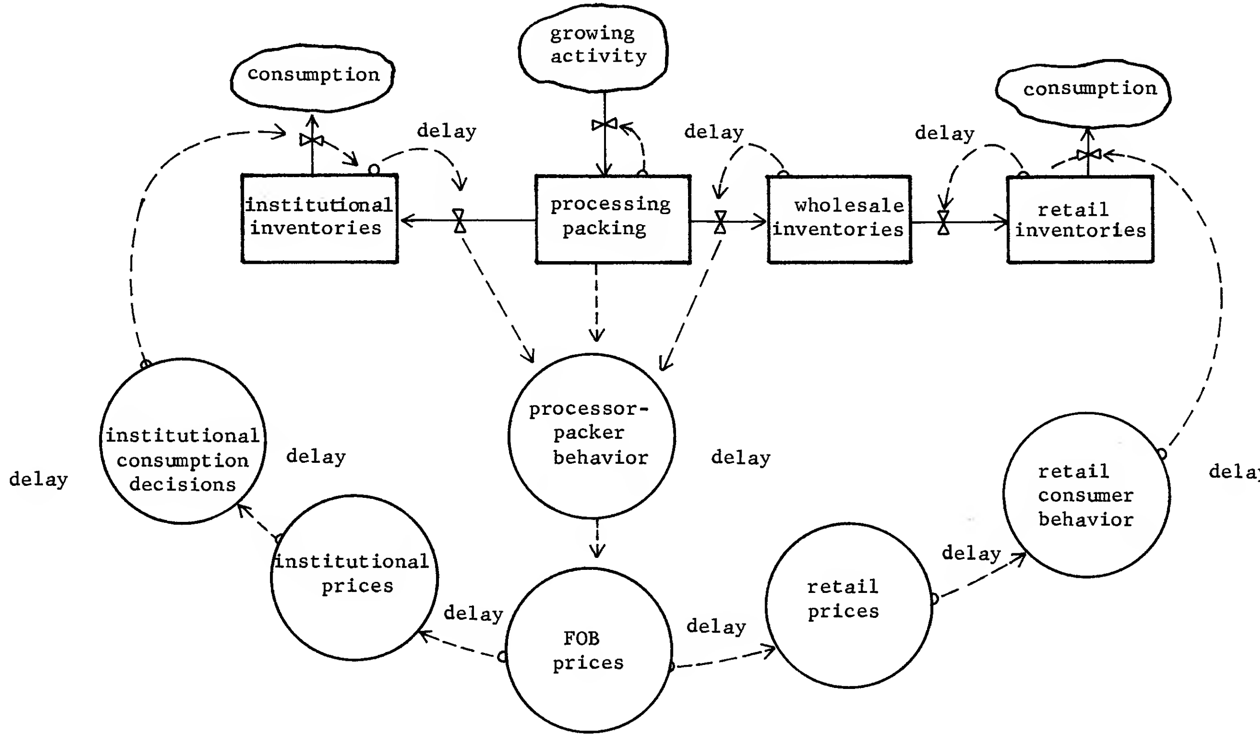

Figure 1. Simplified flow diagram of the orange subsector.

components. Information may be in the form of order rates or prices. Associated with information flows are various delay factors. These delays represent the time lags required for information to move through the system. Information passed through the marketing system is the basis for management decisions.

Several allocation problems must be solved by the market mechanism. The rate at which fruit flows from the growing activity into the processing sector must be controlled. This control is recognized in Figure 1 by hourglass shaped symbols. The solid lines represent physical flows. Whole fruit must also be allocated among alternative product forms, markets and consumers.

Given a competitive market system, economic theory indicates that the allocation of productive resources will be made on the basis of the value of the marginal product. The marginal increment of a productive resource will go to the usage where it has the greatest value. Products will be produced until that output is reached where the value of the marginal unit of product is equal to its cost of production. The price system will allocate products among competing customers according to their ability and willingness to pay. Since information must be collected, it is reasonable to expect adjustments after a time lag.

The demand for orange products is derived from the utility function of the individual consumer and product allocation is accomplished through the interaction of buyers and sellers; however, the allocation process as visualized in Figure 1 shows the processor-packer sector as a major decision point. Processor-packers receive information concerning inventory levels and the rates of flow of various products from inventory. If inventories are larger than desired or if the demand for a particular product changes, processors adjust FOB prices. These price signals pass through the marketing system and eventually affect consumption rates. As consumption rates change, signals are passed back through the system in the form of orders. Processors receive information on the adjusted movement from inventories and evaluate the effects of their pricing policies. If the effects of the pricing policy are not those desired, a new FOB price will be forthcoming. An equilibrium price will probably never result from this process. Consumers react to new prices over a period of time and while decision makers are considering new pricing policies, consumers are still reacting to previous prices.

The relationship between short-run supply and price fluctuations and long-run industry investment patterns is shown in the block diagram presented in Figure 2. Weather is shown as an exogenous variable which affects tree numbers and orange supplies. Assuming relatively stable demand relationships for orange products, restricted supplies following freeze damage reduce product inventories and increase the FOB prices of orange products. Historical data indicate a strong inverse relationship between crop size and the per box return above operating costs received by growers (Figure 3).

During freezes the orange crops of some producers may be severely damaged while other producers with relatively undamaged crops benefit from high prices and high grower profits. These growers, having found orange production profitable, tend to reinvest in new orange groves (Figure 4). Thus, the orange subsector is characterized by periods of restricted capacity followed by periods of large supplies and low prices.

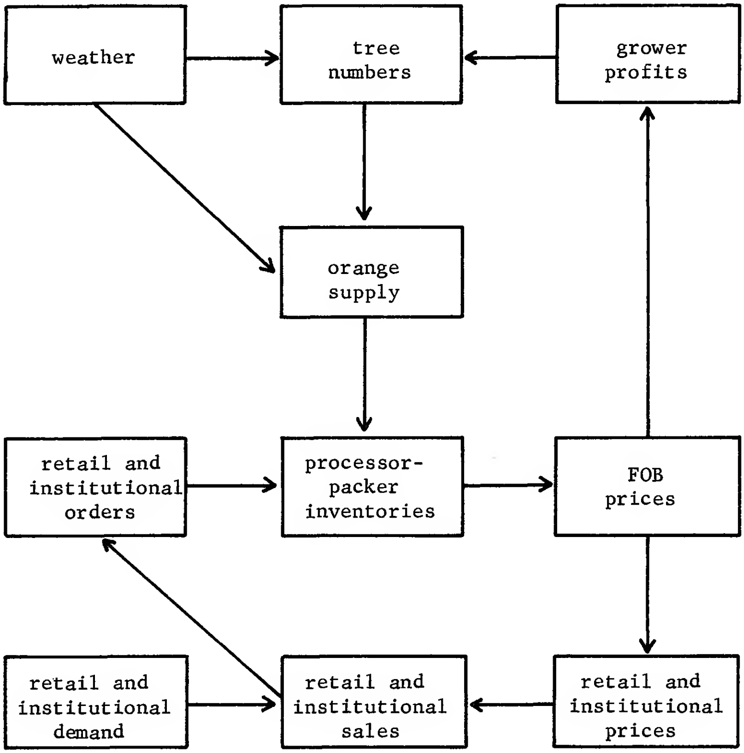

Figure 2. Block diagram of major components of the Florida orange subsector.

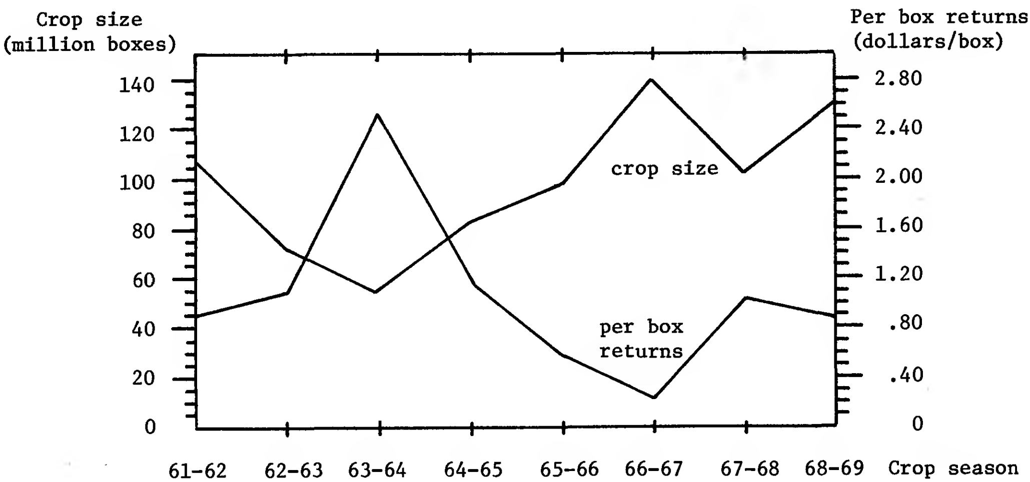

Figure 3. Size of the orange crop and per box return above operating costs received by growers for Florida oranges, 1961-62 through 1968-69 crop seasons.
Source: See Table 3, p. 26, for data on per box returns and [3, 1968-69 season, p. 1] for crop size data.

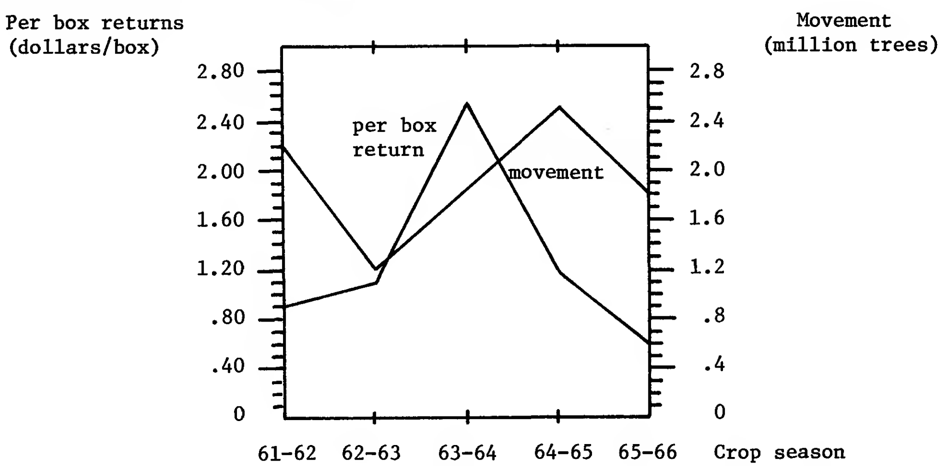

Figure 4. Per box return above operating costs received by growers for Florida oranges and orange tree movements from Florida nurseries, 1961-62 through 1965-66.
Source: See Table 3, p. 26.

CHAPTER III

CHARACTERISTICS OF DYNAMO II

The subsector model was constructed to meet the design and notational requirements of the DYNAMO II computer compiler.[1] The DYNAMO II compiler is a set of computer instructions used to translate mathematical models into tabulated and plotted results. It was developed by the industrial dynamics group at the Massachusetts Institute of Technology.[2]

Special Features

DYNAMO II has several special features that facilitate model construction. These features include the following:

1. The compiler will reorder equations within a variable type whenever necessary in order to perform computations. Reordering will continue until all calculations have been made or until the compiler has identified equations that depend on other equations which in turn depend upon the equation defined, in which case the system is simultaneous and DYNAMO II prints an error statement identifying the equations involved.

---

[1] Version four was used in this study. It runs on the IBM S/360 computing system operating under OS or CP/CMS and is distributed by Pugh-Roberts Associates, Inc., 179 Fifth Street, Cambridge, Mass. 02141. See Pugh [20] for detailed documentation.

[2] The industrial dynamics approach to problem solving is discussed by Forrester [7].

2. System macros[3] in DYNAMO II includes clipping and limiting functions, exponential delays, maximum, minimum, random numbers, pulse, ramp, sample, smooth, step, switch, table, and trigonometric.

3. The compiler contains a convenient method of specifying output. The output routine includes various scaling alternatives and provides output in tabulated and plotted form. Data is outputted chronologically with respect to simulated time and can be requested for each calculation interval or some multiple of it.

Time Notation

The time notation used in DYNAMO II is presented in Figure 5.

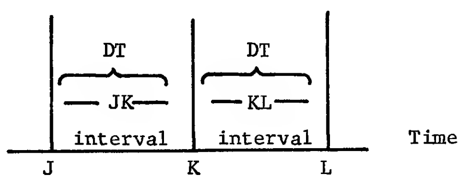

Figure 5. Time notation for DYNAMO II.

In the computational process, DT denotes the period of time between calculations, K corresponds with the point in time for which calculations are currently being made, J represents the time for which calculations were previously made and L denotes the next calculation time. The intervals between these time points are termed JK and KL. Once the computer calculates the values of all variables for time K and the KL interval, the system moves forward one step in simulated time and

[3] For definitions see Pugh [20].

the values associated with time K become associated with time J. In this recursive fashion, the computer moves through the calculation process and time in the simulation.

Type of Variables and Computational Sequence

The DYNAMO II compiler is designed to handle three principal types of variables: levels, auxiliaries and rates.

A level is a variable whose value at time K depends upon its value at time J and on changes during the JK interval. Levels are usually defined by equations of the form:

quantity at time K = quantity at time J + change during the JK interval.

Rates correspond to flows over time and are calculated for the KL interval. They are defined by levels and auxiliaries from time K and sometimes by rates from the preceding time interval.

Auxiliaries are values calculated at time K from levels at time K and from auxiliaries previously calculated at time K.

The computational sequence in DYNAMO II is levels, auxiliaries and rates. In order to assure that the model is recursive and that values will be available for calculations, equations must be consistent with the organizational system presented in Table 2. A detailed exposition of DYNAMO II is given by Pugh [20].

Table 2. Organizational structure for DYNAMO II equations.

Variable on left of equation	Time associated with variable on left	Time associated with variables on right if variable is L	A	R	S	C	N
L Level	K	J	J	JK	*	none	none
A Auxiliary	K	K	K	JK	*	none	none
R Rate	KL	K	K	JK	*	none	none
S Supplementary	K	K	K	JK	K	none	none
C Constant	none	*	*	*	*	*	*
N Initial Value	none	*	*	*	*	none	none

Source: [20, p. 24].

* Not permitted.

CHAPTER IV

THE MODEL

The model of the Florida orange subsector consists of a set of relationships between individual system components. These relationships together with initial starting values provided the information necessary to simulate system behavior. Much of the effort in this study was expended in the specification and estimation of model equations and to a large extent the validity of the study must be judged on the basis of the confidence placed in them. Some relationships are self-explanatory given the definitions of the variables involved, others require explanation and justification. The model presented in this chapter represents a mathematical formulation of the interrelationships that underlie the dynamic behavior of the orange subsector. It draws heavily on previous models constructed by Raulerson [21] and Jarmain [9]. No attempt has been made to acknowledge each duplication. A detailed flow diagram is presented in Figure 6.[1] Appendix A contains an alphabetic list of variable names.

---

[1] The following symbols were used in the flow diagram:

rates	policies
levels	material flows
auxiliaries	information flows
constants	

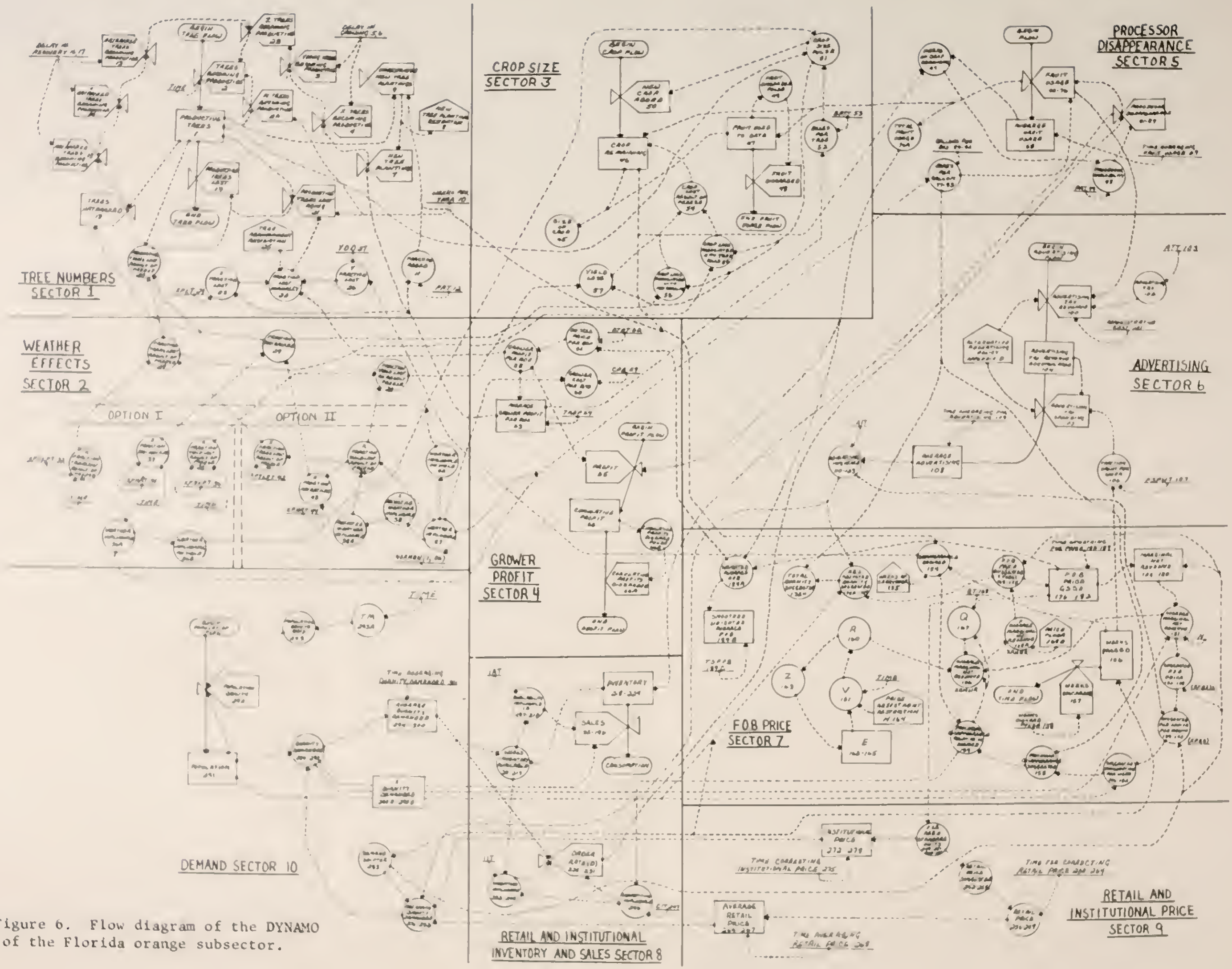

Figure 6. Flow diagram of the DYNAMO model of the Florida orange subsector.

Tree Numbers Sector

The number of productive trees was increased by trees becoming productive and decreased by productive trees lost (equation 1). During an initial period after the start of the simulation, the number of trees becoming productive was expressed as a fraction of the number of productive trees in existence (equations 2 and 2A). This procedure allowed trees planted but not productive at the start of the simulation to be inserted into the system. After the initial period, trees became productive as a result of increases in the productivity of young trees and the recovery of freeze damage (hatracked) trees (equation 2B). The rate at which young trees became productive was expressed as a sixth order exponential delay (actually two cascaded third order delays) with an input equal to the number of new trees planted and a delay in trees becoming fully productive of 13 years (equations 3 - 6).[2] The exponential delay approximated the yield response of newly planted orange trees by allowing larger proportions of a newly planted tree to come into production over simulated time. In Figure 7, the output from the delay in response to a step input is compared with a weighted average of the yields estimated by Chern [2, p. 58].

L $\quad PT.K = PT.J + (DT)(TBP.JK - PTL.JK)$ $\quad$ 1

R $\quad TBP.KL = \begin{cases} ZTBP.JK \text{ if } TIME.K \geq 156 \\ \quad\text{or} \\ NTBP.JK \text{ if } TIME.K < 156 \end{cases}$ $\quad$ 2

R $\quad NTBP.KL = (.178)(PT.K)/WPY$ $\quad$ 2A

R $\quad ZTBP.KL = YTBP.JK + HTBP.JK$ $\quad$ 2B

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[2] See Forrester for detailed explanation of exponential delays [7].

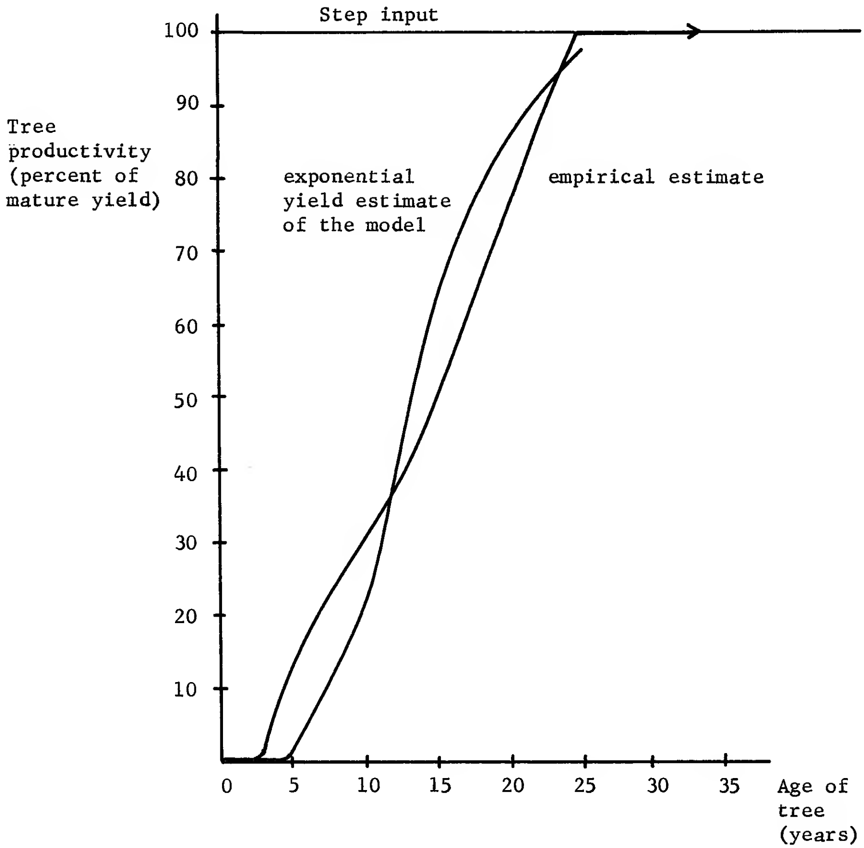

Figure 7. Comparison of output from exponential delay and empirical yield estimates.

Source: Empirical estimates from [2, p. 58].

R YTBP.KL = DELAY3(XTBP.JK, XDG) 3

R XTBP.KL = DELAY3(NTP.JK, XDG) 4

N XDG = DG/2 5

C DG = 676 weeks 6

PT - productive trees (trees)

TBP - trees becoming productive (trees/week)

PTL - productive trees lost (trees/week)

YTBP - young trees becoming productive (trees/week)

HTBP - hatracked trees becoming productive (trees/week)

NTBP - initial trees becoming productive (trees/week)

NTP - new trees planted (trees/week)

DG - delay in growing (weeks)

XTBP - internal transfer variables (trees/week)[3]

XDG - internal transfer variable (weeks)

ZTBP - trees becoming productive after initial period (trees/week)

TIME - simulated time (weeks)

WPY - weeks per year (weeks)

The rate at which new tree plantings occurred was controlled by a clipping function which set the number of new trees planted equal to zero or XNTP depending on whether or not a restriction on new tree planting was in effect (equation 7).

The restriction on new tree plantings was effective when average grower profit was greater than the new tree planting restriction (equation 8). The effect of the policy was to prevent new trees from being planted when average grower profits were high. The rate at which new

[3] Internal transfer variables will be defined in the future only when their meaning is not readily apparent.

tree plantings would have occurred without considering the restriction policy was expressed (equations 9, 11 and 12) as a fraction of the number of productive trees in existence and was dependent upon the level of average grower profits per 90 pound field box (hereafter box). Figure 8 presents the basis for the assumption concerning this dependency. Supporting data are presented in Table 3.

$$\text{R} \qquad \text{NTP.KL} = \begin{cases} \text{XNTP.JK if NTPR} \geq \text{AGP.K} \\ \qquad \text{or} \\ 0 \qquad \text{if NTPR} < \text{AGP.K} \end{cases} \qquad 7$$

$$\text{C} \qquad \text{NTPR} = \begin{cases} \text{1.50 if the policy was to be operative} \\ \qquad \text{or} \\ \text{1,000.0 if the policy was to inoperative} \end{cases} \qquad 8$$

$$\text{R} \qquad \text{XNTP.KL} = \text{(PT.K)(FA.K)/WPY}^{4} \qquad 9$$

$$\text{C} \qquad \text{WPY} = 52 \qquad 10$$

$$\text{A} \qquad \text{FA.K} = \text{TABHL(FAT, AGP.K, 0, 3.00, .50)} \qquad 11$$

$$\text{C} \qquad \text{FAT*} = .022/.054/.086/.118/.150/.182/.214 \qquad 12$$

XNTP - the rate at which new tree plantings would have occurred without the planting restriction (trees/week)

NTPR - the value above which the planting restriction became effective (dollars/box)

FA - fraction of new trees added

Hatracked trees becoming productive were expressed as a ninth order delay with an input equal to the number of trees hatracked (equations 13 - 17). The number of trees hatracked was expressed as a fraction of the productive trees in existence (equation 18). The output from this delay in response to a unit input was faster and the average delay time shorter than for the sixth order delay that controlled the rate at which

[4] The division of WPY was necessary since XNTP was expressed as trees per week.

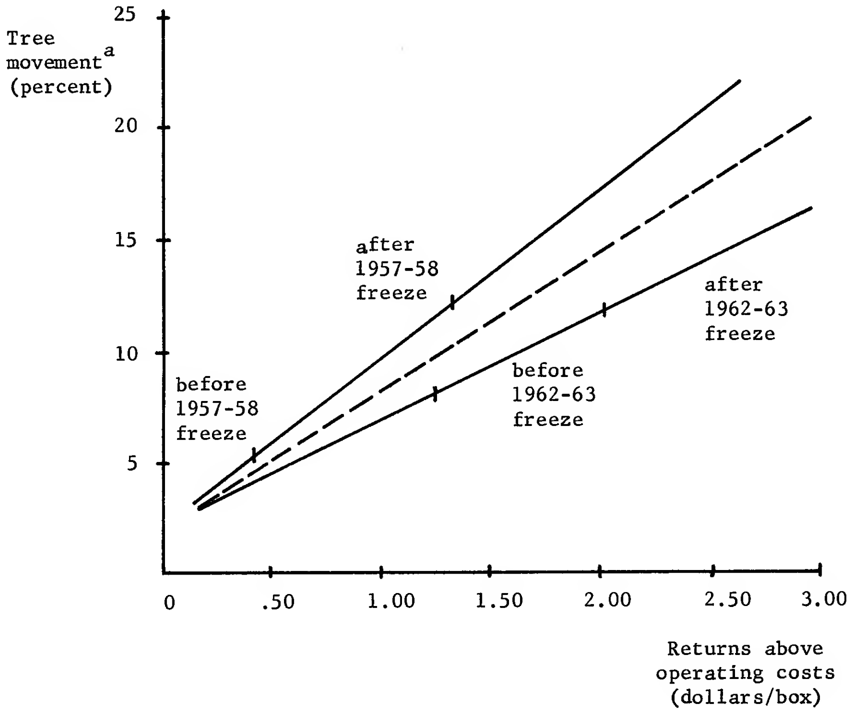

Figure 8. Relationship between per box returns above operating costs and movement of orange trees from Florida nurseries before and after the 1957-58 and 1962-63 freezes.

Source: Table 3.

[a] Movement as a percent of mature tree equivalents.

Table 3. Estimated mature productive orange tree equivalents, movement of orange trees from Florida nurseries to Florida destinations, and returns above operating costs for groves averaging over ten years of age, 1955-56 through 1970-71 seasons.

Season	Estimated number of mature tree equivalents[a]	Movement of trees from Florida nurseries	Movement as a percent of mature tree equivalents	Return above operating costs
	(thousands)	(thousands)	(percent)	(dollars/box)
1955-56	17,478	1,566.3	9.0	.39
1956-57	15,343	1,882.5	12.3	.42
1957-58	15,615	855.5	5.5	1.06
1958-59	14,423	2,181.9	15.1	1.49
1959-60	16,244	1,987.2	12.2	1.15
1960-61	17,660	2,311.1	13.1	1.53
1961-62	18,689	2,229.5	11.9	.90
1962-63	15,353	1,244.2	8.1	1.09
1963-64	14,641	1,834.6	12.5	2.52
1964-65	22,288	2,483.3	11.1	1.18
1965-66	b	1,785.0	b	.56
1966-67	24,809	b	b	.21
1967-68	b	b	b	1.03
1968-69	28,171	b	b	.86
1969-70	b	b	b	.48
1970-71	29,098	b	b	.92

Source: Calculated from data obtained from [2, 3, 4, 5].

[a] Estimates of tree numbers corresponded with the end of the year and the figures may reflect numbers at the beginning of the following season more accurately than the number associated with the season.

[b] Not available.

newly planted trees became productive. This difference reflected the rapid increase in the productivity of hatracked trees. The length of the delay was equal to 208 weeks. The rate at which productive trees were lost depended on the stochastic impact of weather and the "normal" losses associated with the passage of time (equation 19). Productive trees lost as a result of freeze damage was determined by fractions generated within the freeze effects sector of the model and by the number of productive trees in existence (equation 20). The "normal" loss was expressed in a similar fashion (equation 21).

R	HTBP.KL = DELAY3(XHTBP.JK, XDP)	13
R	XHTBP.KL = DELAY3(YHTBP.JK, XDP)	14
R	YHTBP.KL = DELAY3(THR.JK, XDP)	15
N	XDP = DP/3	16
C	DP = 208 weeks	17
R	THR.KL = (FHR.K)(PT.K)	18
R	PTL.KL = PTLA.JK + PTLF.K	19
A	PTLF.K = (1/DT)((FTLF.K)(PT.K) + (FHR.K)(PT.K))[5]	20
R	PTLA.KL = (PT.K)(FL.K)/WPY	21

THR - number of trees hatracked (trees/week)

DP - length of delay in recovery of hatracked trees (weeks)

PTLA - productive trees lost as a result of "normal" aging factors or tree abandonment (trees/week)

PTLF - productive trees lost as a result of freeze damage (trees)

FTLF - fraction of productive trees lost as a result of freeze damage

FHR - fraction of productive trees hatracked

[5] Division by DT is necessary as a result of the multiplication that occurs in equation 1.

FL - fraction of productive trees lost "normally" or as a result of tree abandonment

The value of the "normal" fraction lost variable was controlled by a clipping function (equation 22) which set FL equal to a tabular value which reflected "normal" tree losses (equations 23 and 24) or to a value that simulated a consciously applied policy of tree abandonment on the part of orange producers. The tree abandonment restriction could be made inoperative by setting its value at a sufficiently low level (equation 25). When the policy was effective, trees were removed from production whenever grower profit was less than \$.15 per box. The rate at which trees were removed from production was positively related to crop size through the DD variable (equations 26 and 27).

A $$FL.K = \begin{cases} XFL.K \text{ if } GP.K \geq TAR \\ \text{or} \\ YFL.K \text{ if } GP.K < TAR \end{cases}$$ 22

A $$XFL.K = TABHL(XFLT, AGP.K, -.50, 2.00, .50)$$ 23

C $$XFLT* = .08/.06/.04/.03/.02/.015$$ 24

C $$TAR = \begin{cases} .15 \text{ if tree abandonment policy was operative} \\ \text{or} \\ -1000.00 \text{ if the tree abandonment policy was inoperative} \end{cases}$$ 25

A $$YFL.K = \left(\frac{1}{DD.K}\right)(DD.K - YDD)$$ 26

C $$YDD = 2.012E6$$ 27

XFL - "normal" fraction of trees lost

YFL - fraction of trees lost when tree abandonment restriction was operative

GP - grower profit (dollars/box)

TAR - tree abandonment restriction (dollars/box)

DD - disappearance desired (boxes/week)

YDD - disappearance associated with grower profits of $1.00 per box (boxes/week)[6]

Weather Effects Sector

Values which determined weather effects were obtained in one of two ways depending on whether historical data were needed (for model validation purposes) or whether values were to be generated stochastically. When historical values were desired, option I was used; otherwise, values were generated by option II.[7] Weather effects were divided into three catagories: tree effect, hatracking effect and yield effect. In the model each effect was treated as a pulse input which occurred once each season (equations 28 - 30).[8]

A	FTLF.K = PULSE(XFTLF.K, 52, 52)	28
A	FHR.K = PULSE(XFHR.K, 52, 52)	29
A	FYLF.K = PULSE(XFYLF.K, 52, 52)	30

Option I

Option I allowed predetermined values which reflected historical weather conditions to be incorporated into the model. These values were expressed as table functions dependent on simulated time (equations 31 - 36).

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[6] A disappearance rate of 2.012 million boxes per week was associated with grower profits of $1.00 per box only when weather and inventories were normal, the demand shifter was equal to its mean value, advertising influences were equal to 1, U.S. population was 193.89 million and the yield of oranges was 4.9 single strength gallons per box.

[7] During initial stages of model validation it was desirable to control as many factors as possible and to observe model performance under relatively stable conditions. In order to partially accomplish this a third weather option was constructed. This option maintained "average" weather conditions. For details see Appendix B, p. 129.

[8] Weather effects for the first season are reflected in initial values.

A XFTLF.K = TABHL(XFTLFT, TIME.K, 52, 572, 52) 31

C XFTLFT* = See Table 4. 32

A XFHR.K = TABHL(XFHRT, TIME.K, 52, 572, 52) 33

C XFHRT* = See Table 4. 34

A XFYLF.K = TABHL(XFYLFT, TIME.K, 52, 572, 52) 35

C XFYLFT* = See Table 4. 36

A WI.K = SWITCH(1, 1, TIME.K) 36A[9]

A WIY.K = CLIP(WI.K, 1, WI.K, 1) 36B

Option II

When option II was used, a weather influence was selected from a population that was normally distributed with mean one and standard deviation .06 (equation 37). The total effect of this distribution was consistent with the "weather index" estimated by Parvin [16]. The weather influence selected was subtracted from one to arrive at an adjusted weather influence (equation 38). The yield effect was set equal to the adjusted weather influence when the value of the weather influence was less than one; otherwise, it was set equal to zero (equation 39). Good weather was accounted for through a weather influence which increased yield (equation 40). Tree and hatracking effects were expressed as functions of the yield effect (equations 41 - 44).

A WI.K = NORMRN(1, .06) 37

A XAWI.K = 1 - WI.K 38

A AWI.K = MIN(XAWI.K, 1) 38A

---

[9] Equations 36A and 36B have only mechanical significance in option I. They set to constants variables determined stochastically under option II.

Table 4. Yield loss, tree loss and hatrack loss factors, 1962-63 through 1972-73 seasons.

Season	Loss[a] (proportion)			
	Tree	Hatrack	Yield	Total
1962-63	.226	.080	.066	.372
1963-64	.185	0	.051	.236
1964-65	0	0	.246	.246
1965-66	0	0	.155	.155
1966-67	0	0	-.189	-.189
1967-68	0	0	.176	.176
1968-69	0	0	-.029	-.029
1969-70	0	0	-.057	-.057
1970-71	0	0	-.058	-.058
1971-72	0	0	.012	.012
1972-73	0	0	0	0

[a]Negative fractions indicate that the effect of the factor was to increase crop size above expected.

$$\text{A} \quad XFYLF.K = \begin{cases} 0 & \text{if } WI.K \geqq 1 \\ & \text{or} \\ AWI.K & \text{if } WI.K < 1 \end{cases} \quad 39$$

$$\text{A} \quad WIY.K = \begin{cases} WI.K & \text{if } WI.K \geqq 1 \\ & \text{or} \\ 1 & \text{if } WI.K < 1 \end{cases} \quad 40$$

A XFTLF.K = TABHL(XFTLFT, XFYLF.K, 0, .35, .35) 41

C XFTLFT* = 0/.15 42

A XFHR.K = TABHL(XFHRT, XFYLF.K, 0, .35, .35) 43

C XFHRT* = 0/.35 44

WI - weather influence

AWI - adjusted weather influence

WIY - weather influence on yield

Crop Size Sector

Crop size was equal to the quantity of fruit remaining plus the quantity of fruit used to date (equation 45). The quantity of fruit remaining at time K was equal to the quantity remaining at time J plus fruit added minus fruit used or lost during the JK interval (equation 46). Fruit usage was accumulated as a level which was cleared at the end of each season (equation 47). This was accomplished through a fruit discarded pulse which occurred once each year (equation 48). The pulse that cleared the level equation was a function of the quantity of fruit used (equation 49).

A CS.K = CR.K + FUTD.K 45

$$\text{L} \quad CR.K = CR.J - CLF.J + NCA.JK - (DT)\left(\sum_{I=1}^{n} FU(I).JK\right) \quad 46$$

$$\text{L} \quad FUTD.K = FUTD.J + (DT)\left(\sum_{I=1}^{n} FU(I).JK - FD.JK\right) \quad 47$$

R FD.KL = PULSE (FDP.K, 52, 52) 48

A FDP.K = FUTD.K/DT 49

CS - crop size (boxes)

CR - crop remaining (boxes)

FUTD - fruit used to date (boxes)

NCA - new crop added (boxes/week)

FU(I) - fruit used in I^{th} product[10] (I = 1, . . . , 7) (boxes/week)

CLF - crop lost as a result of freeze damage (boxes)

FD - fruit discarded (boxes/week)

FDP - fruit discarded pulse (boxes)

N - number of orange products considered in the model

New crop added was a function of the new crop pulse which occurred at the beginning of each new crop season (equation 50). The size of the pulse depended on the number of productive trees, yield per tree and a stochastic weather influence on yield (equation 51). Yield per tree was considered a function of (lagged) average grower profit and reflected the improved cultural practices provided by growers in response to higher prices (equations 52 and 53).

R NCA.KL = PULSE(CSP.K, 52, 52) 50

A CSP.K = (PT.K)(BPT.K)(WIY.K) 51

A BPT.K = TABHL(BPTT, AGP.K, -.50, 2.00, .50) 52

---

[10] The following numerical code was used to identify the I^{th} product.

Product	Market: Retail (I^{th} product)	Market: Institutional (I^{th} product)
Frozen concentrated orange juice	1	5
Chilled orange juice	2	6
Canned single strength orange juice	3	7
Fresh oranges	4	*

* Not included.

ATTENTION!

Error Note

The influence of weather on grower costs (equation 60) was intended to be determined once at the beginning of each season and then to be held constant until the start of the next crop year. During years when weather was favorable (WI>1) grower costs per box would be decreased. On the other hand, unfavorable weather (WI<1) would cause a cost increase. Due to an error in programming, this was not what actually occurred in the operation of the model. The weather influence was an auxiliary (equation 37) which, with DT specified as .5 , was calculated twice per week. This caused grower cost per box (equation 60) to be subject to a stochastic influence.

The major effects of the error are the following.

(1) On the average, grower profits were overstated (understated) during seasons of unfavorable (favorable) weather.

(2) The rate at which new trees were planted was affected through average grower profits; however, since the averaging period was two years the stochastic effect was small.

(3) When the tree abandonment policy was operative (equations 22 and 25), the rate of tree abandonment was influenced since it was based directly on the level of grower profits.

Correction

The problem may be corrected by changing equation 60 to

```
A     GC.K=CPB/XWI.K                                    60
```

and adding the following equations:

A XWI.K= $\begin{cases} \text{WI.K} & \text{if WP.K} \geq 52 \\ \text{or} & \\ \text{LWI.K} & \text{if WP.K} < 52 \end{cases}$ 60A

L LWI.K=XWI.J 60B

N LWI=1 4 60B

Comparison

A comparison of results from uncorrected and corrected versions of the model is presented below for two of the policies (B and TA2, see page 96) considered in the study.

Policy		Grower profits		Average FOB price		Crop size	
		Present value[a]	Std. dev.[b]	Present value[b]	Std. dev.[b]	Present value[a]	Std. dev.[b]
Base (B)	U[c]	1000.98	106.59	7.16	.20	1746.39	61.82
	C	1007.48	100.02	7.15	.20	1747.96	64.33
Tree abandonment (TA2)	U	1165.11	61.35	7.43	.15	1649.96	47.60
	C	1139.58	63.11	7.36	.17	1673.84	52.07

[a] Large values preferred.

[b] Small values preferred.

[c] U - uncorrected; C - corrected.

C BPTT* = 4.5/4.6/4.7/4.8/5.0/5.3 53

CSP - crop size pulse (boxes)

BPT - yield per tree (boxes/tree)

AGP - average grower profit (dollars/box)

The crop lost as a result of freeze damage was the sum of the loss from each of the three freeze effect catagories (equation 54). Each of these losses was the product of the appropriate loss factor (from the freeze effects sector) and the crop size pulse (equations 55 - 57).

A CLF.K = TLOSS.K + HLOSS.K + YLOSS.K 54

A TLOSS.K = (FTLF.K)(CSP.K) 55

A HLOSS.K = (FHR.K)(CSP.K) 56

A YLOSS.K = (FYLF.K)(CSP.K) 57

TLOSS - crop loss associated with tree kills (boxes)

HLOSS - crop loss associated with hatracking (boxes)

YLOSS - yield loss (boxes)

Grower Profit Sector

Grower profit per box was the difference in on-tree price per box and grower cost (equation 58). Grower cost was initially set at .85 dollars per box and remained at that level until option II was employed to generate a weather influence (equation 59). When option II was used, grower cost was influenced by weather conditions (equation 60). On-tree price was a function of the weighted average FOB price paid for orange products (equations 61 and 62). Average grower profit was an exponentially smoothed function of grower profit (equations 63 and 64). Profit was calculated by multiplying profit per box times the number of boxes used (equation 65). It was then accumulated for each year in a level equation (equations 66, 66A and 66B).

A	GP.K = OTP.K - GC.K	58
C	CPB = .85 dollars per box	59
A	GC.K = CPB/WI.K	60
A	OTP.K = TABHL(OTPT, AFOB.K, .35, 1.25, .18)	61
C	OTPT* = .03/1.00/1.96/2.94/3.90/4.86	62
L	$AGP.K = AGP.J + (DT)(\frac{1}{TAGP})(GP.J - AGP.J)$	63
C	TAGP = 104 weeks	64
R	PROFT.KL = (GP.K)(TFU.K)	65
L	CP.K = CP.J + (DT)(PROFT.JK - CPD.JK)	66
R	CPD.KL = PULSE(CPDP.K, 52, 52)	66A
A	CPDP.K = CP.K/DT	66B

OTP - on-tree price (dollars/box)

GC - grower cost (dollars/box)

CPB - cost per box (dollars/box)

AFOB - weighted average FOB price of orange products (dollars/gallon single strength equivalent)

TAGP - time for averaging grower profits (weeks)

PROFT - profit (dollars/week)

TFU - total fruit usage per week (boxes)

CP - cumulative profit per year (dollars)

CPD - cumulative profits discarded (dollars)

CPDP - cumulative profit discard pulse (dollars)

Processor Disappearance Sector

Weeks of crop (supply) remaining was a function of crop remaining and average fruit usage (equation 67). Average fruit usage was equal to fruit usage exponentially smoothed with a four week averaging period (equations 68 and 69). Fruit usage associated with the Ith product depended on the disappearance of product I and a conversion factor (equations70 - 76). The constant portion of the conversion factor was based on yield figures for the 1969-70 and 1970-71 seasons (Table 5). The conversion factor remained at the constant level until the weather influence was generated. When the weather influence was available, yield was influenced by weather conditions (equations 77 - 90). Processor disappearance was a function of retail and institutional demand and processor availability (equations 91 - 97). Processor availability was related to the number of weeks of crop remaining (equations 98 and 99).

A	WCR.K = CR.K/AFU.K	67
L	$AFU.K = AFU.J + (DT)\left(\frac{1}{TAFU}\right) \sum_{I=1}^{n} (FU(I).JK - AFU.J)$	68
C	TAFU = 4 weeks	69
R	FU(I).KL = (PD(I).JK)(BPG(I).K)	70-76
A	$TFU.K = \sum_{I=1}^{n} FU.JK$	76A
A	$BPG(I).K = \frac{1}{(GPB(I))(WI.K)}$	77-83
C	GPB(I) = See Table 5.	84-90
R	PD(I).KL = (D(I).JK)(PA.K)	91-97
A	PA.K = TABHL(PAT, WCR.K, 0, 15, 5)	98
C	PAT* = 0/.84/.97/1.0	99

WCR - weeks of crop remaining (weeks)

AFU - average weekly fruit usage (boxes)

TAFU - time for averaging fruit usage (weeks)

PD(I) - processor disappearance product I (gallons single strength equivalent/week)

BPG(I) - conversion factor for product I (boxes/gallon single strength equivalent)

GPB(I) - conversion factor for product I (gallon single strength equivalent/box)

D(I) - order rate for the I^{th} product (gallons single strength equivalent/week)

PA - processor availability

Table 5. Conversion factors for major orange products.

Product	Conversion factors: Gallons single strength equivalent per 90 pound box
1	4.90
2	5.29
3	5.20
4	5.29
5	4.90
6	5.29
7	5.20

Source: Based on yield estimates for 1969-70 and 1970-71 seasons.

Advertising Sector

Advertising revenue was equal to fruit usage times the advertising tax less administrative and other nonadvertising costs (equation 100). Administrative and other nonadvertising costs were assumed to be a constant $26,306 per week (equation 101). The advertising tax rate was based on actual values for the 1962-63 through 1970-71 seasons (Table 6). After the 1970-71 season, the tax was assumed constant at

Table 6. Advertising tax rates for Florida oranges by type of use, 1962-63 through 1970-71 seasons.

Season	Advertising tax rate	
	Fresh	Processed
	(cents/box)	
1962-63	9	9
1963-64	9	9
1964-65	10	8
1965-66	10	8
1966-67	10	8
1967-68	10	8
1968-69	10	8
1969-70	10	8
1970-71	10	10

Source: Personal interview with the Economic Research Department, Florida Department of Citrus.

10 cents per box (equations 102 and 103). Advertising tax revenue accumulated at time K was equal to revenue accumulated at time J plus revenue collected minus revenue spent during the JK interval (equation 104). The weekly advertising expenditure was the product of revenue available for advertising and the fraction spent each week (equation 105). The fraction spent each week reflected the seasonal expenditure pattern presented in Figure 9 and was a function of the number of weeks remaining in the season (equation 106 and 107). Trademark advertising was not considered in this study.

R	$ATR.KL = (\sum_{I=1}^{n} FU(I).JK)(AT.K) - AC$	100
C	AC = 26,306	101
A	AT.K = TABHL(ATT, TIME.K, 0, 416, 52)	102
C	ATT* = .09/.09/.08/.08/.08/.08/.08/.08/.10	103
L	ATRA.K = ATRA.J + (DT)(ATR.JK - ATS.JK)	104
R	ATS.KL = (ATRA.K)(FSPW.K)	105
A	FSPW.K = TABHL(FSPWT, WP.K, 1, 52, 1)	106
C	FSPWT* = See Figure 9.	107

ATR - advertising tax revenue (dollars/week)

AC - administrative cost (dollars/week)

AT - advertising tax (dollars/box)

ATRA - advertising tax revenue accumulated (dollars)

ATS - advertising tax spending (dollars/week)

FSPW - fraction spent per week

WP - weeks passed (weeks)

Consumers were assumed to respond gradually to advertising expenditures in the model. The magnitude of their response at a given time was

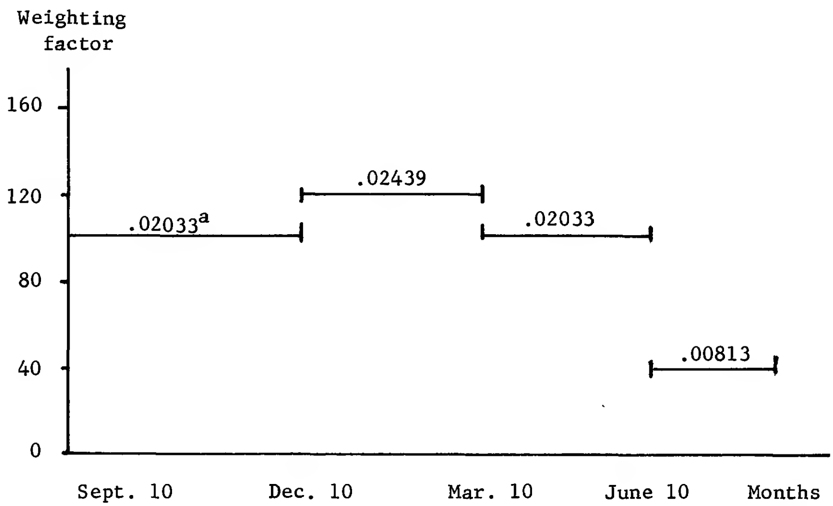

Figure 9. Seasonal pattern of generic advertising and promotional expenditures for Florida oranges.

Source: Personal interview with the Economic Research Department, Florida Department of Citrus.

[a] Fraction of tax revenue spent per week.

determined on the basis of the average advertising expenditure for the preceding two years (equations 108 - 117).

Since little data were available, advertising responses for institutional products were based on the assumption that customer oriented institutional purchasers such as restaurants and drugstore fountains were affected by advertising programs in the same manner as retail consumers. Noncustomer oriented institutions such as hospital and military establishments were assumed to be unaffected by advertising programs (equations 118 - 123).[11]

L	AA.K = AA.J + (DT)(1/TAA)(ATS.JK - AA.J)	108
C	TAA = 104 weeks	109
A	AI1.K = TABHL(AI1T, AA.K, .5E5, .3E6, .5E5)	110
C	AI1T* = .96625/.9810/.9925/1.0030/1.0095/1.015	111
A	AI2.K = TABHL(AI2T, AA.K, .5E5, .3E6, .5E5)	112
C	AI2T* = .9445/.9720/.9895/1.0055/1.0195/1.027	113
A	AI3.K = TABHL(AI3T, AA.K, .5E5, .3E6, .5E5)	114
C	AI3T* = .9555/.9920/.9990/.9990/.9910/.9840	115
A	AI4.K = TABHL(AI4T, AA.K, .25E5, .225E6, .5E5)	116
C	AI4T* = .74/.92/1.068/1.116/1.146	117
A	AI5.K = TABHL(AI5T, AA.K, .5E5, .3E6, .5E5)	118
C	AI5T* = .97604/.98651/.99468/1.00213/1.00675/1.01065	119
A	AI6.K = TABHL(AI6T, AA.K, .5E5, .3E6, .5E5)	120
C	AI6T* = .96781/.98376/.99391/1.00319/1.01131/1.01566	121
A	AI7.K = TABHL(AI7T, AA.K, .5E5, .3E6, .5E5)	122
C	AI7T* = .97419/.99536/.99942/.99942/.99478/.99072	123

[11] For the data on which these relationships were based, see Appendix E.

AA - average advertising (dollars/week)

TAA - time for averaging advertising (weeks)

AI(I) - advertising influence on demand for the I^{th} product

FOB Price Sector

The FOB price of orange products was the mechanism through which allocation was accomplished. Allocation occurred in a resursive fashion. A time lag existed during which the model waited for consumers to respond to the most recent price adjustment. When price adjustments did not produce the desired effect or when conditions changed, new prices would be forthcoming. In making price changes, the model considered the size of the orange crop, the time that remained in the marketing season, the rate at which fruit was being used and the relative profitability of orange products. When fruit usage was less than desired, the model attempted to increase consumption and order rates by reducing prices. When it appeared that shortages would occursthe model increased prices. Price adjustments designed to alter fruit usage were accompanied by adjustments in the relative price of orange products. The model adjusted relative price whenever the marginal net revenue from the sale of one product was different from another. For example, when the marginal net revenue from product I was greater than that from product J, the model increased the price of J, reduced the price of I, or both. Thus, the model attempted to equate marginal net revenues among orange products.[12]

The marginal net revenue of product I at time K was specified as a function of the FOB price of the I^{th} product at time J (equations 124 -

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[12]Refer to pp. 47-49 for a discussion of the allocation problem. Net marginal revenue functions were derived from cost and revenue relationships. For details see Appendix C.

130). Marginal net revenues were weighted by the quantity of each product to arrive at a weighted average marginal net revenue per gallon single strength equivalent (equation 131). This weighted average was used to suggest an FOB price for each product (equations 132 - 138). Suggested FOB prices along with demand equations and advertising influences on demand provided estimates of the monthly per capita quantity of product demanded (equations 139 - 145). When multiplied times an estimate of U.S. population, summed and converted to boxes per week, these estimates suggested processor disappearance (equations 146 - 153). Tables 7, 8 and 9 show the demand functions, mean values of variables and the data periods, respectively, for the demand relationships.

L $\quad MNR(I).K = A1(I) + (A2(I))(FOB(I).J) + (A3(I))(DS.J) \qquad$ 124-130

A $$AMNR.K = \frac{\sum_{I=1}^{n} (MNR(I).K)(XQD(I).K)}{\sum_{I=1}^{n} XQD(I).K} \qquad 131$$

A $\quad XFB(I)S.K = A4(I) + (A5(I))(AMNR.K) + (A6(I))(DS.K) \qquad$ 132-138

A $$XPQS(I).K = (AI(I).K)(A7(I) + \sum_{I=1}^{n} ((A8(I))(XFB(I)S.K)) + (A9(I))(DS.K) \qquad 139\text{-}145$$

A $\quad XQS(I).K = (XPQS(I).K)(POP.K)/4 \qquad$ 146-152

A $$PDS.K = \sum_{I=1}^{n} ((BPG(I).K)(XQS(I).K)) \qquad 153$$

MNR(I) - marginal net revenue of I^{th} product (dollars/ gallon single strength equivalent)

Table 7. Relationship between per capita quantity of an orange product that would be demanded by retail and institutional consumers given adequate time for system adjustment and the FOB price of the product.

Quantity[a] (gallons single strength equivalent per capita per month)	Intercept	FOB price (dollars/gallon single strength equivalent)	Seasonal shifter[b]
Q^R_{FCOJ}	.145935	-.106017	-.009218
Q^R_{COJ}	.035136	-.047900	-.000294
Q^R_{CSSOJ}	.023731	-.027704	.000131
Q^R_{FO}	.126176	-.117840	c
Q^I_{FCOJ}	.052886	-.055452	c
Q^I_{COJ}	.078273	-.058530	c
Q^I_{CSSOJ}	.173864	-.185287	c

Source: Retail demand relationships for processed products were obtained from the Economic Research Department, Florida Department of Citrus. The fresh orange relationship was derived from elasticity estimates reported by Langham [10, p. 20]. Demand relationships for institutional products were obtained from [26, 27]. All relationships have been adjusted.

[a] Superscript represents retail or institutional market. Subscript indicates product type.

[b] Seasonal shifter $= \begin{cases} 0 \text{ Sept. - Mar.} \\ 1 \text{ Apr. - Aug.} \end{cases}$

[c] Not included in regression model.

Table 8. Mean values associated with estimated demand relationships.

Product[a]	FOB price (dollars/gallon single strength equivalent)	Quantity (per capita gallons single strength equivalent/month)
$FCOJ_R$	.5242	.0867
COJ_R	.5532	.0085
$CSSOJ_R$	.5547	.0084
FO_R	.7618	.0364
$FCOJ_I$	.7492	.0113
COJ_I	1.0600	.0162
$CSSOJ_I$	.9043	.0062

[a]The subscript refers to the retail or institutional market.

Table 9. Base data periods associated with estimated demand relationships.

Product	Market	
	Retail	Institutional
FCOJ	January, 1968 - April, 1971	December, 1963 - November, 1966
COJ	January, 1968 - April, 1971	December, 1963 - November, 1966
CSSOJ	January, 1968 - April, 1971	December, 1963 - November, 1966
Fresh oranges	August, 1962 - July, 1963	a

[a]Not applicable.

FOB(I) - FOB price of I^{th} product (dollars/gallon single strength equivalent)

AMNR - weighted average marginal net revenue (dollars/gallon single strength equivalent)

XQD(I) - quantity of the I^{th} product demanded at time J (gallons single strength equivalent/week)

XFB(I)S - suggested FOB price for product I (dollars/gallon single strength equivalent)

XPQS(I) - monthly per capita consumption of product I suggested (gallons single strength equivalent per capita/month)

POP - U.S. population

XQS(I) - suggested consumption of I^{th} product (gallons single strength equivalent/week)

PDS - suggested processor disappearance (boxes/week)

In order to maximize profits, economic theory indicates that a product should be allocated among markets so as to equate the marginal net revenue from the sale of the product in each market. The use of the average marginal net revenue to suggest new FOB prices insured that this condition was met. Perhaps this should be illustrated by an example. Assume that the FOB prices (P_1, P_2 and P_3) of products 1, 2, 3 yield the marginal net revenues (MNR_1, MNR_2 and MNR_3) shown in Figure 10. Further assume that the marginal net revenue of product 1 is less than the marginal net revenue of product 2 and greater than that of product 3. Since prices and marginal net revenues are positively related, profit maximization requires that the price of product 2 be reduced relative to product 1 while that of product 3 should be increased. A simple average

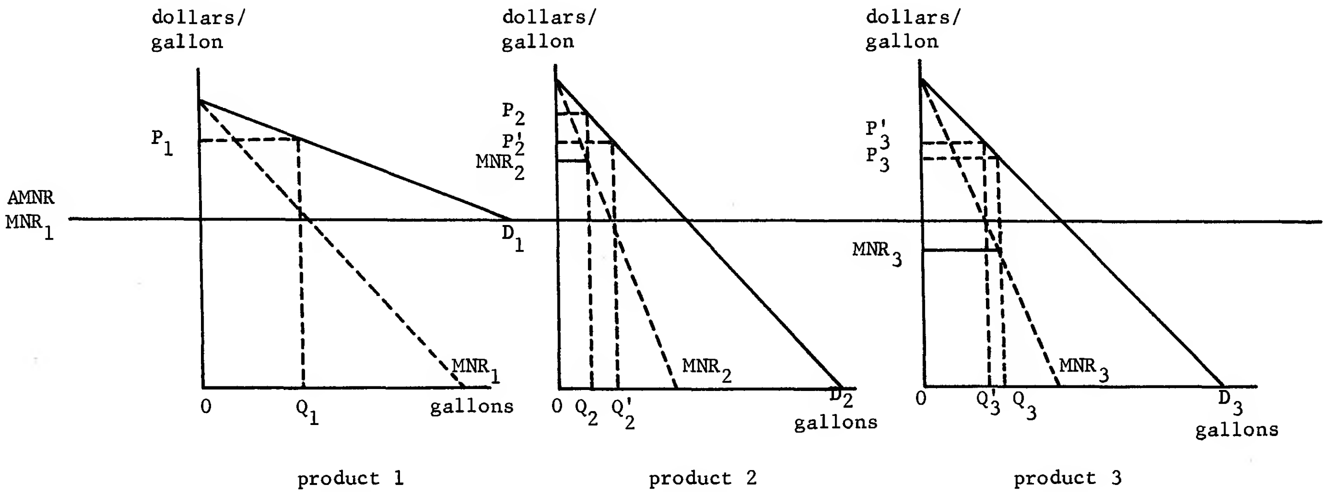

Figure 10. Relative price adjustment for three product case.[a]

[a]The diagram simplifies the price adjustment technique by assuming zero cost and ignoring the effect of advertising.

of the three marginal net revenues yields a value equal to AMNR.[13] Prices suggested by this average value will be associated with equal marginal net revenues. In the example, the FOB price for product 1 would be unchanged while prices of products 2 and 3 would be reduced and increased, respectively. This technique adjusts relative prices; however, it does not consider adjustments in overall fruit usage relative to desired. In order to make this adjustment, it was necessary to compare processor disappearance suggested with processor disappearance desired.[14]

Desired disappearance was a function of crop remaining, the number or weeks left in the marketing season, and the end of season carry-over (equation 154). The carry-over was set equal to an eight week supply, except when an increased carry-over was operative in which case the desired carry-over increased to a 16 week supply (equation 155). Weeks passed were accumulated by a level equation which was reset to zero at the beginning of each season (equations 156 - 158).

A DD.K = (CR.K)/(WPY - WP.K + WCO) 154

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[13]The weighted average actually used in the model reduces the magnitudes of the fluctuations in aggregate fruit usage that result from relative price adjustments.

[14]Bharat Jhunjhunwala has pointed out that an alternative approach would be to solve the constrained maximization problem and to use the resulting relationships as the basis for selecting the new price set. This method would allow the selection of prices that equate marginal net revenues while conforming to a quantity constraint. If the constraining quantity was set equal to desired disappearance, the movement suggested by the new price set would be that required to deplete available orange supplies (less carry-overs). This method was not used since it was believed that the iterative technique provided a closer approximation of real world behavior and was computationally less demanding than a solution to the constrained maximization problem. The constrained maximization problem becomes computationally complex if the B matrix defined in Appendix C is nondiagonal.

$$\text{C} \qquad \text{WCO} = \begin{cases} \text{8 if the increased carry-over policy was inoperative} \\ \text{or} \\ \text{16 if the increased carry-over policy was operative} \end{cases} \qquad 155$$

$$\text{L} \qquad \text{WP.K} = \text{WP.J} + (\text{DT})(1 - \text{WD.JK}) \qquad 156$$

$$\text{R} \qquad \text{WD.KL} = \text{PULSE}(\text{WDP}, 52, 52) \qquad 157$$

$$\text{N} \qquad \text{WDP} = (\text{WPY}/\text{DT}) \qquad 158$$

WCO - weeks of carry-over (weeks)

WD - weeks discarded (weeks)

WDP - weeks discarded pulse (weeks)

Processor disappearance relative to desired was the variable that determined whether an adjustment in product flow was necessary (equation 159). When its value was not equal to one, an overall price adjustment was indicated; however, whether or not the adjustment was made depended on the value (either 0 or 1) of R (equation 160). The value of R depended on the value of V which in turn depended on the values of E, H and TIME (equations 161 - 165). These equations allowed specification of a minimum time period during which price adjustments could not occur.

$$\text{A} \qquad \text{PDRD.K} = \text{PDS.K}/\text{DD.K} \qquad 159$$

$$\text{A} \qquad \text{R.K} = \begin{cases} 1 \text{ if V.K} \geq 0 \\ \text{or} \\ 0 \text{ if V.K} < 0 \end{cases} \qquad 160^{15}$$

$$\text{A} \qquad \text{V.K} = (\text{TIME.K}/\text{H}) - \text{E.K} \qquad 161$$

$$\text{L} \qquad \text{E.K} = \text{E.J} + (\text{DT})(\text{Z.J}) \qquad 162$$

[15] The mechanics of the mechanism was as follows: no adjustment was allowed when R.K was equal to zero. R.K was equal to zero whenever V.K was negative. V.K was negative when the ratio TIME.K/H was less than E.K. When the ratio was equal to E.K, V.K became zero and R.K was set equal to one allowing the adjustment to be made. In order to prevent continuous price adjustments beyond time H, the value of E.K was incremented by one. Then, the process was repeated.

A $\quad Z.K = R.K/DT$ 163

$$H = \begin{cases} .5 \text{ if the price adjustment restriction was inoperative} \\ \text{or} \\ 4 \text{ if the price adjustment restriction was operative} \end{cases}$$ C 164

N $\quad E = 1$ 165

PDRD - processor disappearance relative to desired

When adjustments were allowed, average marginal net revenue was adjusted and prices increased or decreased according to processor disappearance suggested relative to desired (equation 166). When suggested disappearance was greater than desired, average marginal net revenue was adjusted upward. When suggested disappearance was less than desired, the average net marginal revenue was adjusted downward. The magnitude of the adjustment was increased by the Q variable as the disappearance ratio moved further from its equilibrium value (equations 167 and 168). A policy option allowed the specification of a limit below which average marginal net revenue could not be adjusted (equations 168A and 168B). Once the average marginal net revenue had been adjusted and new prices suggested they became the basis for new FOB prices (equations 169 - 189). Thus, when the policy was effective lower limits were placed on the prices of the orange products. Finally weighted average FOB price was smoothed (equations 189B and 189C).

A $\quad ZAMNR.K = AMNR.K + (R.K)(PDRD.K - 1)(Q.K)$ 166

A $\quad Q.K = TABHL(QT, PDRD.K, .94, 1.06, .01)$ 167

C $\quad QT* = 20/18/16/14/12/10/1/10/12/14/16/18/20$ 168

A $\quad XAMNR.K = MAX(FLOOR, ZAMNR.K)$ 168A

$$FLOOR = \begin{cases} -.20 \text{ if lower limit on XAMNR was operative} \\ \text{or} \\ -1000 \text{ if lower limit on XAMNR was inoperative} \end{cases}$$ C 168B

A $\quad FOB(I)S.K = A2(I) + (B2(I))(XAMNR.K) + (B4(I))(DS.K)$ 169-175

A $\quad AQS(I).K = (POP.K)(AI(I).K)(A3(I) + (B3(I))(FOB(I)S.K) + (B4(I))(DS.K))$ 175A-175G

A $\quad AQS.K = \sum_{I=1}^{n} (AQS(I).K)(BPG(I).K)$ 175H

L $\quad FOB(I.K = FOB(I).J + (DT)(\frac{1}{TCFP(I)})(FOB(I)S.J - FOB(I).J)$ 176-182

C $\quad TCFP(I) = 4$ weeks 183-189

A $\quad AFOB.K = \frac{\sum_{I=1}^{n} (FU(I).JK)(FOB(I).K)}{TFU.K}$ 189A

L $\quad SFOB.K = SFOB.J + (DT)(\frac{1}{TSFOB})(AFOB.J - SFOB.J)$ 189B

C $\quad TSFOB = 12$ weeks 189C

ZAMNR - average marginal net revenue before considering the policy limit

FLOOR - lower limit on XAMNR

XAMNR - average marginal net revenue after the overall adjustment (dollars/gallon single strength equivalent)

FOB(I)S - FOB price of I^{th} product suggested after the overall adjustment (dollars/gallon single strength equivalent)

AQS(I) - quantity of the I^{th} product suggested after price adjustment (gallon single strength equivalent/week)

AQS - total quantity suggested after the price adjustment (boxes/week)

TCFP(I) - smoothing period used in determining FOB price for I^{th} product (weeks)

SFOB - smoothed weighted average FOB price (dollars/box)

TSFOB - time for smoothing weighted average FOB price (weeks)

Retail and Institutional Inventory and Sales Sector

Sales of orange products were equal to the product consumers demanded as long as adequate supplies were available at the consumer level (equations 190 - 196). The model's ability to satisfy consumer demand depended on the number of weeks of product inventory on hand relative to "normal." Data collected by the A. C. Nielsen Company and a priori knowledge provided a basis for estimating "normal" inventory levels for orange products (Table 10). When inventories dropped below "normal," a portion of consumer demand went unsatisfied (equations 197 - 210).

The number of weeks of product inventory on hand was calculated by dividing the inventory level by average consumer demand (equations 211 - 217). Inventories were increased by processor disappearance and decreased by product sales (equations 218 - 224).

R	S(I).KL = (QD(I).K)(IA(I).K)	190-196
A	IA1.K = TABHL(IA1T, WIA1.K, 0, 1.5, .5)	197
C	IA1T* = 0/.85/.98/1.0	198
A	IA2.K = TABHL(IA2T, WIA2.K, 0, 1.5, .5)	199
C	IA2T* = 0/.85/.98/1.0	200
A	IA3.K = TABHL(IA3T, WIA3.K, 0, 4, 2)	201
C	IA3T* = 0/.85/1.0	202
A	IA4.K = TABHL(IA4T, WIA4.K, 0, .6, .2)	203
C	IA4T* = 0/.85/.98/1.0	204

Table 10. "Normal" retail inventories of major orange products.

Product	Inventory level (C(I))
	(weeks)
$FCOJ_{R \text{ and } I}$	1.3
$COJ_{R \text{ and } I}$	1.2
$CSSOJ_{R \text{ and } I}$	3.7
FO_R	.5

Source: The estimate for fresh oranges was based on a priori knowledge. Estimates for processed products were based on data collected by the A. C. Nielsen Company.

A IA5.K = TABHL(IA5T, WIA5.K, 0, 1.5, .5) 205

C IA5T* = 0/.85/.98/1.0 206

A IA6.K = TABHL(IA6T, WIA6.K, 0, 1.5, .5) 207

C IA6T* = 0/.85/.98/1.0 208

A IA7.K = TABHL(IA7T, WIA7.K, 0, 4, 2) 209

C IA7T* = 0/.85/1.0 210

A WIA(I).K = I(I).K/AQD(I).K 211-217

L I(I).K = I(I).J + (DT)(PD(I).JK - S(I).JK) 218-224

S(I) - sales of the I^{th} product (gallons single strength equivalent/week)

IA(I) - influence of product availability on sales of the I^{th} product

QD(I) - quantity of the I^{th} product demanded (gallons single strength equivalent/week)

WIA(I) - number of weeks of inventory available (weeks)

I(I) - inventory level (gallons single strength equivalent)

AQD(I) - average quantity of I^{th} product demanded (gallons single strength equivalent/week)

Retail and institutional order rates depended on the level of average consumer demand, the inventory level relative to "normal" and a competitive influence which was associated with future price expectations (equations 225 - 231). When inventories were below "normal" regular order rates were increased in an effort to rebuild inventories, while above "normal" inventories caused a reduction in orders (equations 232 - 245). The competitive influence was expressed as a function of processor disappearance relative to desired and reflected the influence of price expectations on current order rates (equations 246 - 247).

When the ratio of suggested and desired processor disappearance was larger than unity, a price increase was expected at the FOB level and retail and institutional purchasers increased their orders in an attempt to take advantage of the lowest possible price. Similarly, when processor disappearance relative to desired was less than unity, order rates were reduced in anticipation of lower FOB prices.

R	D(I).KL = (AQD(I).K)(II(I).K)(CI.K)	225-231
A	II1.K = TABHL(II1T, WIA1.K, .3, 2.8, .5)	232
C	II1T* = 2.2/1.4/1.0/.9/.85/.82	233
A	II2.K = TABHL(II2T, WIA2.K, .2, 2.7, .5)	234
C	II2T* = 2.2/1.4/1.0/.9/.85/.82	235
A	II3.K = TABHL(II3T, WIA3.K, .7, 6.7, 1.5)	236
C	II3T* = 1.5/1.2/1.0/.9/.85	237
A	II4.K = TABHL(II4T, WIA4.K, .1, .9, .2)	238
C	II4T* = 3.0/2.4/1.0/.81/.72	239
A	II5.K = TABHL(II5T, WIA5.K, .3, 2.8, .5)	240
C	II5T* = 2.2/1.4/1.0/.9/.85/.82	241
A	II6.K = TABHL(II6T, WIA6.K, .2, 2.7, .5)	242
C	II6T* = 2.2/1.4/1.0/.9/.85/.82	243
A	II7.K = TABHL(II7T, WIA7.K, .7, 6.7, 1.5)	244
C	II7T* = 1.5/1.2/1.0/.9/.85	245
A	CI.K = TABHL(CIT, PDRD.K, .6, 1.4, .2)	246
C	CIT* = .9/.97/1.0/1.03/1.1	247

II(I) - inventory influence associated with I^{th} product

CI - competitive influence

Retail and Institutional Price Sector

Retail prices of orange products normally adjust to levels suggested by FOB prices. The length of the adjustment period and the degree to which retail prices respond to changes at the FOB level depend on several factors, among these is the price protection policy of processors. At the time of this study, price protection was offered for processed products for a two week period. No protection was offered for fresh oranges. Factors such as the magnitude of the FOB price adjustment, the rate of product sales, and the level of inventories probably influence the length of the adjustment period. For this study, the time to correct the retail price of each product was assumed constant. Once the FOB price of a product was known, it was used to suggest a price which exponentially smoothed over an adjustment period determined the retail price of the product (equations 248 - 263). These retail prices were averaged and used as inputs to the consumer demand sector (equations 264 - 268).

A XFOB1.K = (2.2501)(FOB1.K) 248

A XFOB2.K = (3)(FOB2.K) 249

A XFOB3.K = (4.3119)(FOB3.K) 250

A XFOB4.K = (2.645)(FOB4.K) 251

A RPS1.K = 4.60 + (8.3333)(XFOB1.K) 252

A RPS2.K = 16.91 + (8.3333)(XFOB2.K) 253

A RPS3.K = 12.38 + (8.3333)(XFOB3.K) 254

A RPS4.K = 2.34 + (4.0)(XFOB4.K) 255

L $RP(I).K = RP(I).J + (DT)\left(\frac{1}{TCRP(I)}\right)(RPS(I).J - RP(I).J)$ (I = 1, 2, 3, 4) 256-259

C TCRP1 = 2 weeks 260

C TCRP2 = 2 weeks 261

C TCRP3 = 4 weeks 262

C TCRP4 = .5 weeks 263

L $ARP(I).K = ARP(I).J + (DT)(\frac{1}{TARP})(RP(I).J -$

$ARP(I).J)$ (I = 1, 2, 3, 4) 264-267

C TARP = 2 weeks 268

XFOB1 - FOB price of frozen concentrated orange juice (dollars/dozen 6 ounce cans)

XFOB2 - FOB price of chilled orange juice (dollars/dozen quarts)

XFOB3 - FOB price of canned single strength orange juice (dollars/dozen 46 ounce cans)

XFOB4 - FOB price of fresh oranges (dollars/45 pound carton)

RPS1 - retail price suggested for frozen concentrated orange juice (cents/6 ounce can)

RPS2 - retail price suggested for chilled orange juice (cents/quart)

RPS3 - retail price suggested for canned single strength orange juice (cents/46 ounce can)

RPS4 - retail price suggested for fresh oranges (cents/pound)

RP(I) - retail price of the I^{th} product (same units as retail price suggested)

TCRP(I) - time for correcting the retail price of the I^{th} product (weeks)

ARP(I) - average retail price of the I^{th} product (same units as retail price suggested)

TARP - time for averaging retail price (weeks)

The heterogeneity of the institutional market makes data collection and analysis at the consumer level difficult and costly. The difficulty is further complicated by the fact that many institutional outlets purchase orange products through retail stores. For example, restaurant sales accounted for the consumption of about 88 million gallons of orange juice during 1971 [1]. Of this, 19 percent was reported to have been purchased by restaurants through retail outlets. The total institutional consumption of orange products during 1971 was estimated to be 196 million single strength gallons. This represented about 28 percent of total 1971 orange juice consumption.

Demand estimates for institutional products at the FOB level were available from a study by Weisenborn [25]. This information was used as the basis for predicting consumption in the institutional market. It should be noted that the model estimates neither wholesale nor consumer prices for orange products sold through institutional outlets.

The FOB prices of institutional products were converted to units consistent with Weisenborn's equations (equations 269 - 271). They were then exponentially smoothed and used as inputs to the demand sector (equations 272 - 275).

A XFOB5.K = (12)(FOB5.K) 269

A XFOB6.K = (3)(FOB6.K) 270

A XFOB7.K = (4.3125)(FOB7.K) 271

L $IP(I).K = IP(I).J + (DT)\left(\frac{1}{TCIP}\right)(XFOB(I).J - IP(I).J)$ 272-274

(I = 5, 6, 7)

C TCIP = 2 weeks 275

XFOB5 - FOB price of FCOJ (dollars/dozen 32 ounce cans)

XFOB6 - FOB price of COJ (dollars/dozen quarts)

XFOB7 - FOB price of CSSOJ (dollars/dozen 46 ounce cans)

IP(I) - smoothed institutional FOB price of the I^{th} product; (I = 5, 6, 7) (same units as XFOB prices)

TCIP - time for correcting institutional price (weeks)

Demand Sector

Relationships used to estimate product comsumption are presented in Table 11 and the mean values for prices and quantities are given in Table 12. Advertising and price information (inputs to the sector) were used in conjunction with the demand equations to predict the quantity of each product demanded (equations 276 - 282). Estimates were made on a monthly per capita basis. These estimates, converted to weekly per capita quantities and multiplied times projected U.S. population, provided an estimate of the total weekly consumption of each product (equations 283 - 290). Population was accumulated in a level equation and was dependent on a growth rate which was related to time (equations 291 - 293). Average quantity demanded was an input to the retail and institutional inventory and sales sector (equations 294 - 301).

A $$PQD(I).K = (AI(I).K)\left[A(I) + \sum_{I=1}^{4} (B(I))(ARP(I).K) + (B8)(DS.K)\right] \quad (I = 1, 2, 3, 4)$$ 276-279

A $$PQD(I).K = (AI(I).K)\left[A(I) + \sum_{I=5}^{7} (B(I))(IP(I)).K\right] \quad (I = 5, 6, 7)$$ 280-282

Table 11. Retail and institutional demand relationships for Florida orange products.

Quantity[a] (gallons single strength equivalent per capita)	Intercept	Pricing Unit	Retail or institutional price coefficient	Seasonal shifter[b]
Q^{R}_{FCOJ}	.171943	cents/6 ounce	-.005654	-.009218
Q^{R}_{COJ}	.067536	cents/quart	-.001916	-.000294
Q^{R}_{CSSOJ}	.033276	cents/46 ounce	-.000771	.000131
Q^{R}_{FO}	.152239	cents/pound	-.011138	c
Q^{I}_{FCOJ}	.052886	dollar/dozen 32 ounce	-.004621	c
Q^{I}_{COJ}	.078273	dollar/dozen 32 ounce	-.019510	c
Q^{I}_{CSSOJ}	.173864	dollar/dozen 46 ounce	-.042965	c

Source: Retail demand relationships for processed products were obtained from the Economic Research Department, Florida Department of Citrus. The fresh orange relationship was derived from elasticity estimates reported by Langham [10, p. 20]. Demand relationships for institutional products were obtained from [26, 27]. All relationships have been adjusted.

[a]Superscript represents retail or institutional market. Subscript indicates product type.

[b]Seasonal shifter = $\begin{cases} 0 & \text{Sept. - Mar.} \\ 1 & \text{Apr. - Aug.} \end{cases}$

[c]Not included in model.

Table 12. Mean values associated with estimated demand relationships.

Product[a]	Price/Unit	Quantity (per capita gallon single strength equivalent)
$FCOJ_R$	14.43 cents/6 ounce	.0867
COJ_R	30.74 cents/quart	.0085
$CSSOJ_R$	32.31 cents/46 ounce	.0084
FO_R	10.40 cents/pound	.0364
$FCOJ_I$	$8.99/dozen 32 ounce	.0113
COJ_I	$3.18/dozen 32 ounce	.0162
$CSSOJ_I$	$3.90/dozen 46 ounce	.0062

[a]The subscript refers to the retail or institutional market.

A DS.K = CLIP(1, 0, WP.K, 30.3) 283

A QD(I).K = (PQD(I).K)(POP.K)/4 (I = 1, . . . , 7) 284-290

L XQD(I).K = QD(I).J 290A-290G

L POP.K = POP.J + (DT)(PG.JK) 291

R PG.KL = (.01)(PGR.K)(POP.K) 292

A PGR.K = .0232 + (.0462/TM.K) 293

A TM.K = MAX(4, TIME.K) 293A

L $AQD(I).K = AQD(I).J + (DT)\left(\frac{1}{TAQD}\right)(QD(I).J - AQD(I).J) \quad (I = 1, \ldots, 7)$ 294-300

C TAQD = 2 weeks 301

PQD(I) - per capita quantity of the I^{th} product demanded (gallons single strength equivalent/month)

DS - demand shifter = $\begin{cases} 0 & \text{Sept. - Mar.} \\ 1 & \text{Apr. - Aug.} \end{cases}$

PG - U.S. population growth (people/week)

PGR - weekly U.S. population growth rate (percent)

TM - TIME proxy (TM $\geq$ 4)

TAQD - time for averaging quantity demanded (weeks)

Initial Conditions

In order to start the computation process, a requirement of computer simulation is that initial conditions be specified. The values specified in this section roughly approximate subsector conditions at the beginning of the 1961-62 season. Once the starting conditions were specified, the DYNAMO compiler had the information required to compute initial values for level equations. These values were then available for the solution of auxiliary and rate equations. Within the computing sequence (levels, auxiliary, rates), the DYNAMO compiler rearranges the solution order of equations when necessary.

		Initialization for Sector	Equation(s)
N	PT = 18.7E6	1	1
N	WI = 1	2	37
N	CR = 108.8E6	3	46
N	FUTD = 0	3	47
N	AGP = GP	4	63
N	CP = 0	4	66
N	AFU = $\sum_{I=1}^{n}$ FU(I) (I = 1, . . . , 7)	5	68
N	FU(I) See Table 13. (I = 1, . . . , 7)	5	70-76
N	ATRA = (AT)(CS) - (.15)(AT)(CS)	6	104
N	AA = ATS	6	108
N	MNR(I) See Table 14. (I = 1, . . . , 7)	7	124-130
N	WP = 0	7	156
N	FOB(I) See Table 15. (I = 1, . . . , 7)	7	176-182
N	SFOB = AFOB	7	189B
N	I(I) = (C(I))(AQD(I)) See Table 10 for values of C(I). (I = 1, . . . , 7)	8	218-224
N	RP(I) = RPS(I) (I = 1, 2, 3, 4)	9	256-259
N	ARP(I) = RP(I) (I = 1, 2, 3, 4)	9	264-267
N	IP(I) = XFOB(I) (I = 5, 6, 7)	9	272-274
N	XQD(I) = QD(I)	10	290A-G
N	POP = 184.8E6	10	291
N	AQD(I) = QD(I) (I = 1, . . . , 7)	10	294-300

Table 13. Estimated fruit usage rate by product type, 1961-62 season.[a]

Product	Retail		Institutional		Total	
	Quantity	Percent	Quantity	Percent	Quantity	Percent
FCOJ	1,210,339.8	59.5	119,703.9	5.9	1,330,043.7	65.4
COJ	71,891.5	3.5[b]	70,467.9	3.5[b]	142,359.4	7.0
CSSOJ	97,593.5	4.8[b]	77,305.2	3.8[b]	174,898.7	8.6
FO	386,404.1	19.0	c	c	386,404.1	19.0
Total	1,766,228.9	86.8	267,477.0	13.2	2,033,705.9	100.0

Source: [3, 1961-62 season].

[a]Quantities in boxes per week.

[b]Estimates based on information from [25, Appendix C].

[c]Assumed negligible.

Table 14. Net marginal revenues used to initialize model.

Product	Market	
	Retail	Institutional
	(dollars/gallon single strength equivalent)	
FCOJ	.105654	.516743
COJ	.410560	1.043205
CSSOJ	.145009	.523586
FO	.560814	a

Source: Calculated.

[a]Not applicable.

Table 15. FOB prices used to initialize model.

Product	Market	
	Retail	Institutional
	(dollars/gallon single strength equivalent)	
FCOJ	.862362	.856507
COJ	.660564	1.278780
CSSOJ	.688240	.918408
FO	.911312	a

Source: Calculated.

[a]Not applicable.

CHAPTER V

VALIDATION

The usefulness of the model presented in the preceding chapter depends upon its ability to characterize the response of the Florida orange subsector to changes in economic conditions. If the model is a "good predictor" of subsector response, it should be useful as a tool for policy analysis. If not, its value for studying economic policies may be limited. The predictive ability of a model can be evaluated on the basis of a set of criteria established for this purpose. However, the choice of criteria is a subjective process. The model can also be evaluated from the standpoint of the reasonableness of the estimates and assumptions presented in Chapter IV. The purpose of this chapter is to provide insight into the model's ability to predict.

In his book, Computer Simulation Experiments with Models of Economic Systems, Naylor makes the following statement:

> In general, two tests seem appropriate for validating simulation models. First, how well do the simulated values of the endogenous or output variables compare with known historical data, if historical data are available? Second, how accurate are the simulation model's predictions of the behavior of the actual system in future time periods? [15, p. 21]

In this study, a simulation was made to determine whether or not the model would converge when run for a long period of time with weather conditions held constant. The model was then evaluated on the basis of its ability, when given empirical weather data, to reproduce the behavior of the orange subsector during the 1961-71 period.

Long-run Stability

The model was intitialized to reflect, as nearly as possible, conditions that existed in the orange subsector at the beginning of the 1961-62 crop season. During the run stochastic weather generation was suppressed and weather effects were set equal to constants that reflected average weather conditions. With 1961-62 initial conditions, there was reason to expect the model to start from a disequilibrium position. However, a run period of one hundred years was believed long enough to allow the model to overcome initial disequilibrium and to provide an opportunity for observing whether the model, if left undisturbed, would come to a stable position. Partial results of this run are presented in Figure 11.

In Figure 11 variables were plotted against time and the appropriate vertical scale. The vertical scales are identified by groups of numbers. Each number is associated with a respective variable identified by letter. The number of mature productive orange tree equivalents, represented by T, was initialized at 18.7 million. After the start of the simulation this figure increased at a rapid but decreasing rate for approximately sixteen years. After this period, tree numbers remained relatively stable within the 40-41 million range for about six years, before taking a slight dip and beginning a substained increase that lasted the remainder of the run. At the end of the simulation the number of mature productive orange trees stood at 94.7 million and had been increasing by 1.2 million trees per year. This behavior may be compared to the behavior of average grower profit during the same period.

At the beginning of the run, prices were initialized at levels which yielded an average grower profit of $1.99 per box. The fact that this

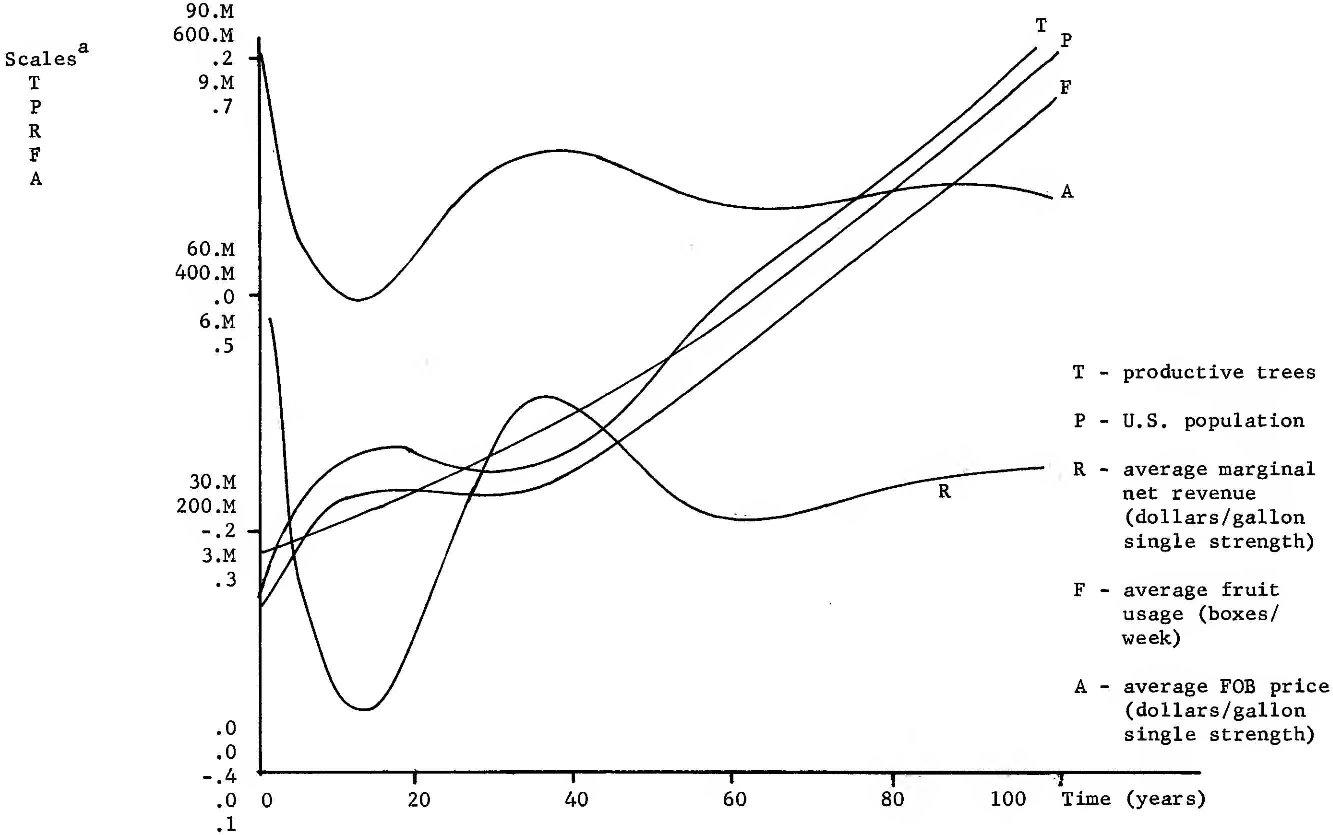

Figure 11. Simulated time path of selected variables.

[a]Scale numbers on the vertical axis are in the same order as the variables listed. Scales with an M are in millions.

figure was immediately adjusted downward by the model seemed consistent with the behavior that would have been expected from the orange subsector, if rather than having experienced the 1962-63 freeze, "normal" weather conditions had been encountered. The absence of freeze damage would have resulted in an estimated 42-44 million additional boxes of fruit during the 1962-63 season and would have prevented the temporary or permanent loss of approximately 13.5 million trees. In the simulation, average grower profit ranged from $1.99 to $.09 per box. Compared to a realized range during the 1961-70 period of $2.52 to $.21 per box, the simulated range seemed reasonable, particularly considering that the model, operating with "normal" weather conditions generated larger supplies than those experienced by the orange subsector. Other variables in Figure 11 follow similar patterns.

Average marginal net revenue stabilized at a negative 16 cents per box. This behavior seemed inconsistent with the behavior required to maximize long-run net revenue at the FOB level and reflected a tendency of the model to overplant trees even under "normal" weather conditions. This overplanting tendency may represent a hedge against recurring crop damage. At any rate, it resulted from the specification of new tree plantings relative to average grower profits. As specified in Chapter IV (equations 11 and 12), the response table required that new tree plantings occur at the minimum rate of 2.2 percent of productive orange trees even when average grower profit was zero or negative. An earlier simulation, which used a response function that allowed new tree plantings to fall to zero, reached a stable position after approximately the same number of years with an average marginal net revenue of $-.03 per box. Differences between the two runs indicate behavior of the model is sensitive to changes in this relationship.

The purpose of this run was to determine whether the model would stay within reasonable ranges and exhibit relatively stable behavior or whether it would explode if given time to overcome its initial disequilibrium. Results of the run seemed to affirm reasonable behavior, i.e., the model converged.

Retrospective Comparison

A simulation was made with initial values corresponding to conditions that existed at the beginning of the 1961-62 season and with weather effects specified to replicate as nearly as possible those that occurred during the 1961-62 through 1971-72 period. Results were compared with empirical data reflecting the behavior of the Florida orange subsector during the same period.

Tree Numbers

Figure 12 presents a comparison of simulated and observed numbers of mature productive orange tree equivalents during the 1961-62 through 1971-72 period. In the simulation, the tree numbers variable was initialized at 18.7 million and had increased to 22 million trees by the end of the 1961-62 crop season.[1] As a result of the freeze which occurred in the simulation at the beginning of the 1962-63 season, tree numbers were reduced to 16.9 million by mid-season. Carry-over effects of the freeze also caused a reduction in productive trees during 1963-64. During this period, an almost identical pattern of change was reflected

[1] Initialization of tree numbers at 18.7 million probably overstated the number of trees in existence at the beginning of the 1961-62 season. Reflection indicated that this figure was more nearly associated with the end than with the beginning of the season.

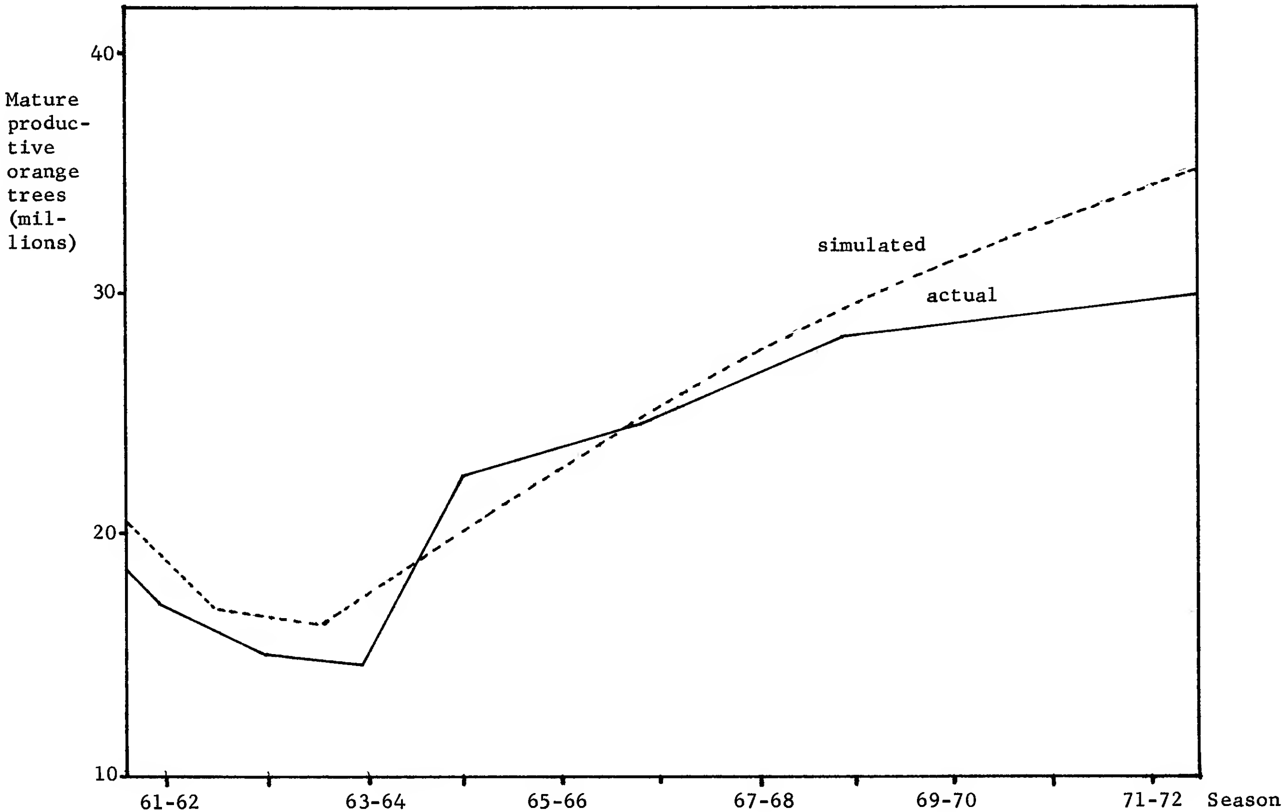

Figure 12. Simulated and actual numbers of mature productive orange trees, 1961-62 through 1972-73 seasons.

Source: Table 3 and simulated.

in the observed data; however, levels of observed tree numbers were approximately ten percent lower than those generated by the model. Following the 1963-64 season, the combined effect of new trees becoming productive and damaged tree recovery produced a sharp increase in tree numbers. This increase was particularly evident in the time path of the observed variable and may have partially resulted from the reassessment of freeze damage. At any rate, there were 3.5 million more trees observed than simulated in 1964-65. Further comparison of the time paths revealed high correspondence between observed and simulated tree numbers during the 1966-67 and 1968-69 seasons. However, after the 1968-69 season, simulated tree numbers increased at a rate faster than the rate based on the observed data point.

A summary of observed versus simulated changes in tree numbers is presented in Figure 13.[2] In this diagram, completely accurate predictions fall on the line of perfect forecasts. As points move away from this line, predictive accuracy decreases. The second and fourth quadrants of the diagram map turning point errors, i.e., the prediction of a change in direction when no change occurred or a change in direction not predicted. For the six points for which comparable tree numbers data were available, the model overestimated realized changes three times, underestimated once and predicted one point on the perfect forecast line.

A quantitative measure of the correspondence between observed and simulated values was provided by Theil's inequality coefficient [24, p. 28]. Of the several versions of the coefficient, the one used in

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[2] A detailed discussion of the prediction-realization diagram is given in [24, pp. 19-26].

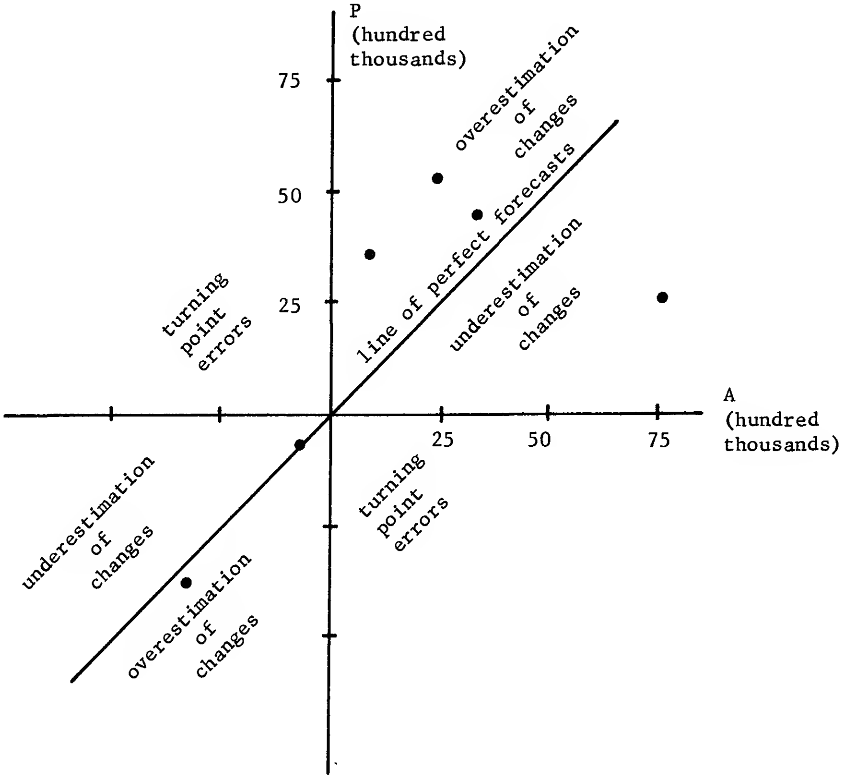

Figure 13. Prediction-realization diagram for changes in numbers of mature productive orange trees.

$A_t = a_t - a_{t-1} \qquad P_t = p_t - p_{t-1}$

this study was defined as follows:

$$U = \left[\frac{\sum_t (a_t - p_t)^2}{\sum_t (a_t - a_{t-1})^2} \right]^{1/2}$$

where a_t represents the observed or actual value at time t and p_t represents the simulated or predicted value. In the case of perfect forecasts, Theil's coefficient takes on the value zero. The value of one indicates that predictions are no better than those that would have been made with the model $p_t = a_{t-1}$. For the tree numbers data, the coefficient was equal to .5513 indicating that the root mean square prediction error was 55 percent of the root mean square error that would have been realized had predictions been made with the model $p_t = a_{t-1}$.

Crop Size

Figure 14 presents a comparison between simulated and observed crop size data. In general, the path of the simulated variable corresponded fairly closely with observed behavior; however, noticeable disparities existed in 1963-64 and after the 1967-68 crop season. After 1967-68, estimates made by the model overstated crop size and the magnitude of the overstatement increased each season. The prediction-realization diagram, Figure 15, indicated that of the nine changes generated, the model overestimated five and underestimated the remainder. Theil's coefficient, equal to .98, indicated that predictions were slightly better than those that would have been realized with the no-change model.

On-Tree Price

A comparison of observed and simulated on-tree prices of Florida oranges is presented in Figure 16. Again, the general behavior of the

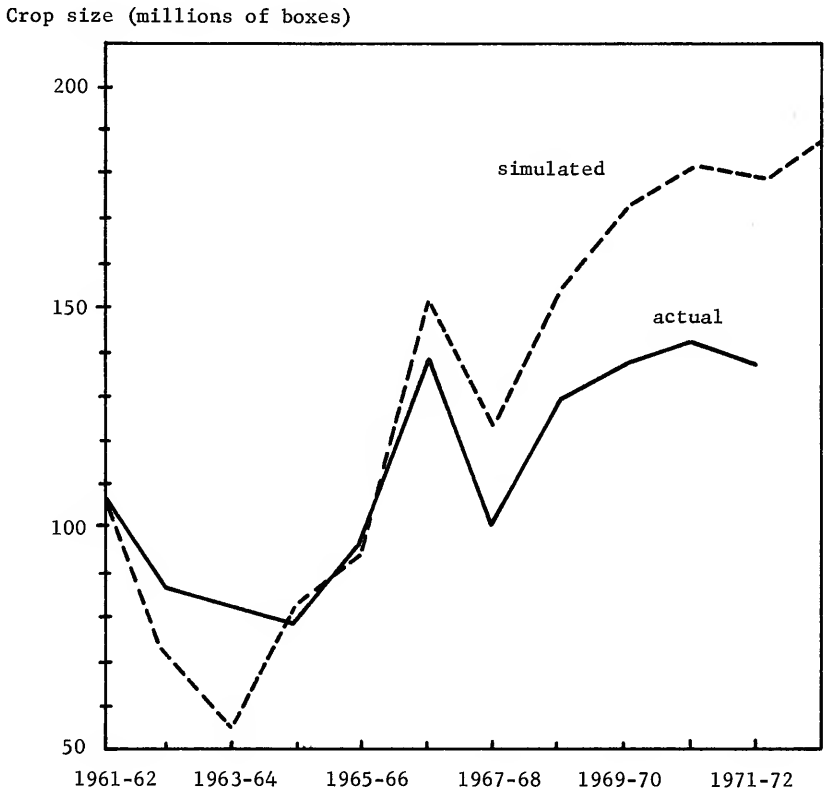

Figure 14. Simulated and actual crop size, 1961-62 through 1971-72 seasons.

Source: [3, 1971-72 season] and simulated.

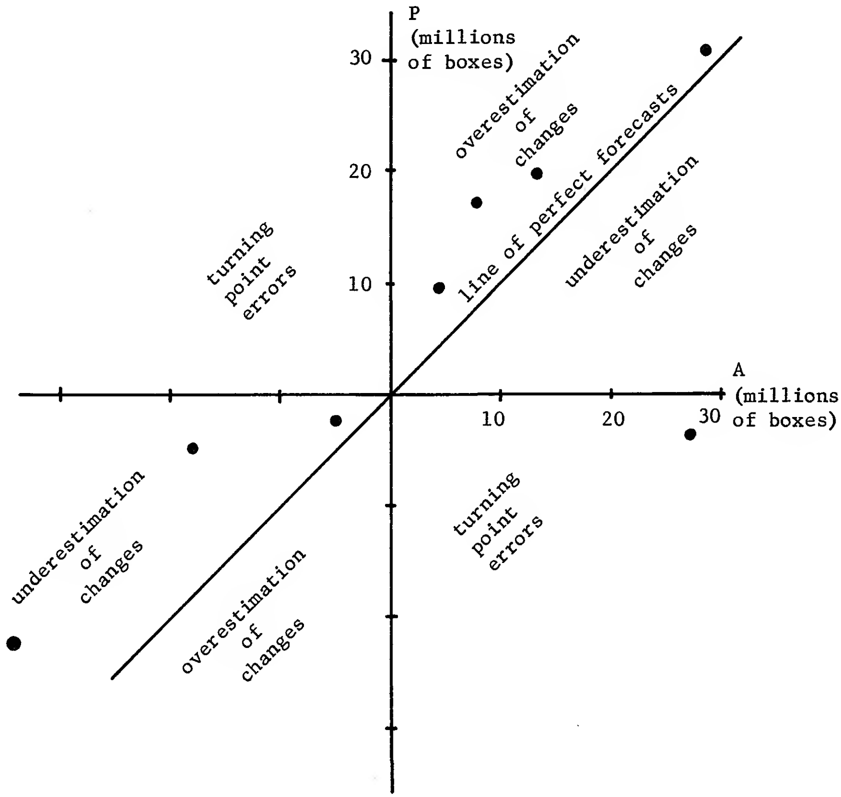

Figure 15. Prediction-realization diagram for changes in Florida orange production.

$$A_t = a_t - a_{t-1} \qquad P_t = p_t - p_{t-1}$$

Source: [3, 1971-72 season] and simulated.

Figure 16. Simulated and actual on-tree price, 1961-62 through 1970-71 seasons.

Source: [3, 1968-69 season, p. 95, and 1971-72 season, p. 104].

simulated variable corresponded with observed data. Restricted supplies following the 1962 freeze led to increased prices; whereas, the large crop of 1966-67 caused a sharp price dip. A relatively small crop in 1967-68 was again associated with increased prices. The prediction-realization diagram, Figure 17, indicated that the model underestimated the magnitude of four changes, overestimated three and made two turning point errors--one between the 1963-64 and 1964-65 seasons and another between 1969-70 and 1970-71. The Theil coefficient equaled .67.

Market Proportions

As mentioned in Chapter IV, in order to maximize net returns, processors as a group should attempt to allocate oranges so as to equate marginal net revenues among product markets. Table 16 shows proportioned allocations of the orange crop as observed during the 1963-64, 1964-65 and 1965-66 seasons and as performed by the model during the validation period.[3] As can be seen from the data, the proportion of the orange crop allocated into a given product-market varied somewhat from season to season. This variance, however, was relatively insignificant compared to differences between simulated and observed allocations. Relative to observed, the model allocated fewer oranges to each retail product and more to each institutional product.

The allocation performed by the model, though somewhat different from the observed, followed directly from the derived marginal net revenue equations (equations 129 - 135). The demand equations used in the derivations were obtained from several sources and most included variables exogenous to the simulator. Since the model was designed to

[3]Simulated figures corresponded to the end of each season; however, there was little variation within seasons.

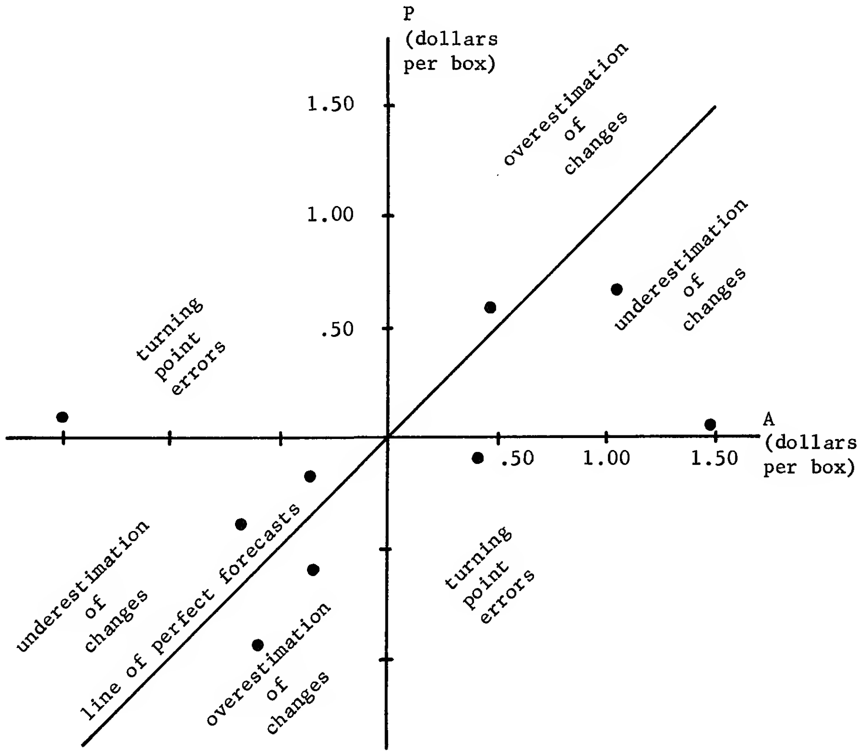

Figure 17. Prediction-realization diagram for changes in on-tree price.

$$A_t = a_t - a_{t-1} \qquad P_t = p_t - p_{t-1}$$

Source: [3, 1968-69 season, p. 95, and 1971-72 season, p. 104] and simulated.

Table 16. Observed and simulated fruit usage, by product-market.

Season	Product-Market[a] 1	2	3	4	5	6	7
				(percent)			
Observed							
1963-64	41.6	7.3	4.2	33.5[b]	5.5	4.4	3.5
1964-65	44.7	7.0	3.6	27.8[b]	6.3	7.5	3.1
1965-66	41.9	8.0	4.2	26.2[b]	5.3	11.5	2.9
Average 1963-66	42.8	7.5	4.0	28.7[b]	5.7	8.2	3.1
	83				17		
Simulated[c]							
1961-62	22.6	4.7	2.3	31.0	7.8	12.9	18.7
1962-63	25.7	3.9	1.7	29.8	7.8	15.1	16.0
1963-64	26.5	3.9	1.7	28.6	7.8	15.6	15.9
1964-65	27.7	3.8	1.6	26.8	8.0	16.4	15.8
1965-66	25.1	4.5	2.2	27.3	8.1	14.5	18.3
1966-67	24.8	6.0	3.2	18.4	9.4	13.9	24.3
1967-68	24.2	4.8	2.4	27.0	8.3	13.8	19.5
1968-69	23.3	5.6	2.9	24.3	8.7	13.1	22.2
1969-70	22.8	5.6	3.0	24.7	8.7	12.8	22.4
1970-71	23.3	5.9	3.1	22.7	9.0	13.0	23.1
1971-72	23.5	5.8	3.0	22.9	8.9	13.2	22.6
1972-73	23.5	5.9	3.0	22.5	9.0	13.1	23.0
Average 1961-73	24.1	5.3	2.7	24.9	8.6	13.7	20.9
	57				43		

Source: [25, Appendix C] and simulated.

[a]Rows may not add to one hundred due to rounding.

[b]Assumes 12,000 fresh oranges equals 396.75 gallons single strength equivalent.

[c]Simulated figures were at the end of each season; however, within season variation was minor.

operate in a recursive fashion, the coefficients of these variables were removed from the equation by incorporating them into the intercept. The resulting equations, along with cost and margin information, were used to derive marginal net revenue equations for each product-market. An examination of these relationships revealed that several cross-product coefficients had signs different from those expected and in some cases the cross-price effect outweighted the own-price effect. Further examination indicated that these coefficients could lead to results inconsistent with economic theory, e.g., when all prices increase, total quantity demanded increased. In order to prevent this problem cross-product coefficients were incorporated into intercept terms. The loss of these coefficients resulted in relatively naive demand equations. A different set of equations might have led to results more consistent with the observed data.

Conclusion

The obvious implication of the preceding comparisons is that there exists room for improvement in the predictive accuracy of the DYNAMO model. However, a definite similarity existed between real world and model behavior especially with regard to turning points and it was believed that the model captured the dynamics of the orange subsector.

CHAPTER VI

POLICY ANALYSIS

The term "policy" as used in this chapter refers to changes in either the model's operating rules or its structure. Most policies were implemented by parameter changes in functions discussed in Chapter IV. These changes altered the operating rules of the model and affected performance by reducing orange supplies, increasing desired carry-overs, and by modifying pricing and advertising schemes.

A set of five runs, each covering a twenty-five year period, was made to provide a base with which to compare policy results. This base was an attempt to characterize the orange subsector as it is currently structured. Ten policies were then examined. Each run started with a set of initial conditions based on the 1961-62 crop season and was associated with weather effects computed by the stochastic procedure. The weather effects used for the base run were also used for each policy and provided comparable results for a variety of weather conditions.[1] Policies were replicated five times--once with each of the weather sets presented in Table 17. The weather effect for each season was greater than, equal to, or less than one and denoted better than average, average or poorer than average weather conditions, respectively.

[1] DYNAMO contains a function which generates "pseudo random numbers" that satisfy all of the statistical tests for randomness. However, each number is calculated from the previous one by a fixed procedure. Thus, a given noise seed always generates the same sequence of numbers. In the normal distribution mode, the DYNAMO procedure does not perfectly reproduce a normal distribution in that no number can diverge from the mean by more than 2.4 standard deviations. For more information, see Pugh [20].

Table 17. Weather conditions used in the five simulation runs for each policy.

Season	Weather sets[a]				
	1	2	3	4	5
2[b]	1.14	1.01	1.07	1.07	1.10
3	1.01	.92	.89	.99	1.03
4	1.11	.95	1.01	.92	1.06
5	.95	.95	.99	.98	.97
6	1.08	1.11	.99	.96	.89
7	1.00	1.06	1.00	1.08	1.08
8	.98	1.00	1.05	1.02	.87
9	.94	.98	.95	1.01	1.02
10	1.11	1.08	1.03	1.03	.99
11	1.00	.97	.98	.98	1.01
12	.93	.91	1.05	1.01	1.04
13	1.00	.88	1.07	.96	.98
14	.97	.98	.97	1.03	1.02
15	1.06	1.06	.96	1.04	1.01
16	1.05	.96	.94	.95	.99
17	1.07	1.07	.94	.96	.97
18	1.05	.97	1.06	1.01	1.06
19	1.00	.99	1.06	1.04	1.03
20	.99	.98	1.01	1.04	.96
21	1.00	1.00	1.04	.90	.96
22	1.04	1.00	.92	.92	.97
23	.92	.95	1.08	1.01	1.01
24	1.03	1.03	1.08	1.03	.98
25	.97	.97	1.00	1.02	1.04

[a]Weather conditions are based on an index (average weather = 100). The larger (smaller) the index the more favorable (unfavorable) the weather. The noise seeds used to generate weather sets 2 through 5 were 943805, 7641403, 10861407 and 86451509, respectively. The seed for weather set 1 was already in the noise function.

[b]Initial values were used for the first season.

Policies

The policies examined in this study are briefly described as follows:

1. Restricted tree planting. A restriction was placed on new tree planting whenever average grower profits rose above specified levels. Three levels were considered in the study, $1.25, $1.50 and $1.75 per box. When the policy was operative, tree planting was permitted or not permitted depending on whether grower profits were below or above the level specified. On first glance, this restriction may seem in conflict with logical decision making since high profits would be expected to call forth increased supplies. However, in the orange subsector, growers have tended to react to high profits as if a permanent shift in marketing structure has occurred in spite of the fact that high grower profits have normally been associated with a freeze. Consequently, they tend to overinvest in new orange groves. It takes several years for these groves to become fully productive, after which the additional supplies have precipitated periods of relatively low returns and low grove investment. These reactions have caused the subsector to be characterized by production and price cycles and it was believed that a restriction on tree plantings during periods of high grower profits might exert a stabilizing influence on the system.
2. Tree abandonment. The tree abandonment policy, when operative, removed fully productive trees from the system whenever grower

profits fell below \$.15 or \$.25 per box, depending on which level had been specified in a particular run. The effect of the policy, by immediately reducing tree numbers, was similar to the sale of grove acreage for nonagricultural purposes.

3. Increased carry-over. A policy which increased the end of season carry-over of orange supplies from 8 to 16 weeks of average consumer demand was implemented. The purpose of this policy was to determine if increased carry-overs would improve system performance by providing buffer inventories. Carry-overs were specified as a constant multiple of average consumer demand. Thus, when large supplies remained at the end of the season, price would be low, the level of average consumer demand high and a relatively large inventory would be carried over. This inventory would be available the next season and would tend to stabilize prices and retail inventories in case of a small crop. On the other hand, if a large crop occurred, the increased carry-over could contribute to even lower prices. An increase in carry-over from 8 to 16 weeks provided an opportunity to evaluate the model's reaction to changes in carry-over while other components of the model were the same.

4. Price adjustment restriction. A policy which altered the time that must elapse following a price adjustment before another adjustment could be made was incorporated into the model. In the base model, pricing was continuous and price adjustments could be made as often as twice each week. This is more often than price adjustments occur in the orange industry. When the price adjustment restriction was in effect, price could be

altered only twice each month. In reality, the citrus industry does not adjust price even this often and in the past has extended two week price protection to wholesalers in the case of a price decrease. However, decision rules within the model were not as flexible as those used by the industry and it was felt that a two week restriction would provide a test of the model's sensitivity to changes in the price response relationship without preventing the model from reacting for a long period when conditions indicated that a price change was necessary. The system could become more or less stable as this response function was changed.

5. Price floor. Implementation of this policy, by placing a lower limit on the average marginal net revenue of orange products, effectively set lower limits on FOB and retail prices. In the base run, the model was allowed to reduce prices to the levels required to sell the desired quantities of orange products. When the price floor was effective, prices were not allowed to fall below the level set by the floor. Supplies which could not be sold without causing unacceptably low prices were carried over to periods of higher prices, normally coincident with a freeze. When the price floor was operative it set a lower limit on average marginal net revenue of $-.20 per gallon single strength. The prices associated with this marginal net revenue allowed a large proportion of the oranges to be sold, yet exerted a stabilizing effect on the system by not allowing extremely low prices.

6. Alternative advertising.[2] An alternative method of determining advertising revenues and expenditures was adapted from a proposal by Myers [13].[3] In his report, Dr. Myers suggested a procedure for funding the Florida Department of Citrus that related revenue collection to a five year moving average of citrus production rather than the yearly production level. This procedure was designed to change the incidence of the tax by causing a larger tax per box to be collected during periods of small crops which are generally associated with high per box prices. Revenue collection based upon the procedure were expected to be more stable than if they were collected by the method currently used in the industry. Expenditures, on the other hand, allowed more to be spent on advertising when there was a large crop to be sold.

The DYNAMO equations used to construct this policy are listed in Appendix D. The general procedure used to calculate revenues and expenditures was as follows:

Total revenue was determined by the formula:

$$TR = (2.6E6)(1.05)^{YP} + a(ACS) + b(SACS) + c$$

---

[2] Two changes were made in the structure of the base model before running the advertising policy. Advertising costs were made variable and added to grower costs rather than being deducted from on-tree price per box (a change in equations 59, 60 and 62 in Chapter IV) and administrative and other costs were allowed to increase over time (a change in equation 100 in Chapter IV). A new base was then generated in order to be comparable with the advertising policy. Specific changes in the model are presented in Appendix D. For a more detailed discussion see footnote 6.

[3] There are differences between the procedure presented here and the one proposed by Dr. Myers. The most important being that Myers' proposal based revenue collection and expenditure on a standardized production level that included grapefruit, while the procedure used in the simulation was based only on oranges.

TR - total revenue (dollars/year)

YP - years passed (years)

ACS - five year moving average of crop size (boxes)

SACS - the sum of squares of the five elements in the moving average divided by five (boxes)

2.6E6 - a constant 2.6 million dollars, the E6 represents millions

a, b, c - values that were variable depending upon average crop size as follows:

Average crop size (million boxes)	Value of the numerical coefficients "a"	"b"	"c"
0-77	.06	-.0001	0
78-230	.11	-.00007	0
231 or more	.05	.00003	6.9E6

If advertising revenues had fallen below 3.8 million dollars at the beginning of a new crop season, a special tax of two cents per box was levied against the orange crop. Proceeds from this tax were used to rebuild advertising reserves.

Total expenditures were determined by the formula:

$$TE = (2.6E6)(1.05)^{YP} + d(CS) + e(CS)^{2} + f$$

TE - total administrative and advertising expenditures (dollars/year)

CS - crop size (boxes)

d, e, f - values that were variable depending upon crop size as follows:

Crop size (million boxes)	Value of the numerical coefficients "d"	"e"	"f"
0-77	.06	-.0001	0
78-230	.11	-.00007	0
231 or more	.05	.00003	6.9E6

Administrative costs were deducted from total receipts and expenditures before determining the advertising influence on consumer demand. The initial amount deducted was $26,306 per week. And since costs and revenues increased over time in the total receipt and expenditure equations, the amount deducted was also increased.

7. Restricted tree planting and price floor. The final policy considered in this study consisted of a combination of restrictions that limited increases in productive capacity in response to high grower profits and at the same time set a limit which prevented extremely low prices following a succession of large crops. It was felt that these restrictions might, by leveling out "ups and downs," improve the performance of the orange subsector. The policy prevented tree planting when grower profit was above $1.50 per box and placed a lower limit of $-.20 per box on average marginal net revenue.

Measures of Performance

In theory, for a given set of alternatives, it is possible for the participants in a subsector to bargain with each other until they arrive at a preferred position. This implies that for a given set of policies, one which is Pareto optimal will be chosen. In practice and particularly in the short-run, it is difficult to arrive at such a position since participants must be able to determine the relevant factors on which to base their decisions and obtain the information necessary to evaluate the effect of the dynamics of the system.[4] This analysis examined two factors believed to be of major importance for each major interest group participating in the orange subsector. No attempt was made to define the tradeoffs between subsector participants.

Policies were examined from the viewpoints of three major groups of subsector participants: the producers, processors and distributors, and consumers of orange products. The assumption was made that the interests of participants within each of these groups were homogeneous enough to be represented by a variable selected from the mathematical model. This is, of course, an oversimplification of the real world and ignores many conflicts of interest within each group. However, it was believed that the present values of three representative variables and the variances associated with those values provided a reasonable basis for comparing alternative policies.[5] Present values were used in the analysis since it was believed that participants within the orange subsector view costs and returns from a point in time and base their decisions on discounted values. For example, consider the two hypothetical streams of income presented in Table 18 and assume that t denotes the present and t + 1, t + 2, t + 3 and t + 4 the next four years.

The total value of each income stream is equal to five hundred dollars and assuming that no time preference exists and that both streams

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[4] For a theoretical discussion see Langham [11].

[5] The term "present value" as used in this study refers to the value of the variable discounted to the beginning of the simulation run. A note on the calculation of these values is presented in Appendix F.

Table 18. Discounted values[a] of two hypothetical streams of income received over a five-year period.

Year	Income stream		Discounted value at time t	
	A	B	A	B
t	$120.00	$ 80.00	$120.00	$ 80.00
t + 1	110.00	90.00	102.80	84.11
t + 2	100.00	100.00	87.34	87.34
t + 3	90.00	110.00	73.47	89.79
t + 4	80.00	120.00	61.03	91.55
Total	$500.00	$500.00	$444.64	$432.79

[a]Discounted to time t at the rate of seven percent per year.

will occur with a probability of one, they would be equally preferred. However, if a time preference equivalent to a seven percent discount rate is assumed, policy A would be the more attractive since it has the higher present value. This comparison, based only on present values, ignores the fact that income streams may be associated with different levels of risk. For example, one policy may be relatively insensitive to weather conditions and the income stream it generates may have a small variance compared to other policies. It was believed that most men are risk averters and, therefore, prefer to minimize risk for a given level of income. The variances of present values over the five weather replications were, therefore, considered to be important in the decision maker's utility function.

Grower profit was selected as the variable which best represented the interests of orange producers. The premise underlying this assumption was that the utility of producers was directly related to the present value of grower profits and inversely related to the variance of grower profits.

Processors and distributors were also assumed to be interested in the return on their investment; however, this return was believed to be related to the volume of oranges moving through the marketing system. Processors and distributors tend to formulate prices on the basis of cost plus a constant markup per unit of output. Thus, their interest is closely associated with crop size which was chosen to reflect their preference. In order to account for time and risk, the size of the orange crop was discounted in the same manner and at the same rate as grower profit and the variances associated with present values calculated.

ATTENTION!

See error note on pages 33A and 33B.

Consumers were assumed to prefer the lowest possible prices and since, in general, prices were inversely related to crop size, their interests seemed somewhat parallel to those of processors and distributors. A stream of retail prices was generated for each of the seven orange products considered in the model; however, the variable which seemed to best summarize consumer interests was the average price of single strength orange juice at the FOB level. This variable was related to each of the retail prices and provided a less complex and computationally more efficient basis for evaluating consumer interests than could be obtained by considering all of the retail prices directly. Like other participants in the orange subsector, consumers were assumed to base their decisions on present values, except in their case, they preferred the policy which provided the lowest present value of the price stream, ceteris paribus. Consumers were also considered to be risk averters and their utility was believed to increase with a decrease in either the level or variance of the present value of average FOB price.

Analysis of Alternative Policies

The alphanumeric names used to identify the simulation runs are presented in Table 19. Fifty of the runs were for the ten policies described in this chapter and the remainder for two slightly different versions of the base model.[6] The results of policy analysis emphasized

[6] In the base (except for advertising) model, the cost of administering the Florida Department of Citrus was deducted at a constant rate of $26,306 per week; however, when modeling the alternative advertising policy, administrative costs were compounded at the rate of five percent per year. This was a change in structure which needed to be and was reflected in the base (for advertising) model.

A problem resulted from the ability of advertising queues in the

Table 19. Alphanumeric names used to identify simulation runs.[a]

Policy	Weather replications				
	1	2	3	4	5
Base (except for advertising)	B1	B2	B3	B4	B5
Restricted tree planting:					
$1.25	PR11	PR12	PR13	PR14	PR15
$1.50	PR21	PR22	PR23	PR24	PR25
$1.75	PR31	PR32	PR33	PR34	PR35
Tree abandonment:					
$.15	TA11	TA12	TA13	TA14	TA15
$.25	TA21	TA22	TA23	TA24	TA25
Increased carry-over	CO1	CO2	CO3	CO4	CO5
Price adjustment restriction	PA1	PA2	PA3	PA4	PA5
Price floor	F1	F2	F3	F4	F5
Base (for advertising)	B21	B22	B23	B24	B25
Alternative advertising	ADV1	ADV2	ADV3	ADV4	ADV5
Restricted tree planting and price floor	PR2 + F1	PR2 + F2	PR2 + F3	PR2 + F4	PR2 + F5

[a]The last number in each name identifies the weather replication and was dropped when referring to the average for the five replications.

that tradeoffs exist between subsector participants. Discounted values of the averages of the variables over the five weather replications are presented in Table 20. In the base (B), the discounted values of grower profits, average FOB price and crop size were $1,000.98 million, $7.16 and 1,746.39 million boxes, respectively. Policies that reduced orange supplies either by a restriction on tree planting or by tree abandonment or removal caused corresponding increases in the discounted values of FOB prices and grower profits. A comparison, with base values equal to 100, is presented for the nonadvertising policies in Table 21.

Each of the three planting restrictions considered in the study increased the present value of grower profits by at least fifty percent indicating that orange producers would benefit from the policy. Each of the restrictions also reduced crop size by as much as 28.5 percent and caused an increase in the prices paid by consumers by as much as 19 percent. The variance of grower profits decreased but remained unchanged or increased for the other variables.

Estimates of the cost of storing the end of season carry-overs associated with the alternative policies are presented in Table 22. For the planting restrictions (PR1, PR2 and PR3), reductions in storange costs ranged from 11.3 to 13.4 million dollars. These reductions were

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base (for advertising) and advertising policy to accumulate different levels of unspent advertising revenue. To the extent that this occurred, grower profits net of advertising tax collections would have reflected the costs of advertising without the benefits, and the policy which accumulated the largest unspent revenue would have been unfairly penalized in the comparison. A change in the model which made grower profits net of advertising expenditures rather than receipts partially corrected the problem in that accumulated advertising funds were no longer deducted from grower profits; however, some discrepancy remained because the potential gain from the use of these funds was ignored.

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See error note on pages 33A and 33B.

Table 20. The level and standard deviation of the present value of grower profits, average FOB price and crop size for twelve sets of simulations.[a]

Policy	Grower profit		Average FOB price		Crop size	
	Present value[b]	Standard deviation[c]	Present value[c]	Standard deviation[c]	Present value[b]	Standard deviation[c]
B	1000.98	106.59	7.16	.20	1746.39	61.82
PR1	1524.77	56.12	8.52	.24	1248.43	76.64
PR2	1516.53	60.69	8.39	.21	1301.42	67.93
PR3	1505.93	63.13	8.31	.20	1331.24	61.97
TA1	1105.38	77.47	7.32	.17	1687.96	53.00
TA2	1165.11	61.35	7.43	.15	1649.96	47.60
CO	1009.48	108.29	7.22	.20	1758.07	62.28
PA	962.66	107.04	7.22	.20	1747.30	61.29
F	1017.41	94.87	7.17	.19	1755.01	66.10
B2[d]	1026.10	107.92	7.14	.20	1753.68	61.95
ADV[d]	989.16	107.11	7.20	.20	1744.43	61.10
PR2 + F	1518.99	56.85	8.39	.21	1301.70	68.24

[a]Present values were based on the average of the variable for the five weather replications.

[b]Large values preferred.

[c]Small values preferred.

[d]Grower profits were net of advertising tax spending rather than tax receipts for these two runs.

Table 21. Relative value[a] of the level and standard deviation of the present value of grower profit, average FOB price and crop size for policies comparable with the base (B) run.

Policy	Grower profit		Average FOB price		Crop size	
	Present value[b]	Standard deviation[c]	Present value[c]	Standard deviation[c]	Present value[b]	Standard deviation[c]
			(percent of base)			
B	100.0	100.0	100.0	100.0	100.0	100.0
PR1	152.3	52.7	119.0	120.0	71.5	124.0
PR2	151.5	56.9	117.2	105.0	74.5	109.9
PR3	150.4	59.2	116.1	100.0	76.2	100.2
TA1	110.4	72.7	102.2	85.0	96.7	85.7
TA2	116.4	57.6	103.8	75.0	94.5	77.0
CO	100.8	101.6	100.8	100.0	100.7	100.7
PA	96.2	100.4	100.8	100.0	100.1	99.1
F	101.6	89.0	100.1	95.0	100.4	106.9
PR2 + F	151.8	53.3	117.2	105.0	74.5	110.4

[a] Percent of the base (B) value.

[b] Large values preferred.

[c] Small values preferred.

Table 22. Size and discounted costs of the carry-overs associated with alternative policies.

Policy	Average carry-over[a]	Cost of storage[b]	Relative cost
	(million gallons concentrate)	(million dollars)	(B = 100)
B	30.70	50.08	100.0
PR1	20.54	36.67	73.2
PR2	21.90	37.98	75.8
PR3	22.64	38.74	77.4
TA1	29.52	48.49	96.8
TA2	28.82	47.46	94.8
CO	59.95	97.22	194.1
PA	33.99	57.98	115.8
F	56.46	79.88	159.5
B2	30.85	50.27	100.4
ADV	30.64	50.01	199.9
PR2 + F	22.09	38.50	76.9

[a]Averaged across weather replications.

[b]Discounted to the present at seven percent per year. Storage costs were based on the rate of $148,983 per year for one million gallons of concentrate.

directly associated with the reduced crop size and inversely related to the changes in grower profits. The increase in grower profits ranged from 505 to 523.8 million dollars (Table 20).

Tree abandonment policies (TA1 and TA2), while not as successful at increasing grower profits as the planting restrictions, were the most successful of the policies at reducing the variance associated with FOB price and crop size. In other respects, the effects of tree abandonment were similar to those obtained with planting restrictions.

The present value of grower profits increased by eight and one-half million dollars as a result of increasing carry-overs (CO) from eight to sixteen weeks of average consumer demand. There was also a slight increase in the discounted value of FOB prices, crop size and the variances of grower profits and crop size. From the standpoint of orange producers, the policy seemed desirable; however, assuming "normal" returns, the additional storage costs of 47 million dollars more than offset the benefits of the policy from the viewpoint of processors.

The price adjustment restriction (PA), partially implemented to test the sensitivity of the model to changes in the adjustment mechanism, reduced grower profits and at the same time caused an increase in average FOB price and crop size. Taking the price restriction as the norm of present operations, the simulation indicated that producers and consumers would benefit from increased price responsiveness and that processors would benefit from reduced storage costs with only a small sacrifice in crop size. This, of course, ignores other efficiencies associated with stable prices that were beyond the scope of this study and which may be substantial.

Advantages of the price floor (F) were offset by an increase in storage costs to $79.88 million from the base of $50.08 million. This cost increase, even after deducting the $16.4 million increase in grower profits, would have required a return above variable costs (excluding storage) of $1.55 per box on the increased volume handled by processors in order to break even. And, if processors had been required to bear the total cost increase, the break even return would have been $3.46 per box on the increased volume handled. The cost and return estimates presented in Table 23 indicated that during the 1961-71 period fixed costs would have had to represent a very high proportion of total costs in order to have justified the price floor policy. For example, assuming that half the total cost (excluding storage) was fixed, returns above variable costs (excluding storage) during the 1961-71 period never exceeded $2.11 per box and was greater than $1.55 only in 1962-63 and 1968-69. Thus, the policy did not seem to be justified by the increased volume.

The price floor in conjunction with the planting restriction (PR2 + F) performed somewhat better than the price floor alone, probably because with reduced supplies, storage time was shorter and costs did not accumulate over several seasons. At any rate, the increase in grower profits exceeded additional storage costs by $1.94 million. The policy had little effect on FOB price and crop size, except for a slight increase in the variance of the latter and would probably benefit the orange subsector based on the criterion used here. However, the administrative costs of maintaining a price floor might well outweigh the small gains.

Table 23. Estimated costs and returns to orange processors, 1961-62 through 1970-71 seasons.[a]

Season	Total cost less storage	FOB price	Return above total cost less storage
		(dollars/box)	
1961-62	2.73	2.36	- .37
1962-63	3.57	3.90	.33
1963-64	5.09	4.00	-1.09
1964-65	3.26	2.76	- .50
1965-66	2.74	2.76	.02
1966-67	1.97	2.02	.05
1967-68	3.12	2.76	- .36
1968-69	2.77	3.03	.26
1969-70	2.49	2.50	.01
1970-71	2.93	2.72	- .21

Source: Calculated from data obtained from [3 and 22].

[a]Based on the cost of processing and price of frozen concentrate.

Note: These data, intended only as a guide, are based upon several simplying assumptions such as constant conversion rates and should not be considered a substitute for the data presented in the sources.

Implementation of the alternative advertising policy (ADV) caused an increase in the level of advertising expenditures. Expenditures increased from a season average (across weather replications) of $11.9 million for the base (B2) to $19.8 million for the alternative policy, or by 66 percent. Given the advertising response functions of the model, the additional advertising was not profitable, as indicated by the present values presented in Table 20. With increased advertising and higher taxes, the present value of grower profits decreased from $1026.10 to $989.16 million, or by 3.6 percent. Smaller grower profits led to a reduction in the present value of crop size which in turn was associated with an increase in FOB prices. Thus, from the standpoint of all three groups of subsector participants, the policy seemed undesirable. However, these results hold only for the specific formulation of the policy used in this study which does not confront the question of whether or not one method of collection or expenditure is superior to the other. The results also rest heavily upon the advertising response functions used in the model. These functions were based on a limited analysis of data from a study by McClelland which basically reflected conditions during the 1960-67 period [12]. As the functions were specified in Chapter IV, advertising reached a saturation point when expenditures were $300,000 per week and additional advertising did not increase consumer purchases. Thus, the average expenditure of $19.8 million involved considerable waste, at least $105 million over the twenty-five years of the simulation and probably considerably more. The decrease in grower profits (without discounting) was $89 million; thus, had the expenditure level been lower, performance would have improved.

Figure 18 shows simulated tax collections, expenditures and crop sizes associated with weather set 1. Tax collections in the base simulation (B2) followed the same pattern as crop size. Expenditures, on the other hand, were somewhat more stable than the crop. The pattern was reversed with the ADV policy, expenditures were based on crop size and tax collections were more stable except when reserves fell below the $3.8 million minimum and the additional two-cent tax was collected. The latter method has the most intuitive appeal since it advertised more during seasons of large crops and it would have been interesting to compare the two procedures with average advertising at the same levels.[7]

Perhaps the most consistent characteristic of the results was the presence of conflicts of interests. As can be seen from the summary presented in Table 24, none of the nonadvertising policies were clearly preferred by all three groups of subsector participants. If CO and F are eliminated on the basis of increased storage costs, TA1 and TA2 are left or the only policies which might have been preferred by all participants. Whether either TA1 or TA2 were preferred would depend on how consumers and processors and distributors view tradeoffs between present values and variance in their respective decision variables. The remaining policies were preferred by some participants but not by others.

The fact that none of the policies were clearly preferred to the base by all participants would support the supposition that the base was Pareto optimal. A subsector characterized by perfect competition would

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[7]In order to make such a comparison, a series of simulations with incremental changes in the parameters of the total revenue and expenditure functions would be needed. Then, the run with an average advertising expenditure of about $12 million per season could be compared with the base. Further investigation of consumer response to advertising would increase the confidence placed in the results of the analysis.

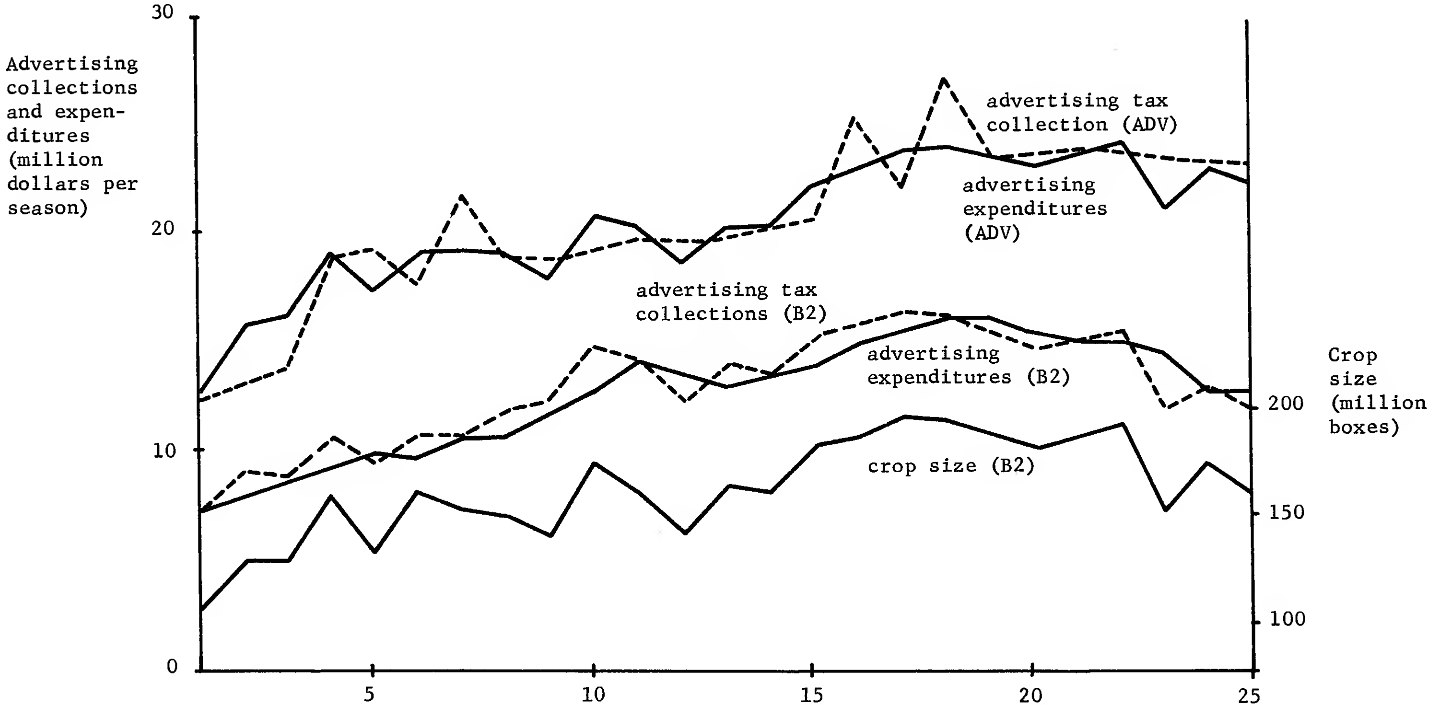

Figure 18. Advertising collections and expenditures for the alternative advertising policy and base runs, weather set 1.

Source: Simulated.

Table 24. A classification of nonadvertising policies by preference category relative to the base (B) by group of participants.[a]

Policy	Participant		
	Producers	Consumers	Processors and distributors
PR1	X	0	0
PR2	X	0	0
PR3	X	0	0
TA1	X		
TA2	X		
CO[b]		0	
PR	0	0	X
F[b]	X		
PR2 + F	X	0	0

[a]The letter X indicates that the policy was clearly preferred to the base. A 0 indicates that the base was clearly preferred to the policy. The space was left blank when the preference was not clear. This classification does not consider changes in storage costs. It is based on the present values and variances of the policies.

[b]The increase in storage cost was believed sufficient to eliminate the policy.

be expected to organize itself in a Pareto optimal fashion; and, in fact, perfect competition in the absence of external economics and diseconomics is a sufficient condition for Pareto optimality. However, other forms of market organization can also lead to positions that are Pareto optimal. Thus, one cannot conclude from these results that the orange subsector is competitive.

In summary, policies that reduced orange supplies led to substantially higher grower profits, lower storage costs and higher retail prices. Supply restrictions also reduced risks for orange producers, but not necessarily for other subsector participants, tree abandonment being the only policy that consistently reduced the variance of the discounted values for all variables. The increased carry-over and price floor policies caused increases in the present value of grower profits and crop size. They also increased storage costs and FOB prices, probably enough to offset their positive effects. When the alternative advertising policy was simulated, expenditures were 66 percent higher than in the base simulation and, given the response functions in the model, were not profitable. A lower average expenditure would have improved the performance of the advertising policy since advertising was often above the level required to maximize retail sales. Restricting price adjustments to every two weeks, reduced the present value of grower profits by \$38 million and increased FOB prices. Taking price stability as the norm, the subsector would benefit from increased price responsiveness. However, these benefits might be offset by externalities associated with frequent price changes. The policy which came closest to being acceptable on the basis of all performance criteria was the price floor operating in conjunction with the planting restriction when compared to the planting restriction alone. However, gains from the floor were small and the policy would be justified only if administrative costs were low.

In addition to economic feasibility, there are other factors that should be considered in the selection of a policy. In many cases, legal mechanisms have been established in order to provide the means for adopting and implementing specific policies which otherwise might be considered illegal, and a major consideration for any policy should be legal requirements. Also, popular support is usually necessary in order for a policy to be effective and policies that are easily understood and intuitively appealing often succeed where more complex policies fail. Undoubtedly, there are additional factors that should be considered in formulating alternative policies. This study provides an example of simulation as an ex ante method of policy investigation and, for the policies examined in this chapter, results provide some insights into potential costs and returns and their distribution among subsector participants.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The Florida orange subsector has been characterized by shifts in production and crop value and subsector participants--particularly growers and processors--have been interested in evaluating the effects of alternative policies on subsector performance. Computer simulation provided a method of studying the effectiveness of alternative policies within the dynamic environment of an abstract model without the risks of experimentation on the actual system. Objectives in the study were (1) to identify the structure underlying the subsector's dynamic behavior, (2) to construct a quantitative model which captured the essential characteristics of this structure, and (3) to use the model to evaluate the effects on subsector performance of alternative inventory, pricing advertising and supply control policies.

A verbal description of the structure of the subsector provided an understanding of the system's dynamic behavior and formed the basis for building the model. The model was a third generation effort drawing from previous work by Jarmain [9] and Raulerson [21]. It was composed of ten sectors and was written in the DYNAMO simulation language.

Validation was on the basis of the model's ability, when given empirical estimates of weather conditions, to reproduce the behavior of the subsector over the 1961-71 period. A quantitative measure of the correspondence between simulated and empirical data was provided by

Theil's inequality coefficient, values of which ranged from .55 to .98, indicating that predictions were better than those that would have been realized with the model $p_t = a_{t-1}$, where a_t and p_t represent actual and predicted values at time t. To verify that the model was internally stable, a simulation was made for a long period of time with weather conditions held constant.

After the model was accepted as an adequate representation of the status quo, a set of simulations was made to establish a base with which to compare the ten policies considered in the study.[1] Comparable results for a variety of conditions were obtained by replicating each simulation with five randomly selected weather patterns. Simulations were started with initial values corresponding to conditions that existed at the beginning of the 1961-62 season and covered a twenty-five year period. The results were examined from the viewpoints of three major groups of subsector participants: orange producers, processors and distributors, and consumers. It was assumed that the interests of these groups could be evaluated on the basis of the present value and variance of grower profits, crop size and average FOB price, respectively. These items were computed with the aid of a FORTRAN computer program and along with estimated storage costs provided the information used in policy evaluation.

The first policy examined was one where restrictions were placed on new tree plantings whenever grower profits exceeded specified levels. Three levels were examined in the study--\$1.25, \$1.50 and \$1.75 per box. In the simulations, these restrictions increased the present value of

[1]Two bases were actually used in the study, one for advertising and the other for nonadvertising policies.

grower profits. They also reduced crop size and caused an increase in the prices paid by consumers. The associated changes in the variance of the decision variables affected participants in a similar fashion. Consequently, the restrictions were beneficial from the viewpoint of orange producers but not from the viewpoints of processors and distributors or consumers.

Policies that abandoned fully productive orange trees whenever grower profits fell below $.15 or $.25 per box were also examined. Like the restrictions on tree plantings, the tree abandonment policies caused an increase in grower profits; however, they reduced the variance of FOB price and crop size. Thus, it was possible that these policies were beneficial from the viewpoint of all three groups of subsector participants. Whether this result would be true, however, would depend on how processors and consumers made tradeoffs between the present value and variance of their respective decision variables.

Three policies were examined which, respectively, increased carry-overs from 8 to 16 weeks of average consumer demand, restricted price adjustments to twice each month (rather than twice each week), and placed a lower limit on average marginal net revenue which, in effect, placed a floor on prices. Results indicated that the orange subsector would receive some benefits from more flexible prices; however, these benefits might be offset by additional costs associated with frequent price changes. Gains from the larger carry-overs and the price floor were offset by increased storage costs.

A policy consisting of a combination of restrictions that limited increases in productive capacity whenever grower profits were above $1.50 per box and also placed a lower limit on average marginal net revenue was examined. The small gains from this policy, when compared to the planting restriction alone, probably would not justify the administrative costs of the price floor.

Finally, a policy which altered the collection and expenditure of advertising funds was considered. In the base model, advertising was funded by a constant tax per box of oranges. In the alternative policy, the tax per box increased with a decrease in crop size. A small crop was normally associated with high prices. Also, the procedure allowed a large proportion of advertising funds to be spent when there was a large crop to be sold. The policy increased average advertising from $11.9 million to $19.8 million per season, or by 66 percent. Given the advertising response functions in the model, this much additional advertising was unprofitable. Thus, the policy was undesirable from the viewpoints of all three groups of subsector participants. No attempt was made in the study to determine the most profitable level of advertising or whether or not one procedure was preferable to the other. However, had the level of advertising been lower in the simulations, the performance of the policy would have improved.

In conclusion, policies that reduced orange supplies caused substantially higher grower profits, lower storage costs and higher retail prices. They also reduced risks for orange producers, but not necessarily for other subsector participants. The alternative advertising proposal did not prove to be profitable, given the advertising response functions in the model. Small gains from policies that failed to alter the long-run behavior of the subsector were partially or completely offset by increased storage costs. The characteristic which dominated policy analysis was the presence of conflicts of interests among subsector participants. In almost every instance, in order for one group to gain, another was placed in a less desirable position. For the policies considered in the study, results provided insights into costs and returns and their distribution among subsector participants.

The model has potential usefulness in the continuing evaluation of alternative policies; since, as specific proposals develop in the orange subsector, the model provides a means of studying their effectiveness and obtaining insights into potential problems. The model's usefulness will depend upon the ingenuity of the user and upon the particular policies to be studied.[2]

Limitations

Several model relationships were estimated on the basis of inadequate information. One of these was the relationship between grower profits and future orange supplies. As orange producers have become more sophisticated in their decision making, they have altered their response to changes in grower profits. Also, real estate values within the orange producing area have increased rapidly with unclear effects on long-run supplies. In estimating the response relationship, the effect of these changes was not completely understood.

Two other areas of the model were bothersome. Several demand equations had coefficients with signs differing from theoretical expectations and cross-product terms that outweighted the own-price effect.

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[2]Large models such as the one discussed in this study have two offsetting characteristics--as the model becomes larger and more detailed, additional linkage points exist and it becomes easier to build in alternative policies. On the other hand, the model becomes more difficult to comprehend and there is greater opportunity for estimation errors in the simulations. Also, the resources required to update the model increase along with the complexity of policy evaluation.

These equations, along with cost functions, formed the basis for product allocation and in the simulations a smaller proportion of the product was channeled through the frozen concentrate retail market and a larger proportion through institutional product markets than was observed in empirical data. This discrepancy was believed indicative of problems with cost and demand relationships. Estimates of consumer response to advertising were also bothersome. The response relationships developed by McClelland could not be accommodated in the DYNAMO model without making alterations in structure. Thus, advertising functions were based upon a simplified adaptation of his results. These estimates had an important effect on the evaluation of the advertising policy.

Mention should be made of the model's overemphasis of the discontinuity between crop seasons. When the end of a season drew near, the model had less time to adjust to specified end of season conditions and made changes more rapidly than would occur in the orange subsector. This characteristic was dampened by averaging and by making operating rules dependent upon conditions that changed as the end of season approached. However, the model overstated the end of season discontinuity of the orange subsector.

Finally, answers provided by the model for particular policies need to be carefully evaluated. Also, questions for which the model is being used need to be evaluated. It may be that other approaches are more suitable for studying a particular question. Sometimes partial analysis will be a more reliable and a less expensive approach. More aggregate econometric type models have advantages for structural estimation.

Implications for Future Research

If the results of current and future research are to be used to improve the model, considerable effort will be required to make results compatible with model structure. In this respect, efforts should come from two directions--from that of researchers involved in studies with relatively specific objectives and from that of the researcher attempting to improve the model. Both will have to be willing to place themselves in the other's position and expend time and energy in understanding the reasons for a particular specification and each will have to compromise in order to make their work compatible. The tendency seems to be for the researcher studying a relatively specific problem, in his search for accuracy, to become involved in more detail than can be accommodated in the model, whereas, on the other hand, the model builder, from his viewpoint of a large and necessarily more abstract model, may tend to gloss over important details. In order to obtain complementary results, both researchers will have to make a conscientious effort to accommodate the other's purpose.

APPENDIX A

Alphabetized List of Variable Names

ALPHABETIZED LIST OF VARIABLE NAMES[1]

		Defined by equation(s)
AA	- average advertising (dollars/week)	108
AC	- administrative cost (dollars/week)	101
AFOB	- weighted average FOB price of orange products (dollars/gallon single strength equivalent)	189A
AFU	- average weekly fruit usage (boxes)	68
AGP	- average grower profit (dollars/box)	63
AI(I)	- advertising influence on demand for the I^{th} product	110-123
AMNR	- weighted average marginal net revenue (dollars/gallon single strength equivalent)	131
AQD(I)	- average quantity of I^{th} product demanded (gallons single strength equivalent/week)	294-300
AQS	- total quantity suggested after the price adjustment (boxes/week)	175H
AQS(I)	- quantity of the I^{th} product suggested after price adjustment (gallon single strength equivalent/week)	175A-175G
ARP1	- average retail price of frozen concentrated orange juice (cents/6 ounce can)	264

[1] "Box" when used in a definition refers to a 90 pound field box.

		Defined by equation(s)
ARP2	- average retail price of chilled orange juice (cents/quart)	265
ARP3	- average retail price of canned single strength orange juice (cents/42 ounce can)	266
ARP4	- average retail price of fresh oranges (cents/pound)	267
AT	- advertising tax (dollars/box)	102
ATR	- advertising tax revenue (dollars/week)	100
ATRA	- advertising tax revenue accumulated (dollars)	104
ATS	- advertising tax spending (dollars/week)	105
AWI	- adjusted weather influence (AWI $\leq$ 1)	38A
BPG(I)	- conversion factor for product I (boxes/gallon single strength equivalent)	77-83
BPT	- yield per tree (boxes/tree)	52
CI	- competitive influence (.9 $\leq$ CI $\leq$ 1.1)	246
CLF	- crop lost as a result of freeze damage (boxes)	54
CP	- cumulative profit per year (dollars)	66
CPB	- cost per box (dollars/box)	59
CPD	- cumulative profits discarded (dollars)	66A
CPDP	- cumulative profit discard pulse (dollars)	66B
CR	- crop remaining (boxes)	46
CS	- crop size (boxes)	45
CSP	- crop size pulse (boxes)	51
D(I)	- order rate for the I^{th} product (gallons single strength equivalent/week)	225-231

		Defined by equation(s)
DD	- desired disappearance (boxes/week)	154
DG	- delay in growing (weeks)	6
DP	- length of delay in recovery of hatracked trees (weeks)	17
DS	- demand shifter = $\begin{cases} 0 & \text{Sept. - Mar.} \\ 1 & \text{Apr. - Aug.} \end{cases}$	283
FA	- fraction of new trees added	11
FD	- fruit discarded (boxes/week)	48
FDP	- fruit discarded pulse (boxes)	49
FHR	- fraction of productive trees hatracked	29
FL	- fraction of productive trees lost "normally" or as result of tree abandonment	22
FLOOR	- lower limit on XAMNR	168B
FOB(I)	- FOB price of the I^{th} product (dollars/gallon single strength equivalent)	176-182
FOB(I)S	- FOB price of I^{th} product suggested after the overall adjustment (dollars/gallon single strength equivalent)	169-175
FSPW	- fraction spent per week	106
FTLF	- fraction of productive trees lost as a result of freeze damage	28
FU(I)	- fruit used in I^{th} product; (I = 1, . . . , 7) (boxes/weeks)	70-76
FUTD	- fruit used to date (boxes)	47
GC	- grower cost (dollars/box)	60
GP	- grower profit (dollars/box)	58

		Defined by equation(s)
GPB(I)	- conversion factor for product I (gallons single strength equivalent/box)	84-90
HLOSS	- crop loss associated with hatracking (boxes)	56
HTBP	- hatracked trees becoming productive (trees/week)	13
I(I)	- inventory level (gallons single strength equivalent)	218-224
IA(I)	- influence of product availability on sales of the I^{th} product	197-210
II(I)	- inventory influence associated with I^{th} product	232-245
IP5	- smoothed institutional FOB price of frozen concentrated orange juice (dollars/dozen 32 ounce cans)	272
IP6	- smoothed institutional FOB price of chilled orange juice (dollars/dozen quarts)	273
IP7	- smoothed institutional FOB price of canned single strength orange juice (dollars/dozen 46 ounce cans)	274
MNR(I)	- marginal net revenue of the I^{th} product (dollars/gallon single strength equivalent)	124-130
N	- number of orange products considered in the model	
NCA	- new crop added (boxes/week)	50
NTBP	- initial trees becoming productive (trees/week)	2A
NTP	- new trees planted (trees/week)	7
NTPR	- the value above which the planting restriction became effective (dollars/box)	8

		Defined by equation(s)
OTP	- on-tree price (dollars/box)	61
PA	- processor availability	98
PD(I)	- processor disappearance of product I (gallons single strength equivalent/week)	91-97
PDRD	- processor disappearance relative to desired	159
PDS	- suggested processor disappearance (boxes/week)	153
PG	- U.S. population growth (people/week)	292
PGR	- weekly U.S. population growth rate (percent)	293
POP	- U.S. population	291
PQD(I)	- per capita quantity of the I^{th} product demanded (gallons single strength equivalent/month)	276-279
PROFT	- profit (dollars/week)	65
PT	- productive trees (trees)	1
PTL	- productive trees lost (trees/week)	19
PTLA	- productive trees lost as a result of "normal" aging factors or tree abandonment (trees/week)	21
PTLF	- productive trees lost as a result of freeze damage (trees)	20
QD(I)	- quantity of the I^{th} product demanded (gallons single strength equivalent/week)	284-290
RP1	- retail price of frozen concentrated orange juice (cents/6 ounce can)	256
RP2	- retail price of chilled orange juice (cents/quart)	257
RP3	- retail price of canned single strength orange juice (cents/46 ounce can)	258

		Defined by equation(s)
RP4	- retail price of fresh oranges (cents/pound)	259
RPS(I)	- retail price suggested for the I^{th} product (same units as retail prices above)	252-255
S(I)	- sales of the I^{th} product (gallons single strength equivalent/week)	190-196
SFOB	- smoothed weighted average FOB price (dollars/box)	189B
TAA	- time for averaging advertising (weeks)	109
TAFU	- time for averaging fruit usage (weeks)	69
TAGP	- time for averaging grower profits (weeks)	64
TAQD	- time for averaging quantity demanded (weeks)	301
TAR	- tree abandonment restriction (dollars/box)	25
TARP	- time for averaging retail price (weeks)	268
TBP	- trees becoming productive (trees/week)	2
TCFP(I)	- smoothing period for FOB price of I^{th} product (weeks)	183-189
TCIP	- time for correcting institutional prices (weeks)	275
TCRP(I)	- time for correcting the retail price of the I^{th} product (weeks)	260-263
TFU	- total fruit usage per week (boxes)	76A
THR	- number of trees hatracked (trees/week)	18
TIME	- simulated time (weeks)	
TLOSS	- crop loss associated with tree kills (boxes)	55
TM	- time proxy ($TM \geq 4$)	293A
TSFOB	- time for smoothing weighted average FOB price (weeks)	189C

		Defined by equation(s)
WCO	- weeks of carry-over (weeks)	155
WCR	- weeks of crop remaining (weeks)	67
WD	- weeks discarded (weeks)	157
WDP	- weeks discarded pulse (weeks)	158
WI	- weather influence	37
WIA(I)	- number of weeks of inventory available (weeks)	211-217
WIY	- weather influence on yield	40
WP	- weeks passed (weeks)	156
WPY	- weeks per year (weeks)	10
XAMNR	- average marginal net revenue after the overall adjustment (dollars/gallon single strength equivalent)	168A
XDG	- internal transfer variable (weeks)	5
XFB(I)S	- suggested FOB price for product I (dollars/ gallon single strength equivalent)	132-138
XFL	- "normal" fraction of trees lost	23
XFOB1	- FOB price of frozen concentrated orange juice (dollars/dozen 6 ounce cans)	248
XFOB2	- FOB price of chilled orange juice (dollars/dozen quarts)	249
XFOB3	- FOB price of canned single strength orange juice (dollars/dozen 46 ounce cans)	250
XFOB4	- FOB price of fresh oranges (dollars/45 pound carton)	251
XFOB5	- FOB price of frozen concentrated orange juice (dollars/dozen 32 ounce cans)	269

		Defined by equation(s)
XFOB6	- FOB price of chilled orange juice (dollars/ dozen quarts)	270
XFOB7	- FOB price of canned single strength orange juice (dollars/dozen 46 ounce cans)	271
XNTP	- the rate at which new tree plantings would have occurred without the planting restriction (trees/ week)	9
XPQS(I)	- per capita monthly consumption of product I suggested (gallons single strength equivalent/ week)	139-145
XQD(I)	- quantity of the I^{th} product demanded at time J (gallons single strength equivalent/week)	290A-290G
XQS(I)	- suggested consumption of I^{th} product (gallons single strength equivalent/week)	146-152
XTBP	- internal transfer variable (trees/week)	4
YDD	- disappearance associated with profits of $1.00 per box (boxes/week)	27
YFL	- fraction of trees lost when tree abandonment restriction was operative	26
YLOSS	- yield loss (boxes)	57
YTBP	- young trees becoming productive (trees/week)	3
ZAMNR	- average marginal net revenue before considering whether or not the policy limit was effective	166
ZTBP	- trees becoming productive after initial period (trees/week)	2B

APPENDIX B

The Computer Program

```
NOTE   DYNAMO MODEL OF THE FLORIDA ORANGE SUBSECTOR            EQUATION NO.
NOTE
NOTE
NOTE   TREE NUMBERS SECTOR 1
NOTE
NOTE
L      PT.K=PT.J+(DT)(TBP.JK-PTL.JK)                                   1
R      TBP.KL=CLIP(ZTBP.JK,NTBP.JK,TIME.K,156)                         2
R      NTBP.KL=(.178)(PT.K)/WPY                                        2A
R      ZTBP.KL=YTBP.JK+HTBP.JK                                         2B
R      YTBP.KL=DELAY3(XTBP.JK,XDG)                                     3
R      XTBP.KL=DELAY3(NTP.JK,XDG)                                      4
N      XDG=DG/2                                                        5
C      DG=676 WEEKS                                                    6
R      NTP.KL=CLIP(XNTP.JK,0,NTPR,AGP.K)                               7
C      NTPR=1000. TREE PLANTING RESTRICTION IS INOPERATIVE             8A
R      XNTP.KL=(PT.K)(FA.K)/WPY                                        9
C      WPY=52                                                          10
A      FA.K=TABHL(FAT,AGP.K,0,3.00,.50)                                11
C      FAT*=.022/.054/.086/.118/.150/.182/.214                         12
R      HTBP.KL=DELAY3(XHTBP.JK,XDP)                                    13
R      XHTBP.KL=DELAY3(YHTBP.JK,XDP)                                   14
R      YHTBP.KL=DELAY3(THR.JK,XDP)                                     15
N      XDP=DP/3                                                        16
C      DP=208 WEEKS                                                    17
R      THR.KL=(FHR.K)(PT.K)                                            18
R      PTL.KL=PTLA.JK+PTLF.K                                           19
A      PTLF.K=(1/DT)((FTLF.K)(PT.K)+(FHR.K)(PT.K))                     20
R      PTLA.KL=(PT.K)(FL.K)/WPY                                        21
A      FL.K=CLIP(XFL.K,YFL.K,GP.K,TAR)                                 22
A      XFL.K=TABHL(XFLT,AGP.K,-.50,2.00,.50)                           23
C      XFLT*.08/.06/.04/.03/.02/.015                                   24
C      TAR=-1000.  TREE ABANDONMENT POLICY IS INOPERATIVE              25B
A      YFL.K=(1/DD.K)(DD.K-YDD)                                        26
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C       YDD=2.012E6                                                      27
NOTE
NOTE    WEATHER EFFECTS SECTOR 2
NOTE
NOTE
A       FTLF.K=PULSE(XFTLF,52,52)                                        28
A       FHR.K=PULSE(XFHR.K,52,52)                                        29
A       FYLF.K=PULSE(XFYLF.K,52,52)                                      30
NOTE
NOTE    ONLY ONE WEATHER OPTION MAY BE INCLUDED IN CARD DECK DURING A
NOTE    GIVEN RUN
NOTE    WEATHER OPTION I - HISTORIC
NOTE
A       XFTLF.K=TABHL(XFTLFT,TIME.K,52,572,52)                           31
C       XFTLFT*=.226/.185/0/0/0/0/0/0/0/0/0                              32
A       XFHR.K=TABHL(XFHRT,TIME.K,52,572,52)                             33
C       XFHRT*=.080/0/0/0/0/0/0/0/0/0/0                                  34
A       XFYLF.K=TABHL(XFYLFT,TIME.K,52,572,52)                           35
C       XFYLFT*=.066/.051/.246/.155/-.189/.176/-.029/-.057/-.058/.012/0
A       WI.K=SWITCH(1,1,TIME.K)                                          36A
A       WIY.K=CLIP(WI.K,1,WI.K,1)                                        36B
NOTE
NOTE    WEATHER OPTION II - STOCHASTIC
NOTE
A       WI.K=NORMRN(1,.06)                                               37
A       XAWI.K=1-WI.K                                                    38
A       AWI.K=MIN(XAWI.K,1)                                              38A
A       XFYLF.K=CLIP(0,AWI.K,WI.K,1)                                     39
A       WIY.K=CLIP(WI.K,1,WI.K,1)                                        40
A       XFTLF.K=TABHL(XFTLFT,XFYLF.K,0,.35,.35)                          41
C       XFTLFT*=0/.15                                                    42
A       XFHR.K=TABHL(XFHRT,XFYLF.K,0,.35,.35)                            43
C       XFHRT*=0/.35                                                     44
NOTE
```

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NOTE   WEATHER OPTION III - MEAN
NOTE
A      WI.K=SWITCH(1,1,TIME.K)                                        44A
A      XAWI.K=1-WI.K                                                  44B
A      AWI.K=MIN(XAWI.K,1)                                            44C
A      XFYLF.K=CLIP(0,AWI.K,WI.K,1)                                   44D
A      WIY.K=CLIP(WI.K,1,WI.K,1)                                      44E
A      XFTLF.K=TABHL(XFTLFT,XFYLF.K,0,.35,.35)                        44F
C      XFTLFT*=0/.15                                                  44G
A      XFHR.K=TABHL(XFHRT,XFYLF.K,0,.35,.35)                          44H
C      XFHRT*=0/.35                                                   44I
NOTE
NOTE
NOTE   CROP SIZE SECTOR 3
NOTE
NOTE
A      CS.K=CR.K+FUTD.K                                               45
L      CR.K=CR.J-CLF.J+NCA.JK-(DT)(FU1.JK+FU2.JK+FU3.JK+FU4.JK+FU5.JK+FU6
X1     .JK+FU7.JK)                                                    46
L      FUTD.K=FUTD.J+(DT)(FU1.JK+FU2.JK+FU3.JK+FU4.JK+FU5.JK+FU6.JK+FU7.J
X1     K-FD.JK)                                                       47
R      FD.KL=PULSE(FDP.K,52,52)                                       48
A      FDP.K=FUTD.K/DT                                                49
R      NCA.KL=PULSE(CSP.K,52,52)                                      50
A      CSP.K=(PT.K)(BPT.K)(WIY.K)                                     51
A      BPT.K=TABHL(BPTT,AGP.K,-.50,2.00,.50)                          52
C      BPTT*=4.5/4.6/4.7/4.8/5.0/5.3                                  53
A      CLF.K=TLOSS.K+HLOSS.K+YLOSS.K                                  54
A      TLOSS.K=(FTLF.K)(CSP.K)                                        55
A      HLOSS.K=(FHR.K)(CSP.K)                                         56
A      YLOSS.K=(FYLF.K)(CSP.K)                                        57
NOTE
NOTE
NOTE   GROWER PROFIT SECTOR 4
```

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NOTE
NOTE
A       GP.K=OTP.K-GC.K                                                   58
C       CPB=.85  DOLLARS PER BOX                                          59
A       GC.K=CPB/WI.K                                                     60
A       OTP.K=TABHL(OTPT,AFOB.K,.35,1.25,.18)                             61
C       OTPT*=.03/1.00/1.96/2.94/3.90/4.86                                62
L       AGP.K=AGP.J+(DT)(1/TAGP)(GP.J-AGP.J)                              63
C       TAGP=104 WEEKS                                                    64
R       PROFT.KL=(GP.K)(TFU.K)                                            65
L       CP.K=CP.J+(DT)(PROFT.JK-CPD.JK)                                   66
R       CPD.KL=PULSE(CPDP.K,52,52)                                        66A
A       CPDP.K=CP.K/DT                                                    66B
NOTE
NOTE
NOTE    PROCESSOR DISAPPEARANCE SECTOR 5
NOTE
NOTE
A       WCR.K=CR.K/AFU.K                                                  67
L       AFU.K=AFU.J+(DT)(1/TAFU)(FU1.JK+FU2.JK+FU3.JK+FU4.JK+FU5.JK+FU6.JK
X1      +FU7.JK-AFU.J)                                                    68
C       TAFU=4 WEEKS                                                      69
R       FU1.KL=(PD1.JK)(BPG1.K)                                           70
R       FU2.KL=(PD2.JK)(BPG2.K)                                           71
R       FU3.KL=(PD3.JK)(BPG3.K)                                           72
R       FU4.KL=(PD4.JK)(BPG4.K)                                           73
R       FU5.KL=(PD5.JK)(BPG5.K)                                           74
R       FU6.KL=(PD6.JK)(BPG6.K)                                           75
R       FU7.KL=(PD7.JK)(BPG7.K)                                           76
A       TFU.K=FU1.JK+FU2.JK+FU3.JK+FU4.JK+FU5.JK+FU6.JK+FU7.JK            76A
A       BPG1.K=1/((GPB1)(WI.K))                                           77
A       BPG2.K=1/((GPB2)(WI.K))                                           78
A       BPG3.K=1/((GPB3)(WI.K))                                           79
A       BPG4.K=1/((GPB4)(WI.K))                                           80
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A       BPG5.K=1/((GPB5)(WI.K))                                          81
A       BPG6.K=1/((GPB6)(WI.K))                                          82
A       BPG7.K=1/((GPB7)(WI.K))                                          83
C       GPB1=4.90                                                        84
C       GPB2=5.29                                                        85
C       GPB3=5.20                                                        86
C       GPB4=5.29                                                        87
C       GPB5=4.90                                                        88
C       GPB6=5.29                                                        89
C       GPB7=5.20                                                        90
R       PD1.KL=(D1.JK)(PA.K)                                             91
R       PD2.KL=(D2.JK)(PA.K)                                             92
R       PD3.KL=(D3.JK)(PA.K)                                             93
R       PD4.KL=(D4.JK)(PA.K)                                             94
R       PD5.KL=(D5.JK)(PA.K)                                             95
R       PD6.KL=(D6.JK)(PA.K)                                             96
R       PD7.KL=(D7.JK)(PA.K)                                             97
A       PA.K=TABHL(PAT,WCR.K,0,15,5)                                     98
C       PAT*=0/.84/.97/1.0                                               99
NOTE
NOTE
NOTE    ADVERTISING SECTOR 6
NOTE
NOTE
R       ATR.KL=(FU1.JK+FU2.JK+FU3.JK+FU4.JK+FU5.JK+FU6.JK+FU7.JK)(AT.K)-AC
X1                                                                      100
C       AC=26306                                                        101
A       AT.K=TABHL(ATT,TIME.K,0,416,52)                                 102
C       ATT*=.09/.09/.08/.08/.08/.08/.08/.08/.10                        103
L       ATRA.K=ATRA.J+(DT)(ATR.JK-ATS.JK)                               104
A       ATS.KL=(ATRA.K)(FSPW.K)                                         105
A       FSPW.K=TABHL(FSPWT,WP.K,1,52,1)                                 106
C       FSPWT*=.02033/.02033/.02033/.02033/.02033/.02033/.02033/.02033/.02
X1      033/.02033/.02033/.02033/.02033/.02439/.02439/.02439/.02439/.02439
```

```
X2      /.02439/.02439/.02439/.02439/.02439/.02439/.02439/.02439/.02033/.0
X3      2033/.02033/.02033/.02033/.02033/.02033/.02033/.02033/.02033/.0203
X4      3/.02033/.02033/.00813/.00813/.00813/.00813/.00813/.00813/.00813/.
X5      00813/.00813/.00813/.00813/.00813/.00813                        107
L       AA.K=AA.J+(DT)(1/TAA)(ATS.JK-AA.J)                              108
C       TAA=104 WEEKS                                                   109
A       AI1.K=TABHL(AI1T,AA.K,.5E5,.3E6,.5E5)                           110
C       AI1T*=.96625/.9810/.9925/1.0030/1.0095/1.015                    111
A       AI2.K=TABHL(AI2T,AA.K,.5E5,.3E6,.5E5)                           112
C       AI2T*=.9445/.9720/.9895/1.0055/1.0195/1.027                     113
A       AI3.K=TABHL(AI3T,AA.K,.5E5,.3E6,.5E5)                           114
C       AI3T*=.9555/.9920/.9990/.9990/.9910/.9840                       115
A       AI4.K=TABHL(AI4T,AA.K,.25E5,.225E6,.5E5)                        116
C       AI4T*=.74/.92/1.068/1.116/1.146                                 117
A       AI5.K=TABHL(AI5T,AA.K,.5E5,.3E6,.5E5)                           118
C       AI5T*=.97604/.98651/.99468/1.00213/1.00675/1.01065              119
A       AI6.K=TABHL(AI6T,AA.K,.5E5,.3E6,.5E5)                           120
C       AI6T*=.96781/.98376/.99391/1.00319/1.01131/1.01566              121
A       AI7.K=TABHL(AI7T,AA.K,.5E5,.3E6,.5E5)                           122
C       AI7T*=.97419/.99536/.99942/.99942/.99478/.99072                 123
NOTE
NOTE    FOB PRICE SECTOR 7
NOTE
NOTE
L       MNR1.K=-1.619070+(2)(FOB1.J)+(.086948)(DS.J)                    124
L       MNR2.K=-.910568+(2)(FOB2.J)+(.006138)(DS.J)                     125
L       MNR3.K=-1.231471+(2)(FOB3.J)-(.004729)(DS.J)                    126
L       MNR4.K=-1.261810+(2)(FOB4.J)                                    127
L       MNR5.K=-1.196271+(2)(FOB5.J)                                    128
L       MNR6.K=-1.514355+(2)(FOB6.J)                                    129
L       MNR7.K=-1.313230+(2)(FOB7.J)                                    130
A       AMNR.K=((MNR1.K)(XQD1.K)+(MNR2.K)(XQD2.K)+(MNR3.K)(XQD3.K)+(MNR4.K
X1      )(XQD4.K)+(MNR5.K)(XQD5.K)+(MNR6.K)(XQD6.K)+(MNR7.K)(XQD7.K))/(XQD
X2      1.K+XQD2.K+XQD3.K+XQD4.K+XQD5.K+XQD6.K+XQD7.K)                  131
```

```
A     SUM1.K=XQD1.K+XQD2.K+XQD3.K+XQD4.K+XQD5.K+XQD6.K+XQD7.K               131A
A     XFB1S.K=.809535+(.5)(AMNR.K)-(.043474)(DS.K)                           132
A     XFB2S.K=.455284+(.5)(AMNR.K)-(.003069)(DS.K)                           133
A     XFB3S.K=.615736+(.5)(AMNR.K)+(.002365)(DS.K)                           134
A     XFB4S.K=.630905+(.5)(AMNR.K)                                           135
A     XFB5S.K=.598136+(.5)(AMNR.K)                                           136
A     XFB6S.K=.757177+(.5)(AMNR.K)                                           137
A     XFB7S.K=.656615+(.5)(AMNR.K)                                           138
A     XPQS1.K=(AI1.K)(.145935-(.106017)(XFB1S.K)-(.009218)(DS.K))            139
A     XPQS2.K=(AI2.K)(.035136-(.047900)(XFB2S.K)-(.000294)(DS.K))            140
A     XPQS3.K=(AI3.K)(.023731-(.027704)(XFB3S.K)+(.000131)(DS.K))            141
A     XPQS4.K=(AI4.K)(.126176-(.117840)(XFB4S.K))                            142
A     XPQS5.K=(AI5.K)(.052886-(.055452)(XFB5S.K))                            143
A     XPQS6.K=(AI6.K)(.078273-(.058530)(XFB6S.K))                            144
A     XPQS7.K=(AI7.K)(.173864-(.185287)(XFB7S.K))                            145
A     XQS1.K=(XPQS1.K)(POP.K)/4                                              146
A     XQS2.K=(XPQS2.K)(POP.K)/4                                              147
A     XQS3.K=(XPQS3.K)(POP.K)/4                                              148
A     XQS4.K=(XPQS4.K)(POP.K)/4                                              149
A     XQS5.K=(XPQS5.K)(POP.K)/4                                              150
A     XQS6.K=(XPQS6.K)(POP.K)/4                                              151
A     XQS7.K=(XPQS7.K)(POP.K)/4                                              152
A     PDS.K=(BPG1.K)(XQS1.K)+(BPG2.K)(XQS2.K)+(BPG3.K)(XQS3.K)+(BPG4.K)(
X1    XQS4.K)+(BPG5.K)(XQS5.K)+(BPG6.K)(XQS6.K)+(BPG7.K)(XQS7.K)             153
A     DD.K=(CR.K)/(WPY-WP.K+WCD)                                             154
C     WCD=8 WEEKS                                                            155
L     WP.K=WP.J+(DT)(1-WD.JK)                                                156
R     WD.KL=PULSE(WDP,52,52)                                                 157
N     WDP=(WPY/DT)                                                           158
A     PDRD.K=PDS.K/DD.K                                                      159
A     R.K=CLIP(1,0,V.K,0)                                                    160
A     V.K=(TIME.K/H)-E.K                                                     161
L     E.K=E.J+(DT)(Z.J)                                                      162
A     Z.K=R.K/DT                                                             163
```

```
C       H=.5 WEEKS                                                          164
N       E=1                                                                 165
A       ZAMNR.K=AMNR.K+(R.K)(PDRD.K-1)(Q.K)                                 166
A       Q.K=TABHL(QT,PDRD.K,.94,1.06,.01)                                   167
C       QT*=.7/.7/.7/.7/.7/.7/1/.7/.7/.7/.7/.7/.7                           168
A       XAMNR.K=MAX(FLOOR,ZAMNR.K)                                          168A
C       FLOOR=-1000. LOWER LIMIT ON XAMNR IS INOPERATIVE                    168B
A       FOB1S.K=.809535+(.5)(XAMNR.K)-(.043474)(DS.K)                       169
A       FOB2S.K=.455284+(.5)(XAMNR.K)-(.003069)(DS.K)                       170
A       FOB3S.K=.615736+(.5)(XAMNR.K)+(.002365)(DS.K)                       171
A       FOB4S.K=.630905+(.5)(XAMNR.K)                                       172
A       FOB5S.K=.598136+(.5)(XAMNR.K)                                       173
A       FOB6S.K=.757177+(.5)(XAMNR.K)                                       174
A       FOB7S.K=.656615+(.5)(XAMNR.K)                                       175
A       AQS1.K=(POP.K)(AI1.K)(.036484-(.026504)(FOB1S.K)-(.002305)(DS.K))
A       AQS2.K=(POP.K)(AI2.K)(.008784-(.011975)(FOB2S.K)-(.000074)(DS.K))
A       AQS3.K=(POP.K)(AI3.K)(.005933-(.006926)(FOB3S.K)+(.000033)(DS.K))
A       AQS4.K=(POP.K)(AI4.K)(.031544-(.029460)(FOB4S.K))                   175D
A       AQS5.K=(POP.K)(AI5.K)(.013222-(.013863)(FOB5S.K))                   175E
A       AQS6.K=(POP.K)(AI6.K)(.019568-(.014633)(FOB6S.K))                   175F
A       AQS7.K=(POP.K)(AI7.K)(.043466-(.046322)(FOB7S.K))                   175G
A       AQS.K=(AQS1.K)(BPG1.K)+(AQS2.K)(BPG2.K)+(AQS3.K)(BPG3.K)+(AQS4.K)(
X1      BPG4.K)+(AQS5.K)(BPG5.K)+(AQS6.K)(BPG6.K)+(AQS7.K)(BPG7.K)          175H
L       FOB1.K=FOB1.J+(DT)(1/TCFP1)(FOB1S.J-FOB1.J)                         176
L       FOB2.K=FOB2.J+(DT)(1/TCFP2)(FOB2S.J-FOB2.J)                         177
L       FOB3.K=FOB3.J+(DT)(1/TCFP3)(FOB3S.J-FOB3.J)                         178
L       FOB4.K=FOB4.J+(DT)(1/TCFP4)(FOB4S.J-FOB4.J)                         179
L       FOB5.K=FOB5.J+(DT)(1/TCFP5)(FOB5S.J-FOB5.J)                         180
L       FOB6.K=FOB6.J+(DT)(1/TCFP6)(FOB6S.J-FOB6.J)                         181
L       FOB7.K=FOB7.J+(DT)(1/TCFP7)(FOB7S.J-FOB7.J)                         182
C       TCFP1=4 WEEKS                                                       183
C       TCFP2=4 WEEKS                                                       184
C       TCFP3=4 WEEKS                                                       185
C       TCFP4=4 WEEKS                                                       186
```

```
C       TCFP5=4 WEEKS                                                    187
C       TCFP6=4 WEEKS                                                    188
C       TCFP7=4 WEEKS                                                    189
A       AFOB.K=((FU1.JK)(FOB1.K)+(FU2.JK)(FOB2.K)+(FU3.JK)(FOB3.K)+(FU4.JK
X1      )(FOB4.K)+(FU5.JK)(FOB5.K)+(FU6.JK)(FOB6.K)+(FU7.JK)(FOB7.K))/TFU.
X2      K                                                               189A
L       SFOB.K=SFOB.J+(DT)(1/TSFOB)(AFOB.J-SFOB.J)                      189B
C       TSFOB=12 WEEKS                                                  189C
NOTE
NOTE
NOTE    RETAIL AND INSTITUTIONAL INVENTORY AND SALES SECTOR 8
NOTE
NOTE
R       S1.KL=(QD1.K)(IA1.K)                                             190
R       S2.KL=(QD2.K)(IA2.K)                                             191
R       S3.KL=(QD3.K)(IA3.K)                                             192
R       S4.KL=(QD4.K)(IA4.K)                                             193
R       S5.KL=(QD5.K)(IA5.K)                                             194
R       S6.KL=(QD6.K)(IA6.K)                                             195
R       S7.KL=(QD7.K)(IA7.K)                                             196
A       IA1.K=TABHL(IA1T,WIA1.K,0,1.5,.5)                                197
C       IA1T*=0/.85/.98/1.0                                              198
A       IA2.K=TABHL(IA2T,WIA2.K,0,1.5,.5)                                199
C       IA2T*=0/.85/.98/1.0                                              200
A       IA3.K=TABHL(IA3T,WIA3.K,0,4,2)                                   201
C       IA3T*=0/.85/1.0                                                  202
A       IA4.K=TABHL(IA4T,WIA4.K,0,.6,.2)                                 203
C       IA4T*=0/.85/.98/1.0                                              204
A       IA5.K=TABHL(IA5T,WIA5.K,0,1.5,.5)                                205
C       IA5T*=0/.85/.98/1.0                                              206
A       IA6.K=TABHL(IA6T,WIA6.K,0,1.5,.5)                                207
C       IA6T*=0/.85/.98/1.0                                              208
A       IA7.K=TABHL(IA7T,WIA7.K,0,4,2)                                   209
C       IA7T*=0/.85/1.0                                                  210
```

```
A      WIA1.K=I1.K/AQD1.K
A      WIA2.K=I2.K/AQD2.K
A      WIA3.K=I3.K/AQD3.K
A      WIA4.K=I4.K/AQD4.K
A      WIA5.K=I5.K/AQD5.K
A      WIA6.K=I6.K/AQD6.K
A      WIA7.K=I7.K/AQD7.K
L      I1.K=I1.J+(DT)(PD1.JK-S1.JK)
L      I2.K=I2.J+(DT)(PD2.JK-S2.JK)
L      I3.K=I3.J+(DT)(PD3.JK-S3.JK)
L      I4.K=I4.J+(DT)(PD4.JK-S4.JK)
L      I5.K=I5.J+(DT)(PD5.JK-S5.JK)
L      I6.K=I6.J+(DT)(PD6.JK-S6.JK)
L      I7.K=I7.J+(DT)(PD7.JK-S7.JK)
R      D1.KL=(AQD1.K)(II1.K)(CI.K)
R      D2.KL=(AQD2.K)(II2.K)(CI.K)
R      D3.KL=(AQD3.K)(II3.K)(CI.K)
R      D4.KL=(AQD4.K)(II4.K)(CI.K)
R      D5.KL=(AQD5.K)(II5.K)(CI.K)
R      D6.KL=(AQD6.K)(II6.K)(CI.K)
R      D7.KL=(AQD7.K)(II7.K)(CI.K)
A      II1.K=TABHL(II1T,WIA1.K,.3,2.8,.5)
C      II1T*=2.2/1.4/1.0/.9/.85/.82
A      II2.K=TABHL(II2T,WIA2.K,.2,2.7,.5)
C      II2T*=2.2/1.4/1.0/.9/.85/.82
A      II3.K=TABHL(II3T,WIA3.K,.7,6.7,1.5)
C      II3T*=1.5/1.2/1.0/.9/.85
A      II4.K=TABHL(II4T,WIA4.K,.1,.9,.2)
C      II4T*=3.0/2.4/1.0/.81/.72
A      II5.K=TABHL(II5T,WIA5.K,.3,2.8,.5)
C      II5T*=2.2/1.4/1.0/.9/.85/.82
A      II6.K=TABHL(II6T,WIA6.K,.2,2.7,.5)
C      II6T*=2.2/1.4/1.0/.9/.85/.82
A      II7.K=TABHL(II7T,WIA7.K,.7,6.7,1.5)
```

```
C       II7T*=1.5/1.2/1.0/.9/.85                                245
A       CI.K=TABHL(CIT,PDRO.K,.6,1.4,.2)                        246
C       CIT*=.9/.97/1.0/1.03/1.1                                247
NOTE
NOTE
NOTE    RETAIL AND INSTITUTIONAL PRICE SECTOR 9
NOTE
NOTE
A       XFOB1.K=(2.2501)(FOB1.K)                                248
A       XFOB2.K=(3)(FOB2.K)                                     249
A       XFOB3.K=(4.3119)(FOB3.K)                                250
A       XFOB4.K=(2.645)(FOB4.K)                                 251
A       RPS1.K=4.60+(8.3333)(XFOB1.K)                           252
A       RPS2.K=16.91+(8.3333)(XFOB2.K)                          253
A       RPS3.K=12.38+(8.3333)(XFOB3.K)                          254
A       RPS4.K=2.34+(4.0)(XFOB4.K)                              255
L       RP1.K=RP1.J+(DT)(1/TCRP1)(RPS1.J-RP1.J)                 256
L       RP2.K=RP2.J+(DT)(1/TCRP2)(RPS2.J-RP2.J)                 257
L       RP3.K=RP3.J+(DT)(1/TCRP3)(RPS3.J-RP3.J)                 258
L       RP4.K=RP4.J+(DT)(1/TCRP4)(RPS4.J-RP4.J)                 259
C       TCRP1=2 WEEKS                                           260
C       TCRP2=2 WEEKS                                           261
C       TCRP3=4 WEEKS                                           262
C       TCRP4=.5 WEEKS                                          263
L       ARP1.K=ARP1.J+(DT)(1/TARP)(RP1.J-ARP1.J)                264
L       ARP2.K=ARP2.J+(DT)(1/TARP)(RP2.J-ARP2.J)                265
L       ARP3.K=ARP3.J+(DT)(1/TARP)(RP3.J-ARP3.J)                266
L       ARP4.K=ARP4.J+(DT)(1/TARP)(RP4.J-ARP4.J)                267
C       TARP=2 WEEKS                                            268
A       XFOB5.K=(12)(FOB5.K)                                    269
A       XFOB6.K=(3)(FOB6.K)                                     270
A       XFOB7.K=(4.3125)(FOB7.K)                                271
L       IP5.K=IP5.J+(DT)(1/TCIP)(XFOB5.J-IP5.J)                 272
L       IP6.K=IP6.J+(DT)(1/TCIP)(XFOB6.J-IP6.J)                 273
```

```
L      IP7.K=IP7.J+(DT)(1/TCIP)(XFDB7.J-IP7.J)                               274
C      TCIP=2 WEEKS                                                          275
NOTE
NOTE
NOTE   DEMAND SECTOR 10
NOTE
NOTE
A      PQD1.K=(AI1.K)(.171943-(.005654)(ARP1.K)-(.009218)(DS.K))             276
A      PQD2.K=(AI2.K)(.067536-(.001916)(ARP2.K)-(.000294)(DS.K))             277
A      PQD3.K=(AI3.K)(.033276-(.000771)(ARP3.K)+(.000131)(DS.K))             278
A      PQD4.K=(AI4.K)(.152239-(.011138)(ARP4.K))                             279
A      PQD5.K=(AI5.K)(.052886-(.004621)(IP5.K))                              280
A      PQD6.K=(AI6.K)(.078273-(.019510)(IP6.K))                              281
A      PQD7.K=(AI7.K)(.173864-(.042965)(IP7.K))                              282
A      DS.K=CLIP(1,0,WP.K,30.3)                                              283
A      QD1.K=(PQD1.K)(POP.K)/4                                               284
A      QD2.K=(PQD2.K)(POP.K)/4                                               285
A      QD3.K=(PQD3.K)(POP.K)/4                                               286
A      QD4.K=(PQD4.K)(POP.K)/4                                               287
A      QD5.K=(PQD5.K)(POP.K)/4                                               288
A      QD6.K=(PQD6.K)(POP.K)/4                                               289
A      QD7.K=(PQD7.K)(POP.K)/4                                               290
L      XQD1.K=QD1.J                                                          290A
L      XQD2.K=QD2.J                                                          290B
L      XQD3.K=QD3.J                                                          290C
L      XQD4.K=QD4.J                                                          290D
L      XQD5.K=QD5.J                                                          290E
L      XQD6.K=QD6.J                                                          290F
L      XQD7.K=QD7.J                                                          290G
L      POP.K=POP.J+(DT)(PG.JK)                                               291
R      PG.KL=(.01)(PGR.K)(POP.K)                                             292
A      PGR.K=.0232+(.0462/TM.K)                                              293
A      TM.K=MAX(4,TIME.K)                                                    293A
L      AQD1.K=AQD1.J+(DT)(1/TAQD)(QD1.J-AQD1.J)                              294
```

```
L      AQD2.K=AQD2.J+(DT)(1/TAQD)(QD2.J-AQD2.J)                     295
L      AQD3.K=AQD3.J+(DT)(1/TAQD)(QD3.J-AQD3.J)                     296
L      AQD4.K=AQD4.J+(DT)(1/TAQD)(QD4.J-AQD4.J)                     297
L      AQD5.K=AQD5.J+(DT)(1/TAQD)(QD5.J-AQD5.J)                     298
L      AQD6.K=AQD6.J+(DT)(1/TAQD)(QD6.J-AQD6.J)                     299
L      AQD7.K=AQD7.J+(DT)(1/TAQD)(QD7.J-AQD7.J)                     300
C      TAQD=2 WEEKS                                                 301
NOTE
NOTE
NOTE   INITIAL CONDITIONS
NOTE                                        INITIALIZATION FOR
NOTE                                        SECTOR NO.  EQUATION NO.
N      PT=18.7E6                                     1              1
N      WI=1                                          2             37
N      CR=108.8E6                                    3             46
N      FUTD=0                                        3             47
N      AGP=GP                                        4             63
N      CP=0                                          4             66
N      AFU=FU1+FU2+FU3+FU4+FU5+FU6+FU7               5             68
N      FU1=1210339.8                                 5             70
N      FU2=71891.5                                   5             71
N      FU3=97593.5                                   5             72
N      FU4=386404.1                                  5             73
N      FU5=119703.9                                  5             74
N      FU6=70467.9                                   5             75
N      FU7=77305.2                                   5             76
N      ATRA=(AT)(CS)-(.15)(AT)(CS)                   6            104
N      AA=ATS                                        6            108
N      MNR1=.105654                                  7            124
N      MNR2=.410560                                  7            125
N      MNR3=.145009                                  7            126
N      MNR4=.560814                                  7            127
N      MNR5=.516743                                  7            128
N      MNR6=1.043205                                 7            129
```

N	MNR7=.523586	7	130
N	WP=0	7	156
N	FOB1=.862362	7	176
N	FOB2=.660564	7	177
N	FOB3=.688240	7	178
N	FOB4=.911312	7	179
N	FOB5=.856507	7	180
N	FOB6=1.278780	7	181
N	FOB7=.918408	7	182
N	SFOB=AFOB	7	199B
N	I1=(1.3)(AQD1)	8	218
N	I2=(1.2)(AQD2)	8	219
N	I3=(3.7)(AQD3)	8	220
N	I4=(.5)(AQD4)	8	221
N	I5=(1.3)(AQD5)	8	222
N	I6=(1.2)(AQD6)	8	223
N	I7=(3.7)(AQD7)	8	224
N	RP1=RPS1	9	256
N	RP2=RPS2	9	257
N	RP3=RPS3	9	258
N	RP4=RPS4	9	259
N	ARP1=RP1	9	264
N	ARP2=RP2	9	265
N	ARP3=RP3	9	266
N	ARP4=RP4	9	267
N	IP5=XFOB5	9	272
N	IP6=XFOB6	9	273
N	IP7=XFOB7	9	274
N	XQD1=QD1	10	290A
N	XQD2=QD2	10	290B
N	XQD3=QD3	10	290C
N	XQD4=QD4	10	290D
N	XQD5=QD5	10	290E
N	XQD6=QD6	10	290F

```
N      XQD7=QD7                                        10         290G
N      POP=184.8E6                                     10         291
N      AQD1=QD1                                        10         294
N      AQD2=QD2                                        10         295
N      AQD3=QD3                                        10         296
N      AQD4=QD4                                        10         297
N      AQD5=QD5                                        10         298
N      AQD6=QD6                                        10         299
N      AQD7=QD7                                        10         300
NOTE
NOTE
NOTE   PRINT AND PLOT INSTRUCTIONS
NOTE
NOTE
PRINT  1)PT(6.3)/2)WI(0.2)/3)CR(0.0)/4)CP(6.0)/5)SFOB(0.2)/6)NCA(5.1)/7)C
X1     LF(6.1)/8)ATRA(6.3)/9)ATR(0.0)/10)ATS(0.0)/11)CATR(6.3)/12)CATS(6.
X2     3)
SPEC   DT=.5/LENGTH=1300/PRTPER=52
RUN    LIST          FLORIDA ORANGE SUBSECTOR MODEL
```

APPENDIX C

Derivation of Marginal

Net Revenue Relationships

DERIVATION OF MARGINAL NET REVENUE RELATIONSHIPS

The keystone of the allocation procedure was the ability of processors to evaluate the marginal net revenues of orange products and adjust prices. Given retail demand equations, retail-wholesale price margins, conversion factors and cost functions, it was possible to derive the marginal net revenue of each product as a function of FOB prices and other variables. Comparison of the marginal net revenue estimates generated with these functions provided a basis for relative price adjustments among product-markets.

Demand relationships implicit in the model were expressed in matrix notation as follows:

$$Q = ZA\ [DE + BP]$$

where: Q denotes a vector of quantities demanded

Z denotes a scalar equal to U.S. population

A denotes a diagonal matrix of advertising influences

D denotes a matrix of demand intercepts and coefficients

E denotes a vector which includes a seasonal demand shifter

B denotes a matrix of FOB price coefficients

P denotes a vector of FOB prices

Total revenue to the processor group was expressed as:

$$R = P'Q$$

Defining $\underline{A} = ZA$ and assuming $|\underline{A}B| \neq 0$, total revenue becomes:

$$R = Q'(\underline{A}^{-1})'(B^{-1})'Q - E'D'(B^{-1})'Q$$

Marginal revenue was:

$$\frac{\partial R}{\partial Q} = 2(\underline{A}^{-1})'(B^{-1})'Q - B^{-1}DE$$

Assuming linear total cost functions (see Table E-5), total variable cost was expressed as follows:

$$C = KQ$$

where: C denotes a vector of total variable costs, and

K denotes a vector of cost coefficients.

Marginal cost was equal to the derivative of total cost with respect to quantity:

$$\frac{\partial C}{\partial Q} = K'$$

Net marginal revenue was equal to marginal revenue less marginal cost:

$$M = 2(\underline{A}^{-1})'(B^{-1})'Q - B^{-1}DE - K'$$

where: M denotes a vector of marginal net revenues.

Solving for net marginal revenue in terms of price, the relationship becomes:

$$M = 2(\underline{A}^{-1})'(B^{-1})'\underline{A}DE + 2(\underline{A}^{-1})'(B^{-1})'\underline{A}BP - B^{-1}DE - K'$$

If $\underline{A}$ and B are diagonal, $(\underline{A}^{-1})'(B^{-1})'\underline{A} = B^{-1}$ and the expression reduces to:

$$M = B^{-1}DE - K' + 2P$$

The derived relationships are presented in Table C-1.[1]

Solution in terms of price yields:

$$P = .5\ (K' - B^{-1}DE + M)$$

---

[1]If the demand equations include cross price-quantity relationships among orange products, the B matrix will be nondiagonal. In the initial calculation of marginal net revenue relationships, cross product terms were present in some equations. However, once marginal net revenue relationships had been derived, weaknesses in the empirical demand equations became apparent and the decision was made to remove cross product terms and adjust intercepts to reflect mean values.

See Table C-2 for the derived relationships.

Table C-1. Derived relationships between marginal net revenue and FOB price.

Relationship[a]						
MNR1	=	-1.619070	+	2FOB1	+	.086948DS
MNR2	=	- .910568	+	2FOB2	+	.006138DS
MNR3	=	-1.231471	+	2FOB3	-	.004729DS
MNR4	=	-1.261810	+	2FOB4		
MNR5	=	-1.196271	+	2FOB5		
MNR6	=	-1.514355	+	2FOB6		
MNR7	=	-1.313230	+	2FOB7		

[a]See Appendix A for definitions of variables.

Table C-2. Derived relationships between FOB price and marginal net revenue.

Relationship[a]					
FOB1	=	.809535	+	.5MNR1	-.043474DS
FOB2	=	.455284	+	.5MNR2	-.003069DS
FOB3	=	.615736	+	.5MNR3	+.002365DS
FOB4	=	.630905	+	.5MNR4	
FOB5	=	.598136	+	.5MNR5	
FOB6	=	.757177	+	.5MNR6	
FOB7	=	.656615	+	.5MNR7	

[a]See Appendix A for definition of variables.

APPENDIX D

DYNAMO Equations for the

Alternative Advertising Policy

DYNAMO EQUATIONS FOR THE ALTERNATIVE ADVERTISING POLICY

The model with the alternative advertising option included may be reconstructed by replacing equations 59, 60, 62, 100 and 105 from Appendix B with the equations listed below. When AP is set equal to zero, the alternative advertising proposal is operative. When AP is nonzero, the structure of the advertising sector is the same as presented in Chapter IV except that advertising costs are variable and accounted for in grower costs rather than on-tree prices (equations 59, 60, and 62) and administrative costs are compounded at five percent per year (equation 100C).

A	GC.K = (.85/WI.K) + VC.K	59
L	VC.K = ATR.JK/TFU.J	60
C	OTPT* = .13/1.10/2.06/3.04/4.00/4.96	62
R	$\text{ATR.KL} = \begin{cases} \text{XATR.JK} & \text{if AP} = 0 \\ & \text{or} \\ \text{YATR.JK} & \text{if AP} \neq 0 \end{cases}$	100
C	$\text{AP} = \begin{cases} 0 & \text{if the alternative advertising proposal is operative} \\ & \text{or} \\ 1 & \text{if the alternative advertising proposal is inoperative} \end{cases}$	100A
R	YATR.KL = (FU1.JK + FU2.JK + FU3.JK + FU4.JK + FU5.JK + FU6.JK + FU7.JK)(AT.K) - (AC)(CE.K)	100B
R	XATR.KL = [(TR.K + ARA.K)/52] - (AC)(CE.K)	100C
A	$\text{TR.K} = \begin{cases} \text{TR1.K} & \text{if ACS.K} \geq \text{230E6} \\ & \text{or} \\ \text{TR2.K} & \text{if ACS.K} < \text{230E6} \end{cases}$	100D

A $TR1.K = (2.6E6)(CE.K) + (.05)(ACS.K) + (.00003)(SACS.K) + 6.9E6$ 100E

A $TR2.K = \begin{cases} TR3.K & \text{if } ACS.K \geq 77E6 \\ \text{or} & \\ TR4.K & \text{if } ACS.K < 77E6 \end{cases}$ 100F

A $TR3.K = (2.6E6)(CE.K) + (.11)(ACS.K) - (.00007)(SACS.K)$ 100G

A $TR4.K = (2.6E6)(CE.K) + (.06)(ACS.K) - (.0001)(SACS.K)$ 100H

A $ARA.K = \begin{cases} YARA.K & \text{if } A.K = 0 \\ \text{or} & \\ XARA.K & \text{if } A.K \neq 0 \end{cases}$ 100I

L $A.K = YPP.JK$ 100J

L $YARA.K = ARA.J$ 100K

A $XARA.K = \begin{cases} 0 & \text{if } ATRA.K \geq 3.8E6 \\ \text{or} & \\ RA.K & \text{if } ATRA.K < 3.8E6 \end{cases}$ 100L

A $RA.K = (.02)(CS.K)$ 100M

A $ACS.K = (CS1.K + CS2.K + CS3.K + CS4.K + CS5.K)/5$ 100N

A $SACS.K = [(CS1.K)(CS1.K) + (CS2.K)(CS2.K) + (CS3.K)(CS3.K) + (CS4.K)(CS4.K) + (CS5.K)(CS5.K)]/5E6$ 100Ø

A $CS1.K = \begin{cases} XCS1.K & \text{if } A.K = 0 \\ \text{or} & \\ CS.K & \text{if } A.K \neq 0 \end{cases}$ 100P

L $XCS1.K = CS1.J$ 100Q

A $CS2.K = \begin{cases} XCS2.K & \text{if } A.K = 0 \\ \text{or} & \\ XCS1.K & \text{if } A.K \neq 0 \end{cases}$ 100R

L $XCS2.K = CS2.J$ 100S

A $CS3.K = \begin{cases} XCS3.K & \text{if } A.K = 0 \\ \text{or} & \\ XCS2.K & \text{if } A.K \neq 0 \end{cases}$ 100T

L $XCS3.K = CS3.J$ 100U

A $CS4.K = \begin{cases} XCS4.K & \text{if } A.K = 0 \\ \text{or} & \\ XCS3.K & \text{if } A.K \neq 0 \end{cases}$ 100V

L XCS4.K = CS4.J 100W

A $$CS5.K = \begin{cases} XCS5.K & \text{if } A.K = 0 \\ \text{or} & \\ XCS4.K & \text{if } A.K \neq 0 \end{cases}$$ 100X

L XCS5.K = CS5.J 100Y

L CATR.K = CATR.J + (DT)(ATR.JK - ATRD.J) 100Z

A XATRD.K = PULSE(CATR.K, 52, 52) A100Z

A ATRD.K = XATRD.K/DT B100Z

A CE.K = EXP(LCE.K) 101A

A LCE.K = (YP.K)LOGN(1.05) 101B

L YP.K = YP.J + YPP.JK 101C

R YPP.KL = PULSE(1, 52, 52) 101D

R YATS.KL = (ATRA.K)(FSPW.K) 105A

R XATS.KL = MAX(ZATS.K, 0) 105B

A ZATS.K = [(TE.K)(SA.K)/52] - (AC)(CE.K) 105C

A SA.K = TABHL(SAT, WP.K, 1, 52, 1) 105D

C SAT* = 1.1112/ . . . /1.1112/1.3332/ . . . /
1.3332/1.1112/ . . . /1.1112/.4444/
. . . /.4444 105E
(where / . . . / represents 11 elements
with the value indicated)

A $$TE.K = \begin{cases} TE1.K & \text{if } CS.K \geq 230E6 \\ \text{or} & \\ TE2.K & \text{if } CS.K < 230E6 \end{cases}$$ 105F

A TE1.K = (2.6E6)(CE.K) + (.05)(CS.K) + [(.00003)
(CS.K)(CS.K)/1E6] 105G

A $$TE2.K = \begin{cases} TE3.K & \text{if } CS.K \geq 77E6 \\ \text{or} & \\ TE4.K & \text{if } CS.K < 77E6 \end{cases}$$ 105H

A TE3.K = (2.6E6)(CE.K) + (.11)(CS.K) - [(.00007)
(CS.K)(CS.K)/1E6] 105I

A TE4.K = (2.6E6)(CE.K) + (.06)(CS.K) - [(.0001)
(CS.K)(CS.K)/1E6] 105J

L	CATS.K = CATS.J + (DT)(ATS.JK - ATSD.J)	107A
A	XATSD.K = PULSE(CATS.K, 52, 52)	107B
A	ATSD.K = XATSD.K/DT	107C

Initial Conditions

		Sector	Equation Number
N	VC = .10	4	60
N	A = 0	6	100J
N	YARA = 0	6	100K
N	XCS1 = CS	6	100Q
N	XCS2 = CS	6	100S
N	XCS3 = CS	6	100U
N	XCS4 = CS	6	100W
N	XCS5 = CS	6	100Y
N	CATR = 0	6	100Z
N	YP = 0	6	101C
N	CATS = 0	6	107A

APPENDIX E

Miscellaneous Data

Table E-1. Florida orange products: crop utilization, advertising tax rates and estimates of receipts, administrative costs, and advertising expenditutes for generic advertising, 1962-63 through 1970-71 seasons.

Season	Crop utilization		Advertising tax rate		Estimated generic advertising[a]		
	Fresh	Processed	Fresh	Processed	Receipts	Administrative cost	Expenditures
	(thousand boxes)		(cents/box)		(thousand dollars)		
1962-63	10,174	62,326	9	9	6,525	979	5,546
1963-64	9,669	45,231	9	9	4,941	741	4,200
1964-65	13,124	69,276	10	8	6,854	1,028	5,826
1965-66	13,059	82,841	10	8	7,933	1,190	6,743
1966-67	15,385	124,115	10	8	11,468	1,720	9,748
1967-68	14,987	85,513	10	8	8,340	1,251	7,089
1968-69	9,840	119,860	10	8	10,573	1,586	8,987
1969-70	9,491	128,209	10	8	11,206	1,681	9,525
1970-71	9,648	132,652	10	10	14,230	2,135	12,095

[a]These estimates were based on budget information from [6].

Table E-2. Mean generic advertising expenditure levels during base data periods associated with estimated demand relationships.

Product	Market	
	Retail	Institutional
	(thousand dollars per year)	
FCOJ	9,424	5,590
COJ	9,424	5,590
CSSOJ	9,424	5,590
Fresh oranges	5,546	a

Source: Calculated from estimates of generic advertising expenditures.

[a] Not applicable.

Table E-3. Proportional[a] retail sales of processed orange products for various generic advertising expenditure levels.[b]

Advertising	Proportional retail sales		
	FCOJ	COJ	CSSOJ
(dollars/week)			
45,127	.965	.942	.951
68,324	.972	.956	.974
97,140	.980	.971	.991
115,988	.985	.979	.998
181,231	1.000	1.000	1.000
188,843	1.002	1.002	1.000
225,633	1.007	1.014	.996
264,597	1.011	1.022	.988
291,601	1.014	1.038	.985

Source: Based upon relationships derived from information obtained from [12].

[a]Sales are proportional to what they were when average advertising expenditures were $181,231 per week.

[b]The relationship assumes the advertising expenditure was optimally allocated among advertising media.

Table E-4. Proportional[a] retail sales of fresh Florida oranges for various generic advertising expenditure levels.[b]

Advertising	Proportional retail sales
(dollars/week)	
23,037	.712
24,424	.733
26,237	.754
31,996	.782
52,794	.870
101,641	.991
106,654	1.000
154,222	1.082
201,576	1.136

Source: Based upon relationships derived from information obtained from [12].

[a]Sales are proportional to what they were when average advertising expenditures were $106,654 per week.

[b]The relationship assumes the advertising expenditure was optimally allocated among advertising media.

Table E-5. Total cost relationships for selected Florida orange products.

Product	Relationships[a]
FCOJ	$C_1 = 119.210220 + .242545\ Q_1$
COJ	$C_2 = 23.649570 + .17704\ Q_2$
CSSOJ	$C_3 = 25.302520 + .37488\ Q_3$
FO	$C_4 = 53.076980 + .19107\ Q_4$

Source: [25, p. 103].

[a] C_I = total cost of the I^{th} product (million dollars)

Q_I = millions of gallons single strength equivalent of the I^{th} product

Table E-6. Percentage of processed Florida orange products going to retail and institutional markets, average 1963-64 through 1965-66 seasons.

Product	Market	
	Retail	Institutional
	(percent)	
FCOJ	88.33	11.67
COJ	50.33	49.67
CSSOJ	53.00	47.00

Source: Calculated from information obtained from [25, Appendix C].

Table E-7. Movement of processed Florida orange products, 1970-71 season.

Product	Quantity
	(million gallons single strength equivalent)
FCOJ	402.9
COJ	110.1
CSSOJ	38.4

Source: Based on movement figures obtained from [3, 1970-71 season, pp. 30, 46, 47].

Table E-8. Institutional sales of Florida orange products by type of outlet, 1970-71 season.

Product	Outlet		Total
	Commercial restaurants	Other	
	(million gallons single strength equivalent)		
FCOJ	29.72	12.18	41.9
COJ	31.59	23.11	54.7
CSSOJ	10.53	7.47	18.0

Source: Commercial restaurant sales were obtained from [1]. Total institutional sales of FCOJ were obtained from [3, 1970-71 season, p. 30]. Total institutional sales of COJ and CSSOJ were estimated by multiplying movement from Table E-7 by the percentage of product going to institutional markets from Table E-6.

Table E-9. Sales of Florida orange products by type institution as a percent of total institutional sales.

Product	Type institution: Customer oriented	Type institution: Noncustomer oriented
	(percent)	
FCOJ	71	29
COJ	58	42
CSSOJ	58	42

Source: Table E-8.

APPENDIX F

A Note on the Calculation of Present Values and the Variance of Present Values

A NOTE ON THE CALCULATION OF PRESENT VALUES AND THE VARIANCE OF PRESENT VALUES

A FORTRAN program was used to perform these calculations. This program read edited output from the DYNAMO model, formed arrays and made calculations for each of the three variables considered in the policy analysis.

Average values for the five weather replications were computed with the equation

$$S = B\ A$$

where:

S - a 1 x 25 vector of means.

B - a 1 x 5 vector with each element equal to .20.

A - a 5 x 25 matrix containing values for one of the three variables used in the policy analysis.

The FORTRAN program formed three separate A matrices, one each for grower profit, average FOB price and crop size. Each matrix contained 125 elements (A_{ij}'s), where i = 1, . . . , 5 represented the five weather replications and j = 1, . . . , 25 represented the twenty-five years of the simulation.

Present values of S and A were computed with equations

$$E = S\ R$$

$$D = A\ R$$

where:

E - a scalar representing the present value of S.

R - a 25 x 1 column vector of discount values (7%). The t^{th} element of the vector $R_t = \frac{1}{(1 + .07)^t}$.

D - a 5 x 1 column vector of present values for each weather replication.

The variances of the present values were computed as follows:

$$W = \frac{1}{n - 1} [A'A - \frac{A'ZZ'A}{n}]$$

$$V = R' W R$$

n = 5, representing the number of weather replications.

Z - a 5 x 1 sum vector.

W - a 25 x 25 variance - covariance matrix.

V - a scalar representing the variance of E.

BIBLIOGRAPHY

[1] Audits and Surveys, Inc., National Sample Census of Product Usage in Commercial Restaurants, New York, 1971.

[2] Chern, Wen-Shyong, "Determination of the Optimum Number, Size and Location of Orange Packing and Processing Plants in Florida," Master's thesis, University of Florida, 1969.

[3] Florida Citrus Mutual, Annual Statistical Report, Lakeland, 1962-63 through 1971-72 annual reports.

[4] Florida Crop and Livestock Reporting Service, Florida Agricultural Statistics: Citrus Summary, Orlando, 1965 through 1968 annual reports.

[5] ___________, Florida Agricultural Statistics: Commercial Citrus Inventory, Orlando, December 1970.

[6] Florida Department of Citrus, Statement of Receipts and Expenditures, Lakeland, 1962-63 through 1970-71 annual reports.

[7] Forrester, Jay, Industrial Dynamics, Cambridge, Massachusetts Institute of Technology Press, 1965.

[8] Hall, L. W., "An Analysis of the U.S. Regional Demands and Marketing Costs for Selected Florida Processed Citrus Products," Master's thesis, University of Florida, 1971.

[9] Jarmain, W. E. C., "Dynamics of the Florida Frozen Orange Concentrate Industry," Master's thesis, Massachusetts Institute of Technology, September 1962.

[10] Langham, Max R., "On-Tree and In-Store Citrus Price Relationships," Proceedings of the Second Annual Citrus Business Conference, Florida Citrus Commission, Lakeland, November 1965.

[11] ___________, "Toward Improving Performance of a System Through Participatory Decisions," unpublished paper, University of Florida, 1969.

[12] McClelland, E. L., Leo Polopolus and Lester H. Myers, Optimal Allocation of the Florida Citrus Industry's Generic Advertising Budget, Agricultural Economics Report 20, Florida Agricultural Experiment Stations, University of Florida, April 1971.

[13] Myers, Lester H., Proposal for Funding the State of Florida Department of Citrus, Florida Department of Citrus, Gainesville, November 1969.

[14] __________, The Consumer Demand for Orange Beverages, Florida Citrus Commission Report No. FCC-ERD-69-1, Lakeland, August 1969.

[15] Naylor, Thomas H., Computer Simulation Experiments with Models of Economic Systems, New York, John Wiley and Sons, Inc., 1971.

[16] Parvin, E. W., Jr., "Effects of Weather on Orange Supplies," Ph.D. dissertation, University of Florida, 1970.

[17] Polopolus, Leo, and W. E. Black, Synthetics and Substitutes and the Florida Citrus Industry, Florida Citrus Commission Report No. FCC-ERD-66-4, Lakeland, April 1966.

[18] Powe, C. E., "A Model for Evaluating Alternative Policy Decisions for the Florida Orange Subsector of the Food Industry," The American Economist, 16:66-75, Fall 1972.

[19] Priscott, R. H., "Demand for Citrus Products in the European Market," Master's thesis, University of Florida, 1969.

[20] Pugh, Alexander L., III, DYNAMO II User's Manual, Cambridge, Massachusetts Institute of Technology Press, 1970.

[21] Raulerson, Richard C., "A Study of Supply-Oriented Marketing Policies for Frozen Concentrated Orange Juice: An Application of Dynamo Simulation," Master's thesis, University of Florida, June 1967.

[22] Spurlock, A. H., Costs of Processing, Warehousing and Selling Florida Citrus Products, Agricultural Economics Mimeo Report, Florida Agricultural Experiment Stations, University of Florida, 1962-63 through 1971-72 annual reports.

[23] Tax Reform Act of 1969, P. L. 91-172, Sec. 216, 83 U.S Statute, December 1969, p. 487.

[24] Theil, H., Applied Economic Forecasting, Amsterdam, North Holland Publishing Co., 1966.

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

[26] Weisenborn, D. E., W. W. McPherson and Leo Polopolus, Demand for Florida Orange Products in Foodstore, Institutional, and Export Market Channels, Florida Agricultural Experiment Stations Bull. 737, University of Florida, May 1970.

[27] __________, Market Allocation of Florida Orange Production for Maximum Net Returns, Florida Agricultural Experiment Stations Bull. 736, University of Florida, March 1970.

BIOGRAPHICAL SKETCH

Charles Everitt Powe was born December 29, 1942, in Waynesboro, Mississippi. He attended the public schools of Wayne County, Mississippi, and graduated from Waynesboro High School in May, 1960. Shortly thereafter, he entered Mississippi State University, and received the degree Bachelor of Science, with honors, in June, 1964. From September, 1964, until June, 1966, he attended the graduate school of Mississippi State University, where he earned the degree Master of Science. In September, 1966, he enrolled in the graduate school of the University of Florida. Since that time, he has pursued a program of work toward the degree Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Max R. Langham

Max R. Langham, Chairman
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Leo Polopolus

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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