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An Analysis of Economic Relationships and Projected Adjustments in the U.S. Processing Tomato Industry

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FOREWORD

This is the second report of a two-part study of the economics of the processing tomato industry. The first report, primarily descriptive in nature, dealt with the structural characteristics and economic performance of the industry over the past 25 years. This report formulates an econometric model of the processing tomato economy. The study differs from another recently published econometric analysis of the tomato industry by Chern and Just (1978) in that it includes estimates of demand relationships for processed products and is broader in its area of coverage. It also develops an alternative formulation of the grower supply and processor demand structure for the raw product component. The model is used as a framework for projecting future levels of industry production and prices and for further evaluation of the economic impact of mechanical harvesting and other technological developments.

Both reports in this series are extensions of research results reported in Brandt's doctoral dissertation (1977). Most of the work was supported by a research agreement between the California Agricultural Experiment Station and the Economics and Statistics Service, U. S. Department of Agriculture.

TABLE OF CONTENTS

LIST OF TABLES

SUMMARY

This study formulates a dynamic econometric model of the U. S. processing tomato industry. The behavioral elements of the model consist of processed product demand equations facing processors, processor market allocation equations, raw product demand equations facing growers, and grower supply equations. The primary focus is on California but included are grower price and acreage equations for the Midwest and East. The processed product demand and market allocation equations involve a block of five sets of simultaneously determined equations—one set for each of the five major commodity forms. The California processor raw product demand and grower supply equations form another block of simultaneous equations. The Midwest and East grower price and acreage equations are sequentially linked to California adjustments through a price relationship.

The estimates of supply and demand equations, which are the basis for the model, are all consistent with theoretical expectations; and the estimates of equation coefficients are generally within acceptable bounds of statistical significance. Altogether, the model consists of 56 endogenous and 14 exogenous variables.

Estimation Results

The most significant of the estimation results of the model can be summarized as follows:

1. The demands for the more concentrated tomato products (catsup and paste) at the f.o.b. processor level are inflexible with respect to quantity.[1] (Puree demand price flexibility was not estimated.) The demands for canned tomatoes and tomato juice are flexible with respect to quantity.

2. Processors' supply allocations to the domestic market for the five processed products are all inelastic with respect to price.

3. Processor demand for the raw product is inelastic when estimated with quantity as the dependent variable. Lagged composite processed product price, deflated income, inventories, and the influence of the growers' bargaining association were all found to be important variables in explaining processor derived demand.

4. Grower short–run supply was estimated to be inelastic with respect to price. Explanation of grower behavior was improved through the incorporation of a partial adjustment model. The adjustment coefficient was estimated to range from .30 to .40, indicating a slow–to–moderate grower adjustment process. Long–run supply elasticity was substantially greater than in the short run.

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[1]Price flexibility is the percentage change in price associated with a given percentage change in quantity. Demand is said to be flexible when the absolute value of the price flexibility is greater than 1.0 and inflexible for values less than 1.0.

Applications of the Model

The industry model provides a tool that may be used to aid in a short–run prediction, to analyze economic performance, and to evaluate potential impacts of changes in exogenous variables on industry development and growth.

Because of the considerable amount of residual variation which remains unexplained by the behavioral equations, the model does not predict year–to–year variation in prices and outputs with great precision. Nevertheless, the estimates of processed product demand slopes, inventory effects, market allocation relationships, and processor demand and grower supply relationships provide a framework within which short–term forecasts may be evaluated. The unexplained disturbances which affect the accuracy of the short–run forecasts are of less concern with respect to evaluating longer term adjustments since they tend to average out. An interesting behavioral characteristic of the industry, also revealed by the study, is the tendency for both inventories and average processor margins to vary cyclically.

An economic performance issue of great public interest and controversy has been the economic and social consequences of the adoption of mechanical harvesting of processing tomatoes. The industry model provides a more rigorous and detailed method of evaluating these consequences than has been available heretofore. The model is used to make comparative estimates of output, employment, and prices with and without the development of mechanized harvesting. Since supply conditions were altered by the termination of the Bracero Program about the time mechanized harvesting began, the effects of several alternative labor cost scenarios are examined.

The model shows that total industry employment was greater after the full adoption of mechanized harvesting than before mechanization. This, however, reflects a response to greatly expanded demand as well as mechanization. When the effects of mechanization are isolated, the model predictions indicate that, even under the most restrictive (high cost) labor scenario considered, total harvest season labor employment would have been greater with a continuation of hand–harvest methods. This has been offset to a considerable degree by growth in cannery and assembly labor employment as a result of greater output induced by mechanization, but total employment is shown to be less under mechanization for all the scenarios considered. Balanced against the labor displacement under mechanization is a reduction in consumer prices compared to hand harvest of from 5 to 15 percent and a shift in the distribution of employment toward higher paying and less physically demanding jobs.

Another application of the model was as a tool for economic projection. The procedure was first to solve the model to obtain long–run multipliers. These are coefficients which predict how a one–unit change in an exogenous variable, with other exogenous variables constant, affects the final values of endogenous variables after the system has stabilized. Since the endogenous variables tend to converge quickly to values near their stationary equilibrium values, the long–run values predicted by the multipliers are not far from interim period values. The long–run multipliers then provide a means of evaluating and separating the effects of conditionally considered changes in exogenous variables.

The first application of the multiplier analysis was to evaluate the impact of the addition of electronic sorting to the mechanical harvester. Using data from a recent study of harvesting cost, the model indicates that the effect of electronic sorting on grower price is modest, and the effect on industry output is surprisingly low. However, it has a substantial impact on employment. Labor displacement with full adoption of electronic sorting is projected at between roughly 4,400,000 and 5,400,000 hours of labor per year (8,800 to 10,800, 10–week jobs). This is not as large as the estimated displacement of seasonal labor due to the initial adoption of the mechanical harvester. The latter is estimated at near 20,000,000 labor hours by 1977. However, seasonal labor displacement from the initial harvester adoption was offset by the creation of new cannery and assembly jobs to a much greater extent than will be the case for the electronic sorter.

An evaluation of other plausible gains in production and processing efficiency indicates that their potential impacts on industry output and prices are likely to be small relative to potential expansion in response to population growth and, possibly, continued growth in per capita demand. Summing these potential effects, the model suggests that California's average acreage could expand by up to 60,000 acres in the next decade, but a figure about half that may be more likely.

The projected adjustments to changes in technology suggest that most, but not all, efficiency gains would be passed on to consumers in the form of reduced prices. However, the price–lowering effects of efficiency gains likely would be offset by price–increasing effects of expanded population and market demand, leaving the real (deflated) prices not greatly changed.

AN ANALYSIS OF ECONOMIC RELATIONSHIPS AND PROJECTED ADJUSTMENTS IN THE U. S. PROCESSING TOMATO INDUSTRY

by

Jon A. Brandt[1] and Ben C. French[2]

1. INTRODUCTION

Tomatoes are the most important vegetable grown for processing in the United States (excluding potatoes), and California is the most important producing state. In the period since the early 1950s, the output of this industry increased from an annual average of 3.4 million tons valued at $98.1 million (1950–1953) to nearly 7 million tons valued at $467 million during 1976–1979.[3] This growth has been associated with major changes in the location of production, in production and processing technology, in the employment of labor, in the demand for various processed tomato products, and in the industry structure. The likelihood of continued change in factors affecting demand and supply make future planning and decision making especially difficult for both producers and processors.

This report describes the formulation and estimation of an econometric model of the tomato industry and its use as a tool for planning and for evaluating the impacts of some of the technological and structural developments which have occurred and still are occurring. The model is a mathematical representation of the processes by which producer and processor prices and quantities are determined. It consists of three types of equations: (1) supply and allocation equations which relate quantities produced or made available for sale to prices and to supply-shifting variables such as costs and inventories; (2) demand equations which relate quantities purchased by consumers, processors, and marketing groups to prices and to demand-shifting variables such as income and population; and (3) identities or technical relationships which tie the equations together to form a complete system.

No econometric model can fully represent all of the adjustment detail and all of the horizontal, vertical, spatial, and temporal dimensions of an industry. The objective here is to provide a framework for estimating how the major *endogenous* price and quantity variables are related and how they are influenced by changes in the values of key *exogenous* factors which affect levels of demand and supply. Economic influences which cannot be captured by the behavioral equations or as technical restrictions are reflected as random errors or disturbances. Thus, the predictions of the model are in the form of expected values of variables from some probability distribution of actual values.

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[1]Assistant Professor, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana.

[2]Professor of Agricultural Economics and Agricultural Economist in the Experiment Station and on the Giannini Foundation, University of California, Davis.

[3]Farm value, measured at the processing plant door; for data sources, see Appendix tables, *infra*, p. 80.

The model development proceeds in two stages. The first step is to formulate hypotheses about the kinds of economic relationships required to model the system and the variables to be included. Most such relationships are obtained from generally accepted theories of economic behavior. However, several aspects, such as the formation of price expectations and lags in adjustment processes, may plausibly assume a number of different forms. The modeler must choose among the alternative formulations in accordance with *a priori* theoretical considerations and statistical criteria.

The second step in the analysis involves empirical estimation of the parameters of the equations hypothesized to exist and testing and comparing the results obtained with alternative behavioral hypotheses. At this stage, the model development was further constrained by a lack of data pertaining to some of the variables believed to be important. It also turned out that some variables move so closely over time that it is difficult to separate their individual influences. Existence of these conditions has required additional simplification or aggregation of some components in the model.

Section 2 briefly describes some key characteristics of the structure and organization of the processing tomato industry. Section 3 develops the theoretical framework for the econometric model and suggests behavioral hypotheses to be tested. Section 4 describes the data used in the analysis. Section 5 reports the results of empirical estimation and testing of alternative model formulations. Section 6 summarizes the other complete model. Section 7 applies the model in a simulation framework to evaluate the impacts of mechanical harvesting developments on output and employment. Section 8 uses the model as a base to evaluate the further impacts of the electronic sorter and to explore potential future impacts of changes in exogenous variables such as population, income, and further technological progress. Section 9 provides a general evaluation of the analysis.

2. *STRUCTURE OF THE INDUSTRY*

Tomatoes for processing are grown primarily in three regions of the United States. California is the dominant producer with over 83 percent of U. S. production for the years 1976–1979. The midwestern states of Indiana, Ohio, and Michigan have accounted for another 10 percent, while the eastern states of Delaware, Maryland, Pennsylvania, Virginia, and New York have produced a little over 4 percent. The remaining production has been scattered among states in several other areas. The shares noted above may be contrasted with 1950–1952 shares of 48 percent for California, 19 percent for the Midwest, and 27 percent for the East.[1]

In the years prior to the mid–1960s, all tomatoes were hand picked and transported to canneries in lug boxes. Today all processing tomatoes in California are harvested mechanically and transported in bulk to the processing plants. Some mechanical harvesting of tomatoes is performed in the Midwest and East, but hand harvesting is still the most common form. At the canneries, tomatoes are converted into six major forms:

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[1]The characteristics of the tomato industry and its evolution during the past 30 years have been described at some length in King, Jesse, and French (1973); Brandt, French, and Jesse (1978); and Chern and Just (1978). Readers interested in the descriptive details are advised to refer to these reports. More recent extensions of production, acreage, and price data may be found in the Appendix tables at the end of this report.

(1) canned tomatoes,[1] (2) juice, (3) catsup and chili sauce, (4) puree, (5) paste, and (6) sauce and other products.[2] Since the harvest season is relatively short (extending mainly from late July to early October), processors accumulate large inventories of processed products which are then reduced by sales during the interval to the next harvest season.

The exchange structure in California has been altered somewhat in recent years by two developments. The first has been an increase in the share of tomatoes processed by associations of farmer cooperatives, currently estimated by industry sources to be near 40 percent. The second development has been the efforts of the California Tomato Growers Association (CTGA), beginning in 1974, to bargain with processors over prices and other terms of trade for its members. In 1979, roughly 70 percent of California tomato growers were members of the CTGA. These structural changes are examined further in the later analysis.

The flow of tomatoes and tomato products from producers to consumers and the interactions among the various stages in the system are illustrated in Figure 1.[3] The total commodity system may be divided into four major components: the grower subsystem, the processor subsystem, the marketing group subsystem, and the consumer group subsystem. In addition, several secondary groups are influenced by the behavior of the main groups. These include, but are not limited to, (1) suppliers of agricultural and nonagricultural inputs such as machinery, fertilizer, seed, and chemical companies as well as banks and credit institutions; (2) cannery and farm labor; (3) communities where tomatoes are produced or processed; and (4) governmental institutions. The influences of federal, state, and local governments on the system are reflected in various laws and policies among which are those regulating (1) pollution levels, (2) pesticide and herbicide use, (3) labor practices and minimum wage rates, (4) product grades and standards, and (5) import/export standards.

The solid rectangles in Figure 1 show the product flow, and the broken rectangles indicate the influence of major exogenous or predetermined variables on the product output and movement. The circles show the interaction and feedback effects of the price variables. The division between year t and year t – 1 illustrates the delayed effects of changes in the values of some of the variables affecting output decisions.

Beginning with the grower subsystem at the bottom of Figure 1, the levels of planted and harvested acreage are affected by the contract price, costs of production, weather conditions, and acreage planted in previous years. The expected profitability levels of alternative crops may also influence the production of tomatoes. The price received by growers is shown to be jointly determined (by the dual directional arrows) with processors' demand for raw tomato production. Through the feedback process, prices at higher levels of the market channel (e.g., f.o.b.) send signals to the grower level.

Processors receive and pack the raw tomatoes into the various product forms illustrated in the center of the diagram. This allocation process is based on expected sales and price levels for the next market period and is also affected by plant operating costs and capacity. Canners distribute their finished products either to domestic sales, export sales,

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[1]Includes whole–round, pear–shaped, and specialty packs such as wedges, sliced, diced, and crushed.

[2]Includes specialized pack items such as tomato aspic, fish sauce, cocktail sauce, pizza sauce, spaghetti sauce, and tomato soup.

[3]To simplify the presentation, regional components have been excluded from the diagram and are discussed in later sections of the model development.

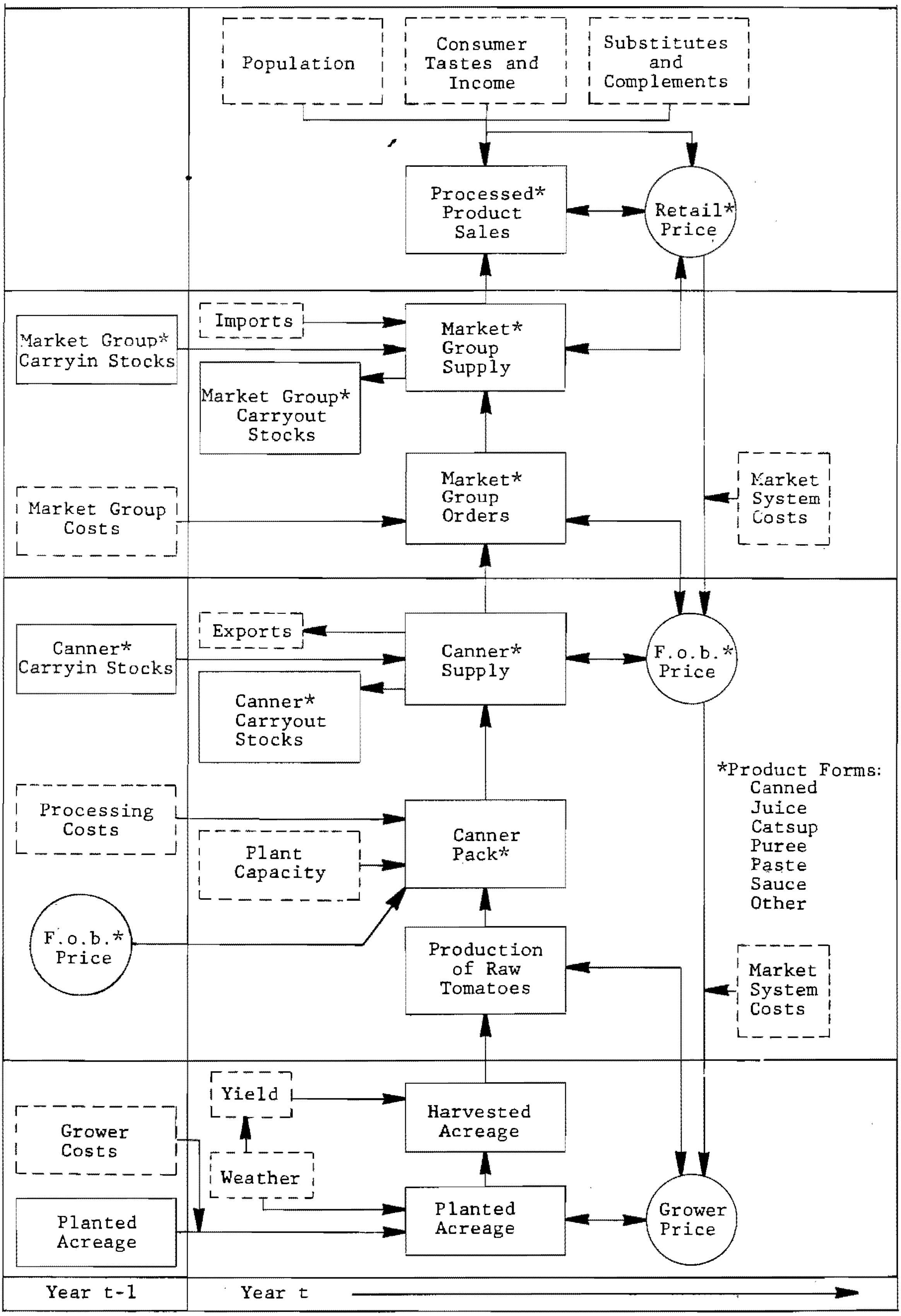

FIGURE 1. Structure of the Processing Tomato Industry

or inventory carry–over. This allocation decision is influenced by current domestic f.o.b. prices, export prices, expected f.o.b. prices in future market periods, and inventory costs.

The marketing group distributes the processed products from the three major production regions to retail outlets and institutional and remanufacturing establishments located throughout the United States. Consumer demand is reflected directly through purchases of the products in their final form (e.g., juice, catsup, and sauce) and indirectly through purchases of prepared food items using tomato products as ingredients. Factors affecting demand include consumer tastes and preferences and disposable income, population, and the prices of competing and complementary products.

3. *THEORETICAL FRAMEWORK OF THE MODEL*

A completely general model of the system illustrated in Figure 1 would include demand functions facing retailers for each processed commodity in each consuming region, distribution cost functions between all producing and consuming regions, and grower supply functions and processor allocation and demand functions for each producing region. Since the data required to estimate such a multimarket, multilevel, multiproduct model are not available, it is necessary to restrict the scope of the model to include only a more limited and more aggregated set of relationships.

The model focuses only on the processor and grower subsystems. This does not preclude the formulation of a complete model since the f.o.b. demand functions facing processors are derived from consumer and distributor demands and contain as variables the major factors thought to influence consumer and distributor demand. The model predicts how changes in exogenous variables, such as population and input prices, affect endogenous variables such as total California and U. S. production, consumption of the various processed commodities, and processed product and grower prices. However, it is not formulated to predict interregional commodity flows or retail prices.

Outline of the Model Structure

The structure of the industry model is outlined in Table 1. The symbols used to identify the variables are defined at the end of the table, and the data series for all variables are given in the Appendix tables. In each of the behavioral equations, the variables listed to the right of the colon are treated as exogenous in this study, *i.e.*, their values are determined primarily by forces outside the tomato economy. Exogenous variables which appear in identities are placed within parentheses. Variables on the left of the colons are endogenous, *i.e.*, their values are determined as outcomes of the system for given values of the exogenous variables. For ease of later reference, all of the behavioral relationships are expressed with one of the endogenous variables as the dependent (normalized) variable. As noted below, however, the values of some of the current endogenous variables appearing in each equation are jointly determined. The variable on the left is the variable chosen for normalization in the simultaneous estimation procedure as described later.

The complete model consists of 16 behavioral equations and about 40 identities and technical relationships which are necessary to complete the system. For analytical and estimation purposes, the behavioral equations are grouped into three blocks.

Block I contains processed product demand equations facing processors for each of the five major commodity types [Table 1, equations (1), (6), (10), (14), and (18)] and processor market allocation equations for the same commodities [Table 1, equations (2),

TABLE 1

Structure of the Industry Model

Type of relationship	Variable structure
I. Processed Product Demand and Market Allocation	
Canned tomatoes (W)	
1. Demand	$PW_t = f_w (DW_t : DOV_t, Y_t, N_t, CPI_t, u_{wt})$
2. Market allocation	$AW_t = h_w [(QW_t + SW_t), PW_t, PW_{t-1} : N_t, CPI_t, v_{wt}]$
3. Consumption identity	$DW_t = AW_t + (IW_t)$
4. Inventory identity	$SW_{t+1} = SW_t + QW_t - AW_t - (EW_t)$
5. California stock prediction	$SWC_t = [QWC_{t-1}/QW_{t-1}]\ SW_t$
Tomato juice (J)	
6. Demand	$PJ_t = f_j (DJ_t : N_t, CPI_t, VJ_t, T, u_{jt})$
7. Market allocation	$DJ_t = h_j [(QJ_t + SJ_t), PJ_t, PJ_{t-1} : N_t, CPI_t, v_{jt}]$
8. Inventory identity	$SJ_{t+1} = SJ_t + QJ_t - DJ_t - (EJ_t)$
9. California stock prediction	$SJC_t = [QJC_{t-1}/QJ_{t-1}]\ SJ_t$
Catsup and chili sauce (C)	
10. Demand	$PC_t = f_c (DC_t, SCC_t : Y_t, N_t, CPI_t, u_{ct})$
11. Market allocation	$DC_t = h_c [(QCC_t + SCC_t), PC_t, PC_{t-1} : N_t, CPI_t, v_{ct}]$
12. California sales prediction	$DCC_t = (KCC_t \cdot DC_t)$
13. Inventory identity	$SCC_{t+1} = SCC_t + QCC_t - DCC_t$
Tomato puree (U)	
14. Demand	$PU_t = f_u (DU_t, SU_t : Y_t, N_t, CPI_t, u_{ut})$
15. Market allocation	$DU_t = h_u [(QU_t + SU_t), PU_t, PU_{t-1} : N_t, CPI_t, v_{ut}]$
16. Inventory identity	$SU_{t+1} = SU_t + QU_t - DU_t$
17. California stock prediction	$SUC_t = [QUC_{t-1}/QU_{t-1}]\ SU_t$
Tomato paste (P)	
18. Demand	$PP_t = f_p (DP_t, SPIC_t : Y_t, N_t, CPI_t, u_{pt})$
19. Market allocation	$AP_t = h_p [(QPIC_t + SPIC_t), PP_t, PP_{t-1} : N_t, CPI_t, v_{pt}]$
20. Consumption identity	$DP_t = AP_t + (IP_t)$
21. California sales prediction	$DPIC_t = (KPC_t)\ [AP_t + (EP_t)]$
22. Inventory identity	$SPIC_{t+1} = SPIC_t + QPIC_t - DPIC_t$

(Continued on next page.)

TABLE 1—continued.

Type of relationship	Variable structure
II. California Grower Supply and Processor Raw Product Demand	
23. California acreage supply	$AC^s_t = f_{ac}\ (PGC_t, AC_{t-1}: YMAC_t, GCR_{t-1}, CPI_t, TC, v_{act})$
24. California quantity supply	$QCT^s_t = (YLDCP_t) \cdot AC^s_t$
25. Processor raw product demand	$QCTD_t = f_{qc}\ (PGC_t, PRW_{t-1}, S1T_t: Y_t, CPI_t, M_t, u_{qct})$
26. Observed processor purchases	$QCT^b_t = QCTD_t + (e_t)$
27. Processor demand for acreage	$AC^d_t = QCTD_t \div (YMAC_t)$
28. January 1 stock prediction	$S1T_t = f_s\ (QCTR_{t-1}, SCT_{t-1}: u_{st})$
29. Stock aggregation	$SCT_t = SWC_t/(h_w) + SJC_t/(h_j) + SUC_t/(h_u) + SCC_t/(h_c) + SPIC_t/(h_p)$
30. Allocation to product pack	
(a) Canned tomatoes	$QWC_t = (g_{wct}) \cdot (h_w) \cdot QCT_t$
(b) Juice	$QJC_t = (g_{jct}) \cdot (h_j) \cdot QCT_t$
(c) Catsup (institutional) and chili sauce	$QCC_t = (g_{cct}) \cdot (h_c) \cdot QCT_t$
(d) Puree	$QUC_t = (g_{uct}) \cdot (h_u) \cdot QCT_t$
(e) Paste (institutional)	$QPIC_t = (g_{pct}) \cdot (h_p) \cdot QCT_t$
(f) Total reported pack	$QCTR_t = QWC_t + QJC_t + QCC_t + QUC_t + QPIC_t$
III. Other Region Production and Acreage	
31. Midwest grower price	$PGM_t = f_{pm}\ (PGM_{t-1}, PGC_t, QMT_{t-1}: T, CPI_t, u_{mt})$
32. Midwest acreage	$AM_t = f_{am}\ (PGM_t, PMS_{t-1}: T, CPI_t, u_{mt})$
33. Midwest production	$QMT_t = (YLDMP_t) \cdot AM_t$
34. Eastern grower price	$PGE_t = f_{pe}\ (PGE_{t-1}, PGC_t, QET_{t-1}: T, CPI_t, u_{et})$
35. Eastern acreage	$AE_t = f_{ae}\ (PGE_t : T, CPI_t, u_{et})$
36. Eastern production	$QET_t = (YLDEP_t) \cdot AE_t$
37. Minor production	$QRT_t = (RR_t) \cdot (QCT_t + QMT_t + QET_t)$
38. Minor acreage	$AR_t = (RA_t) \cdot (AC_t + AM_t + AE_t)$
39. Other region production	$QOT_t = QMT_t + QET_t + QRT_t$
40. Total U. S. production	$QT_t = QCT_t + QOT_t$
41. Allocation of other region pack	
(a) Canned tomatoes	$QWO_t = (g_{wot}) \cdot (h_w) \cdot QOT_t$
(b) Juice	$QJO_t = (g_{jot}) \cdot (h_j) \cdot QOT_t$
(c) Puree	$QUO_t = (g_{uot}) \cdot (h_u) \cdot QOT_t$
42. U. S. product pack	
(a) Canned tomatoes	$QW_t = QWC_t + QWO_t$
(b) Juice	$QJ_t = QJC_t + QJO_t$
(c) Puree	$QU_t = QUC_t + QUO_t$

(Continued on next page.)

TABLE 1—continued.

Variable identification[a]
Endogenous variables
PK = average California f.o.b. price for product K (dollars per case) K = W (canned) 24/303 cans, standard J (juice) 12/46 oz. cans fancy C (catsup) 24/14 oz. glass bottles, fancy U (puree) 6/10 cans, 1.06 sp. gr. P (paste) 6/10 cans, 26 percent solid
DK = U.S. disappearance of processed tomato products (1,000 24/303 case equivalent) K = W (canned), J (juice), C (catsup and chili sauce), U (puree), and P (paste)
DKC = California disappearance of institutional-size tomato products (1,000 24/303 cases) K = C (catsup and chili sauce) and PI (institutional paste)
AK = U. S. processed product allocation to domestic sales (1,000 24/303 cases) K = W (canned) and P (paste)
SK = U. S. carry-over stocks of tomato products, July 1 (1,000 24/303 cases) K = W (canned), J (juice), and U (puree)
SKC = California carry-over stocks of tomato products, July 1 (1,000 24/303 cases) K = W (canned), J (juice), U (puree), and CI (institutional catsup plus chili sauce) and PI (institutional paste)
QK = U. S. pack of tomato products (1,000 24/303 cases) K = W (canned), J (juice), and U (puree)
QKC = California pack of tomato products (1,000 24/303 cases) K = W (canned), J (juice), U (puree), CI (institutional catsup and chili sauce), and PI (institutional paste)
QKO = other regional pack of tomato products, excluding California (1,000 24/303 cases) K = W (canned), J (juice), and U (puree)

(Continued on next page.)

TABLE 1—continued.

Variable identification[a]
Endogenous variables (continued)
PGK = raw tomato contract price (dollars per ton)
K = C (California), M (Midwest), and E (East)
QKT = raw tomato deliveries to processors (1,000 tons)
K = C (California), E (East), M (Midwest), R (Minor), and O (East plus Midwest plus Minor)
QCTR = aggregate California processed tomato pack reported (1,000 tons, farm weight)
AK = planted tomato acreage (1,000 acres)
K = C (California), M (Midwest), E (East), and R (Residual)
S1T = stocks of California tomato products, January 1 (1,000 tons, farm weight)
SCT = carry–in inventory of California processed tomato products reported, July 1 (1,000 tons, farm weight)
Exogenous variables
DOV = U. S. consumption of processed and frozen vegetables other than canned tomatoes (pounds)
Y = total disposable income (1,000 dollars), calendar year
T = time trend (1954 = 1, . . .,)
VJ = dummy variable which accounts for difference in reporting tomato juice pack (1952–1967 = 1; 1968–1977 = 0)
IK = U. S. tomato product imports (1,000 24/303 cases)
K = W (canned) and P (paste)
EK = U. S. tomato product exports (1,000 24/303 cases)
K = W (canned), J (juice), and P (paste)
CPI = consumer price index (1967 = 100), calendar year

(Continued on next page.)

TABLE 1—continued.

Variable identification[a]
Exogenous variables (continued)
N = population as of January 1 of market year (thousands)
YLDKP = average yield of raw tomatoes (tons per planted acre)
K = C (California), M (Midwest), and E (East)
YMAC = three-year lagged moving average of California yield (tons per harvested acre)
GCR = representative grower cost of producing tomatoes in California (dollars per acre)
TC = adoption rate of mechanical tomato harvester (percent of California crop harvested mechanically) as reported in Appendix Table A.14
QRT = residual raw tomato deliveries excluding California, the Midwest, and the East (1,000 tons)
PMS = seasonal average price of soybeans deflated by CPI, Ohio (dollars per bushel)
PRW = weighted average processed product price (farm-weight equivalent)[b]
M = dummy variable: M = 1, 1974–1977; M = 0 all years preceding 1974
h_i^c = farm weight to canned weight conversion factor for tomatoes (tons to 24/303 cases)
i = w (canned), j (juice), c (catsup) u (puree), and p (paste)
KiC = California's institutional share of U. S. sales
i = C (catsup and chili sauce) and P (paste)
g_{ik}^c = raw tonnage to product pack allocation rate (three-year centered moving average)
i = w (canned), j (juice), c (catsup and chili sauce), u (puree) and p (paste)
k = c (California) and o (Other Regions: Midwest plus East plus Residuals)
RR = three-year centered moving average of QRT ÷ (QCT + QMT + QET)
RA = three-year centered moving average of AR ÷ (AC + AM + AC)
u, v, and e = terms to account for unexplained disturbances

[a]A more complete description of the data including sources is contained in section 4 and Appendix A.

[b]For further definition, see Table 7, *infra*, p. 39.

[c]Values of $g_{ik} \cdot h_i$ are defined as RKC and RKO in Table 7, *infra*, p. 39.

(7), (11), (15), and (19)].[1] For each commodity, the product price and quantity allocated to current sales are simultaneously determined within each sales period. Because of data limitations, it was not possible to estimate demand and supply equations for imports and exports. These variables are treated as exogenous in the analysis. This simplified specification is reasonable in view of the very small percentages of production exported and imported and the dominance of exogenous factors on international markets.

Block II contains the California grower supply and processor raw product demand functions. These equations form another interdependent system with grower price, acreage, and production simultaneously determined. The processor demand for the raw product is also influenced by the final product demand through inventory levels and lagged values of product prices. Efforts to estimate functions which would allocate the raw product to processed product forms by economic criteria were unsuccessful. Equation set 30, therefore, allocates California production in accordance with historical shares. Other region raw product is allocated in a similar manner [equation (41)].

Block III contains acreage and grower price equations for the Midwest and East [Table 1, equations (31), (32), (34), and (35)]. These equations are formulated as a recursive system in which grower prices of the Midwest and East are sequentially related to California grower prices and other variables. The small quantities of tomatoes produced outside the three major regions are treated as exogenous variables for purposes of determining total industry output.

The remainder of this section explains the reasoning behind the specification of the particular sets of variables for each of the behavioral equations in Table 1.

Processed Product Demand and Market Allocation

The demand functions facing California processors for each of the five product types are derived from the consumer and marketing group demands and thus include all the major variables thought to influence the levels of consumer and marketing-group demand.[2] The inventory allocation equations explain how available quantities (pack plus carry-in stocks) are allocated between current sales and inventories to be carried into the next season.

The demand function relates product price to quantities sold, quantities of competing products, income, population, price level, time trend (where appropriate), and a residual disturbance term. For catsup, puree, and paste, a stock variable is introduced into the demand function as a proxy variable to account for effects of inventory accumulations by manufacturing purchasers, as explained more fully with the presentation of econometric results. In the case of tomato juice, a trend variable was

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[1]Data for tomato sauce and other specialty products are not of adequate quality to permit meaningful statistical estimation of economic relationships.

[2]The basic formulation of consumer demand theory can be found in numerous publications such as Henderson and Quandt (1971), Malinvaud (1972), and Phlips (1974). The problems of multiple-product choices, aggregation over individuals, and other related issues are largely ignored in this report. Phlips discusses several of these issues and suggests specifying per capita demand relations; for further development of these topics, see Brandt (1977, pp. 119–124).

introduced to account for a general downward shift in per capita demand, and a shift variable, VJ, was included to account for a change in the method of reporting juice packs and movement (Appendix Table A-6, footnote a). In the empirical analysis the effects of population are imposed by expressing quantity variables and income on a per capita basis, and the effects of price level changes are incorporated by expressing prices and income as deflated values [*i.e.,* divided by the Consumer Price Index (CPI)].

Omitted from the demand equations facing processors is a variable which specifically accounts for changes in marketing-group costs such as transportation, warehousing, and retail and distributor margins. It was not possible to find a time series measure of such costs. However, it seems likely that the general movement of marketing costs has been highly correlated with movements of the CPI. To the extent that this has been the case, expressing prices in deflated terms would remove the marketing-cost influence as a variable, leaving it a part of the constant term of each equation. Changes in marketing costs not associated with changes in the CPI may be reflected as trend influences and as elements of the disturbance term. Since income changes have been highly correlated with time, it is likely that, if any other residual influence of changes in marketing costs exists, it may be absorbed by the income variable.

Market-allocation equations are required because available supplies (SK + QK) can be distributed either to current U. S. markets, to export sales, or carried forward as stocks to be sold in the next period. Equations (2), (7), (11), (15) and (19) model the allocation decision.

The dominant factor determining current sales is the available supply. If processors could anticipate production and demand conditions with complete certainty, there would be no carry-over stocks except as might be required to maintain flows through marketing channels. Quantities marketed would be very closely tied to available supplies. In practice, however, processors experience substantial difficulties in coordinating production with demand. Short-term equality of supply and demand may be achieved either by permitting product prices to fall below or rise above expectations, by allowing inventories carried forward to fluctuate, or both.

The allocation equations are based on the hypothesis that, as the current price increases relative to the price expected in the next period, processors increase allocations to current sales and, therefore, reduce carry-out stocks. The expected future price seems likely to be closely related to price experience in the most recent period (P_{t-1}), particularly when expressed in deflated terms (*i.e.*, divided by CPI). In a more constrained formulation, P_t and P_{t-1} are formed into a single variable, $P_t - P_{t-1}$. A positive change in price relative to the previous period may encourage processors to allocate more product to current sales; a decrease in price causes resistance and discourages current sales. The allocation decision might be expected to be further influenced by unit costs of carrying inventories to the next period, primarily by interest rates. However, the interest rate proved nonsignificant as a variable in the empirical analysis and so is excluded in Table 1.

The inclusion of population in the allocation equations permits quantities to be expressed in per capita terms as in the demand equations. Population is a measure of market size, so it is also a factor influencing inventory levels needed to serve the market.

Since prices and current sales are determined simultaneously, either variable might be selected as the dependent variable in the estimation process. The choice of normalized variable is of some importance with two-stage least squares (2SLS) and three-stage least squares (3SLS) estimating methods because the estimation results may differ. The normalized variable choices in Table 1 reflect the authors' view as to primary directions of causation and recursiveness. In particular, the total supply, SK + QK, which is predetermined with respect to product sales, is the dominant variable influencing these sales. With sales DK thus quasi predetermined, it seems appropriate to treat price as the normalized variable in the demand equations.

California Grower Supply and Processor Raw Product Demand

The equation system in this component of the model (Block II of Table 1) determines the California acreage and quantity of tomatoes produced by growers and purchased by processors and the price paid to growers. It rests on the same basic theoretical foundations as an earlier study by Chern and Just. However, the variable structure and the final forms in which the equations are expressed are a bit different. The remainder of the section describes the essential conceptual features of the Chern–Just model and the modifications introduced here.

The Chern–Just Model

The Chern–Just study, published in 1978, is an econometric analysis of supply response and demand for processing tomatoes applied to a 10–county region of California which accounts for 85 percent of the state production. The objectives were to investigate economic trends of key variables in the California tomato industry, to assess the effect of contracting on acreage and price determination in the raw tomato market, and to estimate the impact of the tomato harvester on structural parameters of acreage response and demand for processing tomatoes. Their model consists of an acreage supply response equation, a processor demand for raw product equation, and a demand for acreage equation.

Supply of Acreage.—To develop the acreage supply function, Chern and Just (1978, pp. 30–34) start with the concept of a production function which relates output of raw tomatoes to acreage and other inputs such as labor, fertilizer, and capital. The profit-maximizing calculations generate a grower supply function which relates expected production to the price received by the grower and to prices of the various inputs. Aggregation of quantity over growers then defines an industry supply function which involves the same set of price variables.

An acreage supply function is obtained by (1) using the identity which equates expected production to acreage multiplied by expected yield; (2) substituting the output supply equation in the identity; and (3) solving for acreage to obtain an equation which expresses acreage supplied as a function of the grower price, prices of other inputs, and the expected yield.

Chern and Just note that, while their model could have been derived from a multiproduct production function, such treatment would substantially complicate the theoretical model without adding substantively to it. It is pointed out that the results of the multiproduct model are similar to the single–product model except that the prices of competing crops would be introduced into the acreage–response function. The influence of the competing crop prices is explored in their later empirical analysis.

Since growers may be concerned with the riskiness of an enterprise, Chern and Just initially included the standard deviation of past yields as a risk measure in the supply–response function. The variable did not turn out to be statistically significant in their analysis nor did it in this one. Therefore, it has been omitted in all further discussion.[1]

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[1]For a discussion of tomato yield variation in California, see Brandt, French, and Jesse (p. 79).

A major factor affecting supply response during the period of the study was the development of the mechanical harvester. Chern and Just approached the problem of incorporating this change into the analysis in two ways. They first estimated supply response as an aggregate function for the 10 major tomato–producing counties, with a shift variable included to allow for a change in the slope of the (logarithmic) equation. This took the form of a variable N · ln PGC, where PGC is the grower price and N is the percentage adoption rate of the harvester. This variable turned out to have a different sign than expected. Moreover, when more years of observation were added to the original data set, the model results were changed considerably and the standard errors increased substantially.[1]

The second approach was to estimate separate supply–response functions for periods before and after the adoption of the mechanical harvester, with observations during the transition period excluded. To increase the number of observations and to incorporate the possible benefits of county–level detail, they estimated the second model using pooled county and time series data. These results turned out to be more consistent with the authors' behavioral hypotheses.

Derived Demand for Acreage.—In formulating the demand component of their model, Chern and Just argued that, since there are few processors in the industry, it is plausible to consider that processors procure their raw product in an oligopsonistic market. While equilibrium conditions for oligopsony are generally difficult to derive, a previous study and informal interviews suggest that tomato processors may engage in a form of oligopsony that is more tractable for analytical purposes—that of price leadership. Under price leadership, one firm may take the initiative in making price changes. These changes are followed by other processors who, in effect, act as price takers. The model thus is developed in two stages: it first considers the behavior of the price–taking processor and then considers the effect of the price leader on the industry.

To derive the product demand function for the price–taking processor, Chern and Just start by assuming the existence of a cost–minimizing processing cost function for each product (net of raw product cost) which expresses cost as a function of volume of the processed product. This function may be expressed in relation to the volume of raw product by imposing constant conversion factors (Chern and Just, pp. 34-36). The profit–maximizing calculations yield a set of demand functions for tomatoes used to produce the processed products. Each demand function expresses the quantity of tomatoes desired for a particular processed product as a function of the price paid to growers for tomatoes, the expected price of the processed product, and the raw–to–processed–product conversion ratio. Chern and Just note that prices of inputs used in processing could have been included as variables, but they did not do so.

Summing over all the individual commodity raw product demand functions gives a total demand for raw tomatoes. This equation expresses total quantity demanded as a function of the grower price, the expected prices for each processed product, and the conversion ratios—the latter being fixed parameters.

Expected price for each processed product is assumed to be a function of the processed product price at the time of contracting, inventory of the product at the time of

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[1]The variable N · ln PGC had a positive sign. It is possible that, if N and N · ln PGC had both been included in the same equation thus allowing for a change in the intercept as well as slope, the coefficient of N · ln PGC might have been negative. Even with this adjustment, however, problems of high intercorrelation might have precluded obtaining meaningful estimates.

contracting, and projected U. S. income. To simplify the analysis, the several product prices are consolidated into a single quantity–weighted average price; and inventories of all individual commodities are summed into a single inventory variable. Thus, the final processor demand function expresses quantity of raw tomatoes demanded as a function of grower price, average price for processed products at contracting time, consumer income, and aggregate inventories of processed products of contracting time. Chern and Just used the average f.o.b. price for January–March and inventories were measured as of April 1.

Historically, most processor–grower contracts have been specified in terms of acres.[1] A demand function for acreage may be defined by noting that acreage demanded is equal to quantity demanded divided by expected yield. Using this identity, Chern and Just express the demand for acreage more generally as a function of quantity of tomatoes and expected yield.

Market Equilibrium.—In an industry in which all processors behaved as price takers, the equilibrium grower price, acreage, and quantity processed would be determined by solving the three–equation system described above. That is, the grower price would be determined by the intersection of the grower supply and processor–derived demand curves. In a market characterized by *monopsony* (a single buyer of the raw product), a monopsonist would determine its profit–maximizing rate of purchase by equating marginal input cost of the raw tomatoes with its marginal revenue product. The raw product price to growers would be set at the corresponding output on the grower supply curve which lies below the marginal input cost curve. Thus, the grower price for any output would be less than in the case of purely competitive purchases. Under price leadership *oligopsony*, the observed price would lie somewhere between the monopsony and purely competitive price.

Chern and Just point out that, under oligopsony or monopsony, time series observations of market price and quantity do not provide a basis for estimating the marginal revenue product curve as is the case under pure competition. If the marginal revenue product and supply curves are linear and if the supply curve shifts over time in a parallel fashion (no change in slope), the market observations will trace out what Chern and Just call a "perceived demand" curve. This curve will be steeper than and lie below the marginal revenue product curve.

If the slope of the supply curve should change in the linear model described above, it would result in a change in the slope of the perceived demand curve.[2] This suggests that,

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[1]In recent years, contracts increasingly have been specified in terms of quantities to be delivered, based on an average yield multiplied by a given acreage. If actual yields exceed the average value, processors may not accept all the production from a given acreage.

[2]This may be illustrated by the following simple model:

Marginal revenue product:	$MRP = a_0 - a_1 Q$
Supply function:	$P = b_0 + b_1 Q$
Marginal input cost:	$MIC = b_0 + 2b_1 Q.$

Profit-maximizing Q is obtained where MRP = MIC which yields $Q = (a_0 - b_0)/(a_1 + 2b_1)$ and $b_0 = a_0 - (a_1 + 2b_1) Q$. Substituting for b_0 in the supply function gives the perceived demand function $P = a_0 - (a_1 + b_1) Q$. If b_1 (the slope of the supply curve) remains constant, the slope of the PD curve remains constant. Changes in b_1 alter the slope of the PD curve. For a further illustration as applied to the dominant firm oligopsony model (rather than pure monopsony), see Just and Chern (1980, pp. 589–593).

under these conditions, changes in the structure of supply must be carefully considered in determining what sort of demand relation is being measured by time series of price and quantity observations.

It is possible, of course, that a price leader may behave more as a pure competitor than a pure monopsonist. That is, the leader may determine output and raw product price by equating marginal revenue product with supply price rather than with marginal input cost. It is also possible that a leader firm may act as an oligopsonist during some periods and behave more as a pure competitor at other times. There may also be variations in the extent to which other firms follow a particular leader. Under these circumstances, the perceived demand function that is derived by econometric estimation may be subject to more bias and may be less reliable than the associated supply component of the model.

Modifications of the Supply Relationship

Using the acreage and price symbols of Table 1, the Chern-Just acreage response function may be expressed as

$$AC_t = h_{ac}(PGC_t, W_{0t}, W_{1t}, W_{2t}, W_{3t}, Y_t^*) \quad (1)$$

where the W's refer to the price of land, labor, fertilizer, and capital, and Y_t^* is expected yield. A multiple-product model would add prices of competing crops to the set of price variables. Chern and Just used a three-year average of past yields as a proxy for expected yield, and that procedure is followed here. The variable is defined as $YMAC_t$ and replaces Y_t^*.

A problem with the Chern-Just specification is that it may be difficult to obtain statistically significant estimates of the coefficients of the W's. For example, Chern and Just did not obtain significant coefficients for prices of land (W_0) and capital (W_3). Another limitation is that, with relatively small numbers of observations, only a small number of input variables can be included in the model.

An alternative formulation is to replace the input price variables with a cost series derived from sample cost-of-production studies. This reduces the number of variables and, at the same time, takes account of the effects of changes in prices of the complete set of input variables. It also may incorporate the effects of parameter change associated with changes in production techniques.[1]

With these modifications, the basic supply model takes the general form

$$AC_t = h_{ac}(PGC_t, YMAC_t, CG_t^*, CPI_t, IPG_t, v_t) \quad (2)$$

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[1]The computation of the production cost series is described in section 4 and Appendix B, *supra*, p. 21 and p. 98, respectively.

where

PGC_t = California grower price

$YMAC_t$ = three-year average yield

CG_t^* = measure of expected grower cost per acre

CPI = consumer price index

IPG = index of grower prices for competing crops

and

v_t = unexplained disturbance.

Since current year costs are not known fully at the time of contracting, CG_t^* is expressed as the observed cost measure in t − 1 (*i.e.*, as CG_{t-1}). Note that CG is a function of the input prices, W_0, W_1, W_2, and W_3, which are included in the Chern–Just equation, plus other inputs not included in the Chern–Just formulation.

The use of the CPI as a price–level indicator rather than an alternative indicator, such as the Index of Prices Paid by Farmers, maintains consistency with the demand estimates. This simplifies margin calculations and the later application of the model for projection purposes. The movement of the CPI has been highly correlated with movements of other price–level indicators. The effects of changes in the CPI are incorporated as in the demand formulation by expressing price and cost variables in deflated terms.

Chern and Just made no distinction between long–run and short–run response in their model formulation. It is hypothesized here that, while short–run response rates may change with the substitution of fixed for variable input costs, long–run response rates may not be greatly affected. This may be approached by considering the year–to–year changes as a partial adjustment process of the form

$$AC_t = AC_{t-1} + \alpha(AC_t^* - AC_{t-1}) \tag{3}$$

where AC_t^* is the long–run desired level of acreage in year t, and α is an adjustment coefficient $(0 < \alpha < 1)$. If $\alpha = 1.0$, the adjustment is complete each year, and $AC_t = AC_t^*$. Values of $\alpha < 1.0$ may be associated with factors such as long–term rental commitments, reluctance to change long–standing production operations or buyer relationships, and the existence of sunk investments in specialized machinery. If equation (2) is assumed to represent the *long–run* desired acreage for given values of price, cost, and yield expectation, then the short–run supply response becomes

$$AC_t = \alpha\ AC_t^* + (1 - \alpha)\ AC_{t-1} \tag{4}$$

or

$$AC_t = \alpha h_{ac}(PGC_t,\ YMAC_t,\ CG_{t-1},\ CPI_t,\ IPG_t,\ v_t) + (1 - \alpha)\ AC_{t-1}.$$

One way to test whether or not the value of α may have declined with the shift to mechanization would be to estimate supply functions for periods before and after mechanization. However, the small number of time series observations makes this difficult. A disaggregated pooled county model, such as used by Chern and Just, was not considered appropriate here because of the broader objectives which require functions that encompass the total state industry and because of differences in the basic supply–model formulation. While selected production cost estimates are available for a number of counties, the continuous time series of production cost could be developed only as a general statewide indicator. Thus, the cost–oriented supply model would not be feasible on a county level.

In the more aggregative statewide supply model estimated here, a test for changing α may be formulated by specifying that α is a function of TC, the proportion of acreage harvested mechanically (which is equivalent to Chern and Just's N). In a linear model, this requires adding cross–product terms for each variable with TC and may also be used to evaluate a possible upward shift in the level of supply response as a result of the altered labor environment with mechanization.

As in the Chern–Just study, efforts to measure the influence of a variable (or variables) to account for the profitability of alternative crops [IPG in equation (2)] were generally not very successful. One reason for this is the existence of several alternatives (which may vary among areas) so that no single crop clearly reveals its impact. Consequently, the influence of such variables is reflected as part of the disturbance term. The final supply equation thus includes the general variable specification given in Table 1, equation (23).

Modifications of the Processor Demand Relationship

Chern and Just specified the processor demand for the raw product as a function of grower price, average processed price at contract time, total income, and total stocks at contract time. Using the notation adopted here, the equation may be expressed as

$$QCT_t = f_{qc}(PGC_t, \ PRW_t^c, \ Y_t, \ S1T_t). \tag{5}$$

This study modifies or extends the Chern–Just formulation in several ways.

The first modification was to try to account for changes in the processing cost as a factor affecting processor demand. This was approached in two ways. First, price and income variables were deflated by the CPI. Since much of the change in processing cost has been associated with change in the CPI, deflation by this index removes (or accounts for) much of the cost influence. Second, to consider the possible impact of cost variation not associated with the CPI, an Index of Processing Cost (also deflated) was introduced as an additional variable.[1] However, the addition of this variable did not give plausible results, possibly because it is not a good indicator of changes in tomato–processing costs and, also, because of its high correlation with other variables. It is omitted in the further discussion.

A second modification involved a change in the specification concerning the manner in which processors form their expectations of prices received for processed products.

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[1]Note that, if processing cost is $PC = b \cdot CPI$, then deflation of all dollar variables by CPI gives $PC/CPI = b$, a constant. If $PC = b \cdot IPC$, deflation by CPI gives $PC/CPI = b\,(IPC)/CPI$.

Chern and Just assumed that the expected price may be expressed as a function of the current price at contract time, inventory level, and projected income, the latter assumed to be based on current income.We include the further assumption that processors may recognize that price may also be affected by the quantity of production. Thus, quantity of pack becomes an additional variable in the price expectation function. This does not result in any change in the variables included in the final processor demand function, but it is of some importance in the later interpretation of model results.

Chern and Just used a single weighted average f.o.b. price (PRW_t^c in the notation of this study) to represent processor price expectations for all processed products. That simplification is retained here. However, in order to maintain continuity within the general model, it is necessary to relate the average price at contract time to the season average prices predicted by the general model. The production and marketing year is defined as July 1 to June 30, so contracting for year t occurs during year t – 1 (*i.e.*, from January to April). The average processed product price during contracting thus overlaps and is closely associated with the average price experienced for year t – 1. Therefore, PRW_t^c may be regarded as a function of PRW_{t-1}. The latter variable then replaces PRW_t^c in the demand function.

Since the general model predicts inventory levels on July 1, it is also necessary to specify a relationship between observed stocks at contract time, S1T, and carry–over stocks on July 1.[1] A possible procedure would have been simply to replace S1T with SCT_{t-1} (the July 1 inventory figure). However, a better predictor is obtained by retaining S1T as a variable in the demand equation and specifying an additional technical equation to predict S1T as indicated in Table 1, equation (28).

The initiation of price bargaining by the CTGA in 1974 transformed the industry into a possible bilateral oligopoly-oligopsony structure for which price and output equilibrium conditions may be determined only within some range, with the outcome depending on relative bargaining strength and strategies. This adds to the uncertainty as to the nature of the perceived (or realized) demand–side, price–quantity relationship and possibly may also influence the supply relationship.

One approach to allowing for this change in structure is to introduce a shift variable, M, into the demand and supply equations. This variable has a value of zero for all years prior to 1974 and of one for the periods when the CTGA actively bargained (1974–1977 in the empirical data set used for estimation). If successful, the CTGA bargaining efforts would have the effect of shifting the realized processor demand function upward, *i.e.*, processors would pay more for a given quantity of raw tomatoes than before bargaining. It is possible that the CTGA bargaining procedures would also alter the effective supply curve such that a given quantity would be supplied only at a higher price (or a lesser quantity supplied at any given previous price). However, the CTGA bargaining efforts focus mainly on price issues with restrictions of supply more a threat than an active control variable.[2] Under such conditions, supply would tend to continue to respond to the negotiated price, with little alteration of the basic supply equation itself. The latter hypothesis is supported by the later empirical results in which the shift variable, M, turned

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[1]Chern and Just measured the stock level during contracting as of April 1. In this study the inventory level at time of contracting S1T is specified as the level on January 1. April 1 stock levels are not known during the early part of the contracting period. Stocks on the two dates are closely correlated.

[2]Recall that the CTGA membership has included no more than 70 percent of growers and probably less of production.

out to be statistically nonsignificant in the supply equation but highly significant in the demand equation. It is possible, of course, that, in spite of the apparent oligopoly–oligopsony structure, actual behavior may not depart greatly from the competitive model. Under such conditions, other interpretations of the shift variable, M, are possible. This is discussed with the presentation of empirical results.

As a further modification of the Chern–Just raw product demand model, a partial adjustment hypothesis for processors was explored. The formulation was similar to that specified for the supply relationship. The coefficient of the lagged quantity variable, QCT_{t-1}, was statistically significant in an early model which did not include lagged processed product price, PRW_{t-1}, as a variable (Brandt, 1977, pp. 188–193). However, with the addition of PRW_{t-1} and the shift variable, M, the coefficient for QCT_{t-1} became statistically nonsignificant. This apparently occurred because the lagged process product price introduced an offsetting lagged adjustment process, and the shift variable, M, is positively correlated with QCT, the latter being much higher in the 1974–1977 period than earlier years. The formulation with PRW_{t-1} and M provided better overall estimation results, so the partial adjustment formulation was dropped.

It might also be expected that the levels of production in other regions would be an important variable influencing California processor demand for the raw product. Chern and Just noted that total *other region* production had not fluctuated much during the period of their analysis and argued that treating California demand as independent of production in other regions was, therefore, econometrically feasible. Explorations which included other region production in the demand function of the present analysis did not yield statistically significant results. Therefore, the Chern–Just specification pertaining to that aspect is retained. Changes in other region production influence California production through the impact on the prices of processed products.

With the modifications noted above, the equation for quantity of raw tomatoes demanded by processors takes the form of equation (25), Table 1. Note that the quantity demanded, QCTD, is not necessarily observable. The actual quantity purchased, QCT, may differ from the quantity demanded by a random element due mainly to yield variations as indicated by equation (26), Table 1. In the empirical analysis, equation (25) is substituted into (26). For equilibrium, it is required that the quantity bought equals the quantity supplied ($QCT^b = QCT^s$). Equations (23), (24), and (26), with (25) inserted, thus form a three–equation simultaneous system.

Production and Grower Prices in the Midwest and the East

In both the Midwest and East, tomatoes commonly are produced as a supplementary crop rather than the major farm commodity as is usually the case in California operations. Much of the relative decline in production in these two regions may be attributed to (1) urban sprawl (particularly in the East), which reduces available farmland, (2) grower inability to adopt cost–saving technological improvements (*e.g.*, mechanical harvester), and (3) declining processing capacity causing further grower uncertainty. The effects of changes of this sort are difficult to separate from the influence of other price and cost variables. Consequently, efforts to estimate grower–supply and processor–demand systems having the same form as the California model provided generally unsatisfactory results.

Because one of the objectives of this study was to formulate a model which would account for total U. S. production and consumption of tomatoes, it was important to be able to develop equations which would predict production in the Midwest and East and account for its interaction with California. This was accomplished by formulating equations which are as much descriptive as structural but which still incorporate the influence of price and quantity variables.

Since California contracting begins earlier and since California is the dominant producing region, grower prices in the Midwest and East are influenced by what happens first in California. Other variables used to predict prices of the Midwest and East are the price and quantity of the previous year and a trend factor. Acreage is related to the current season grower price, price of competing crops, and a trend variable.

The price and acreage equations for the Midwest and East are represented by equations (31)–(36), Table 1. These equations form a recursive system in which grower price is regarded as predetermined. Although the endogenous variable, PGC, appears in the Midwest and East grower price equations, it is assumed that the causation is unidirectional; that is, the California grower price affects the prices of the Midwest and East, but the latter have little direct effect on the California price.[1]

4. *DATA AND VARIABLE MEASUREMENT*

The quality of the econometric estimates of the parameters of the model, conceptualized in the previous section, is substantially influenced by the available data. As noted in the introductory discussion, the model formulated is constrained in its scope because some data series either are not available or are not suitable for statistical analysis. This section discusses the characteristics of the data used to estimate the model. The time series observations are given in the Appendix tables.

Farm Prices, Production, and Acreage

Farm prices, production, and acreage data used in the analysis were compiled from reports of the U. S. Statistical Reporting Service, Crop Reporting Board (1954–1980). For California, grower prices are measured at the first delivery point which usually is a receiving station near the area of production (California Crop and Livestock Reporting Service, 1954–1980). For other regions, the prices are measured at the first delivery point until 1964 and at the processing plant door thereafter. Data series were not available to continue the first delivery point series in these regions or to adjust the earlier year values to a processing plant door level. The bias introduced into the price series by the change in reporting point is believed to be small.[2]

The acreage contracted at these grower prices is not identical to acreage planted because small quantities have been produced each year without contracts. The latter is referred to as "open market acreage." Acreage planted is assumed to reflect the amount of acres growers are willing to supply at the reported contract prices.

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[1]The output in other regions has an indirect (lagged) influence on California grower price through the effect on the processed product price which influences California processor demand for the raw product.

[2]The difference in price at the first delivery point and price at the processing plant door is large due to transportation costs. In the Midwest and East, this cost tends to be much smaller than in California due to shorter hauling distances. Thus, there was only a relatively small change in the levels of reported prices in regions other than California.

Since yields are not known at the time of contracting, observed total tonnage produced by growers and purchased by processors is not necessarily identical with tonnage demanded by processors at the given contract price.[1] However, Chern and Just argue that the total quantity produced (sum of quantity from contracted and open-market acreage) may be taken as an approximation of processor demand at the time of contracting. They reason that open-market purchases may be used by the processor to fill a gap between desired quantity and the actual quantity produced from contracted acreage. Thus, total observed purchases approximate the desired quantity. An alternative specification is that the observed total harvested production differs from the unobservable desired production only by a random error term due mainly to yield variations.[2] With this specification, the unobservable desired quantity in the processor demand function may be replaced by the actual observed quantity, noting that this adds conceptually to the error variance of the equation. In practice, both the Chern–Just assumptions and the specification here yield identical variable structures, but the interpretation differs slightly.

Pack and Inventory Data

Data pertaining to quantities of various processed products packed and held as inventories were obtained from publications of the Canners League of California and the National Canners Association (Appendix Tables A.5 to A.10). In order to sum the quantities in various can and bottle sizes, all pack figures were converted to cases of 24/303 can equivalents, using standard conversion factors (Appendix Table A.16).

The scope of the processed product demand analysis is limited by the fact that the industry does not report fully the quantities of all items packed. In 1960, processors discontinued reporting paste pack in retail–size containers and all tomato sauce pack; and the pack of tomato catsup in retail–size containers has not been reported since 1968. The data series used here also omit miscellaneous processed items such as tomato aspic, fish sauce, spaghetti sauce, and soups for which associated price data are generally not available. In the analysis of demand for catsup and paste products, the reported pack figures were supplemented by confidential market survey data on retail–size purchases. This provided a basis for generating more complete estimates of total catsup and paste disappearance. Although the accuracy of the data series is not known, the statistical results obtained were more plausible than obtained using only the reported institutional pack data.

Import and export data were computed from publications of the U. S. Economic Research Service (see Appendix Tables A.5 to A.10). Because of differences in reporting units and reporting year, the final quantities of equivalent 24/303 cases, as calculated for use in this analysis, are approximate. However, imports and exports are small relative to production; and any errors in estimation seem unlikely to have much effect on the analysis.

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[1]Quantities purchased by processors are not actually identical to reported harvested production since small percentages are rejected at inspection stations or discarded in processor inspections.

[2]Recent increases in the use of contracts based on volume rather than acreage could modify the error structure. This would not be an important factor for the period for which the model parameters were estimated.

Processed Product Prices

There are two possible sources of data on wholesale prices for processed tomato products: (1) prices compiled by the U. S. Bureau of Labor Statistics (BLS) used to compute the Wholesale Price Indexes (now called Producer Price Indexes) and (2) reports in trade publications.

The BLS price series currently covers canned tomatoes, tomato juice, and catsup. However, the series generally does not extend back far enough to provide a continuous series appropriate to the period covered in this analysis. Moreover, the sampling base appears very limited, and there is no regional breakdown of the prices. Finally, the BLS data do not include any prices for paste and puree.

F.o.b. processor prices for all the major processed products are published in trade publications such as *The Canning Trade*; *Pacific Fruit News*; and the American Institute of Food Distribution's *Report on Food Markets*. Summary computations are also found in *The Almanac of the Canning, Freezing, Preserving Industries*. These prices are primarily list prices and may not fully reflect discounts and other trade adjustments which determine the final average transaction price. However, they are believed to be generally indicative of price movements from year to year.

The prices used in this analysis are the reported prices for the dominant container type for each product. Annual average values were computed as simple averages of quarterly or monthly reported values. The price series are given in Appendix Table A.11, along with more specific source notes.

Exogenous Variables

Data pertaining to population, income, CPI, and per capita consumption of other processed vegetables were compiled from government publications as indicated in the Appendix tables. Disposable income and the CPI are reported on a calendar year basis, whereas all production and price data used in the analysis are tabulated on a market year basis (July 1 to June 30). Thus, production and prices for, say, July 1, 1971, to June 30, 1972, would be associated with income and the CPI computed for January 1, 1971, to December 31, 1971. This slight lag does not appear to introduce any serious bias for purposes of this analysis, given the continuous nature of changes in the CPI and income series. Population is measured on January 1 of the crop year (*e.g.*, January 1, 1972, for 1971–72).

Cost data were compiled from studies of the Cooperative Extension Service as described in King, Jesse, and French (1973). A description of the updated cost series is given in Appendix B. It differs slightly from the series reported in Brandt, French, and Jesse (1978) in that it fits a slightly different predicting equation to the data observations and uses three-year averages of yields, rather than actual yields, in order to compute expected costs.

5. ESTIMATES OF MODEL PARAMETERS

This section presents the econometric estimates of the behavioral and technical equations outlined in Table 1. The data series for each variable are given in the Appendix tables. All equations were estimated using data for the marketing years, 1954–55 to

1977–78. This period was selected in accordance with data availability and with the objective of providing enough observations to achieve statistical reliability while at the same time keeping the period short enough to avoid major structural changes not accounted for by the variables in the model. Observations for some variables used in the model were not available prior to 1954. Because of the lags in reporting for some of the data series used, more recent 1978–79 and 1979–80 observations were not available at the time the statistical estimation was undertaken. The model's ability to predict prices and quantities for these later years, given reported values of exogenous and lagged endogenous variables, will provide one test of the reliability of the model.

Processed Product Demand and Inventory Allocation

The processed product demand and market allocation block of the model consists of equations (1) to (22) in Table 1. Equations (1), (6), (10), (14), and (18) are demand equations for the five product groups. Equations (2), (7), (11), (15), and (19) allocate supplies of each product between current sales and inventories to be carried to the next period, the latter determined residually by the inventory identity equations. The remaining equations are identities or technical allocation relationships [(3), (5), (9), (12), (17), (20), and (21)] required to complete the model.

Two alternative specifications of the simultaneity of the equation sets were explored. In the first, the equation sets for each of the five commodities were viewed as five separate interdependent systems, with the parameters of the two behavioral equations in each set estimated by 3SLS. A second formulation viewed the equations for each commodity as part of a single simultaneous system, with the 10 behavioral equations estimated simultaneously by 3SLS.[1]

Both estimation procedures yielded results that appeared acceptable by statistical and theoretical criteria. However, while the 10–equation formulation has an advantage in accounting more fully for possible interdependencies in the disturbance elements among commodity demand equations, it has a disadvantage in that specification errors in one set of equations may strongly affect the estimates of demand and allocation equations for other processed products. In view of the data problems encountered with the measurement of quantities of catsup and paste products, specification error may be a possible consideration in these equations. Therefore, separate 3SLS estimates for each commodity system were chosen for use in the final model rather than the single 10–behavioral equation estimates.[2]

The influence of price level changes is incorporated by expressing prices and income as deflated values (divided by the CPI), and the influence of population changes is imposed by expressing quantities on a per capita basis.[3] Formulations linear in the variables and linear in logarithms of the variables were estimated.

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[1] A third specification which treated concentrated products (catsup, puree, and paste) as an interrelated group was also explored. The results were similar to those obtained with the full 10–equation system.

[2] Each of the individual commodity demand and allocation sets was also estimated by 2SLS. In these cases, the results were generally similar to the three–stage estimators.

[3] Previously defined aggregate data variables are denoted as per capita variables with the addition of an N to the variable notation; for deflated values, add a D (see Table 2, footnote c, *infra*, p. 26).

The 3SLS estimation results for the five separate equation systems are given in Tables 2 and 3. Table 2 presents the linear estimates; and Table 3, the estimates obtained with the variables expressed in logs. The coefficient estimates in both tables all have signs in agreement with theoretical expectations, and most coefficients are large relative to their standard errors. The log formulation has an advantage that the price–quantity coefficients provide direct estimates of price flexibilities which show the percentage effects on price of a 1 percent change in quantity. However, the linear formulation is easier to incorporate into solutions of the model. Since there is little difference in the statistical significance of the two formulations, the linear estimates are used in the later model analysis. The log results are reported to facilitate interpretation in percentage terms. In either case, the particular equation form should be viewed as an approximation that is valid only over the general range of past data observations.

Individual Commodity Interpretations

Canned Tomatoes.—The demand function for canned tomatoes suggests that, with other variables held constant, an increase of .01 cases in per capita disappearance has been associated with a decline of 16.9 cents per case. In terms of price flexibilities, as measured in Table 3, a 1 percent increase in per capita disappearance has been associated with slightly over a 1 percent decrease in price. Changes in the sales of competing vegetables, DOVN, also appear to have significantly influenced the price of canned tomatoes. In terms of price flexibilities, a 1 percent increase in DOVN has been associated with about a 1.9 percent decrease in price. Per capita income shows a strong positive relationship with price. The income variable probably is closely correlated with other unmeasurable factors which have shifted demand. The income coefficient thus should be interpreted as a general indicator of demand shifts rather than a true measure of the income effect alone.

The allocation equation for canned tomatoes [equation (2)] indicates that the available supply (pack plus carry–in stocks) is the dominant factor affecting allocations to current sales and, therefore, levels of carry-out stocks.[1] However, this allocation is also significantly influenced by changes in price compared to the previous period. U. S. per capita disappearance, DWN, is obtained by adding per capita imports, IWN, to AWN.

Tomato Juice.—Estimation of the demand for tomato juice presented special problems because of a change in the method of reporting pack and movement beginning in 1968 (Appendix Table A.6) and because of a downward shift in the level of demand for tomato juice. The reporting problem was handled by introducing the dummy shift variable, VJ, which has a value of one for all years through 1967 and a value of zero thereafter. Efforts to account for changes in demand for tomato juice by changes in consumption of frozen orange juice did not provide statistically significant results. The shift thus is accounted for by the trend variable, T, with income omitted as a separate variable. Holding the trend shifter constant, an increase of .01 cases in per capita disappearance has been associated, on the average, with a decrease in price of 20.6 cents per case. The price flexibility coefficient (Table 3) suggests that, in percentage terms, a 1 percent increase in quantities marketed has been associated with about a 1.18 percent decrease in price. The allocation equation (7) is interpreted similarly to that for canned tomatoes.

Catsup and Chili Sauce.[2]—It was noted in the discussion of data problems (section 4) that the reporting of pack of catsup in retail–size containers was discontinued in 1968. Because

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[1]For the inventory identity which completes the system, see Table 1, *supra*, p. 6.

[2]Quantities of catsup and chili sauce were combined in the analysis because of the general similarity of the products and the difficulty of obtaining separate demand estimates. Chili sauce is a minor product compared to catsup.

TABLE 2

Three-Stage Least Squares Estimates of Processed Tomato Product Demand and Market Allocation Relationships, Linear Equations[a] and Five 2-Equation Systems,[b] 1954–1977

(1)	PWD_t	=	7.0763	−	16.9024	DWN_t	−	.0957	$DOVN_t$	+	.0018	YND_t
			(1.1680)[c]		(4.8638)			(.0425)			(.0006)	
(6)	PJD_t	=	7.1758	−	20.6285	DJN_t	+	.6041	VJ_t	−	.0503	T
			(1.3731)		(5.4838)			(.2032)			(.0205)	
(10)	PCD_t	=	5.3873	−	22.5035	DCN_t	−	11.6775	$SCCN_t$	+	.0009	YND_t
			(.9956)		(10.3423)			(15.4600)			(.0004)	
(14)	PUD_t	=	2.6699	−	30.1158	$SQUN_t$	+	.0013	YND_t			
			(.7955)		(16.0254)			(.0004)				
(18)	PPD_t	=	2.5398	−	24.1768	DPN_t	−	147.8438	$SPICN_t$	+	.0033	YND_t
			(3.0184)		(23.7942)			(42.5181)			(.0020)	
(2)	AWN_t	=	.0442	+	.6354	$SQWN_t$	+	.0242	ΔPWD_t			
			(.0207)		(.0192)			(.0097)				
(7)	DJN_t	=	.0270	+	.6877	$SQJN_t$	+	.0344	ΔPJD_t			
			(.0118)		(.0469)			(.0115)				
(11)	DCN_t	=	.1025	+	1.2924	$SQCN_t$	+	.0452	ΔPCD_t			
			(.0158)		(.3290)			(.0193)				
(15)	DUN_t	=	−.0008	+	.7896	$SQUN_t$	+	.0106	ΔPUD_t			
			(.0061)		(.1227)			(.0026)				
(19)	APN_t	=	.0173	+	.9812	$SQPIN_t$	+	.0037	ΔPPD_t			
			(.0026)		(.0331)			(.0010)				

[a]Variable combinations are defined as follows (Table 1, *supra*, p. 6).

Deflated price:	PKD	=	(PK/CPI) · 100; (K = W, J, C, U, and P)
	ΔPKD_t	=	$PKD_t - PKD_{t-1}$
Per capita consumption:	DKN	=	DK/N
Per capita income:	YND	=	(Y · 100) ÷ (N · CPI)
Stocks:	SCCN	=	SCC/N; SPICN = SPIC/N
	SQKN	=	(SK + QK)/N; (K = W, J, C, U, and PI)
U. S. per capita sales:	AWN	=	DWN − IWN; APN = DPN − IPN
Time:	T	=	1 in 1954
	VJ	=	1 for t = 1954–1967; 0 for t = 1968–1977.

[b]The five equation systems are formed by equations (1) and (2), (6) and (7), (10) and (11), (14) and (15), and (18) and (19), plus identities (Table 1, *supra*, p. 6).

[c]Numbers in parentheses are standard errors.

TABLE 3

Three–Stage Least Squares Estimates of Processed Tomato Product Demand and Market Allocation Relationships, Log Formulation[a] and Five 2–Equation Systems, 1954–1977

(1L)	$LPWD_t$[b]	=	–6.0336	–	1.0594	$LDWN_t$	–	1.8929	$LDOVN_t$	+	1.6528	$LYND_t$
			(1.5104)[c]		(.2944)			(.7000)			(.4848)	
(6L)	$LPJD_t$	=	–.5447	–	1.1762	$LDJN_t$	+	.1905	VJ_t	–	.0149	T
			(.4850)		(.3409)			(.0723)			(.0073)	
(10L)	$LPCD_t$	=	–5.2146	–	.8316	$LDCN_t$	–	.0461	$LSCCN_t$	+	.6145	$LYND_t$
			(2.4931)		(.3659)			(.0266)			(.2439)	
(14L)	$LPUD_t$	=	–7.4480	–	.7237	$LSQUN_t$	+	.6685	$LYND_t$			
			(1.2140)		(.0895)			(.1264)				
(18L)	$LPPD_t$	=	–10.1169	–	.4131	$LDPN_t$	–	.1420	$LSPICN_t$	+	1.3243	$LYND_t$
			(5.9446)		(.2958)			(.0260)			(.6621)	
(2L)	$LAWN_t$	=	–.5492	+	.7541	$LSQWN_t$	+	.3506	$\Delta LPWD_t$			
			(.1553)		(.1037)			(.1508)				
(7L)	$LDJN_t$	=	–.3801	+	.8892	$LSQJN_t$	+	.5236	$\Delta LPJD_t$			
			(.0846)		(.0591)			(.1812)				
(11L)	$LDCN_t$	=	–.6676	+	.3718	$LSQCN_t$	+	.7876	$\Delta LPCD_t$			
			(.2108)		(.0673)			(.3101)				
(15L)	$LDUN_t$	=	–.2727	+	.9899	$LSQUN_t$	+	1.2647	$\Delta LPUD_t$			
			(.4216)		(.1387)			(.2917)				
(19L)	$LAPN_t$	=	–.2920	+	.8051	$LSQPIN_t$	+	.4330	$\Delta LPPD_t$			
			(.0911)		(.0328)			(.1086)				

[a]For further variable definitions, see Table 2, footnote c, *supra*, p. 26.

[b]The L preceding a variable indicates logged value.

[c]Numbers in parentheses are standard errors.

this omitted a major portion of sales, an effort was made to improve the series by adding estimates of catsup consumption in retail–size containers obtained from confidential market survey data. The confidential series were available for 1968–1973. Extrapolations for 1974–1977 were made to complete the series.[1]

Another factor which appeared to be influencing the demand facing processors for concentrated products was the accumulation of stocks in the hands of buyers. Continuous data series pertaining to such stocks are not available. However, it seems reasonable to assume that such stock levels might be strongly correlated with levels of carry–in stocks in the hands of canners. Canner carry–in stocks thus were introduced as a proxy shift variable.

With these modifications, the demand estimates for catsup and chili sauce turned out to be similar to those for canned tomatoes and juice but with somewhat lower price and income flexibilities. The influence of the stock variable on price was much smaller than for paste and puree, and the coefficient was less significant as measured by the t ratio. This is not surprising since paste purchases tend to be used more for further manufacturing.

In the allocation equation for catsup and chili sauce, the coefficient for the available supply variable, SQCN, is greater than 1.0. This would not be possible if the stock and pack data accounted for all of the product. However, SQCN refers only to California institutional pack while DCN, as noted previously, has been augmented by additional retail sales data. Thus, the allocation based on SQCN is greater than 1.0.

Puree.—It may be noted that the demand equation for puree departs slightly from the specification in Table 1. Initial estimates with DUN and SUN as separate variables provided coefficients of the correct sign, but the coefficient of DUN was peculiarly large and was not statistically significant. Utilization of this equation in the later applications of the total model injected an element of instability which seemed unwarranted. Consequently, the equation was respecified to express the price of puree as a function of available supply (pack plus carry–in stocks) and income. It may be regarded as a partial reduced–form equation rather than a demand equation. The equation indicates that an increase in the initial supply of puree of .01 cases per capita has been associated with a decrease in price of about 30 cents per case. The income coefficients and the allocation equations are interpreted as described for canned tomatoes, juice, and catsup.

Paste.—As in the case of catsup, recent data on paste pack and stocks exclude retail–size containers. Reporting of these sizes was discontinued in 1960. As in the case of catsup, the data on sales in institutional–size containers were augmented by confidential survey data. Although institutional sales represent a much larger proportion of sales for paste than for catsup, the additional data nevertheless improved the statistical results obtained.

It was noted in the discussion of the estimates for catsup and puree that it appeared that the demand facing processors of concentrated products might be strongly influenced by accumulations of stocks in the hands of institutional–size buyers. This seemed especially important in the case of paste where much of it is purchased for remanufacturing

[1]For a further discussion, see Brandt (1977).

or other food uses. Complete and continuous data pertaining to such stocks were not available, but it was hypothesized that such stocks would be highly correlated with levels of canner carry–in stocks. This hypothesis seems well supported by the demand estimation results for paste where the stock variable is highly significant. For the linear equation, the data suggest that an increase in California institutional carry–in stocks, SPICN, of .01 cases per capita has been associated with a decrease in price of $1.47 per case. The coefficients for per capita disappearance, while not statistically different than zero at a high level of significance, is of the correct sign and is of the same general magnitude as the coefficients for the other products. However, the price flexibility is lower.

The per capita disappearance of paste has tripled over the period of investigation. Its rise in popularity seems to be associated, in part, with the expansion of fast–food outlets, especially pizza establishments, and its wide use as an ingredient in many convenience foods purchased in food stores. Because of this rapid rise in the demand for paste and its importance as the largest volume product packed, extensive efforts were made to identify the factors causing these shifts in demand. Data indicating the expansion of the four largest pizza chains, as well as data reflecting the increase in the volume of business in the franchise food chain industry, were collected and included as explanatory variables. However, these and other *shift* variables failed to explain the variation in the dependent price variable. These shift variables were highly correlated with paste disappearance and with per capita disposable income and led to problems of multicollinearity in the price–dependent relation.

The paste price appears to be highly flexible with respect to income. As in the previous cases, however, income is actually a proxy for a number of factors which have shifted demand upward. Changes in consumer life–styles reflected by more away–from–home eating and purchases of convenience foods associated with higher incomes are undoubtedly contributing factors to the recent rise in use of tomato paste and probably account for the magnitude of the income coefficient.

California Grower Supply and Processor Raw Product Demand

The California raw product supply and processor demand block of the model consists of equations (23) through (30) of Table 1. For estimation purposes, equation (25) is substituted in equation (26) to eliminate the unobservable *ex ante* quantity demanded by processors (as distinguished from actual purchases) at a given price. This equation, along with equations (23) and (24), form a three–equation simultaneous system in which (24) is an identity.[1] Equations (27) through (30) are identities and technical relationships used in the complete model. Equation (28) predicts January 1 stocks as a function of previous pack and July 1 stocks and is estimated independently by ordinary least squares (OLS).

It may be noted that the simultaneous equation specification here differs slightly from that of Chern and Just in that they assumed observed purchases were equivalent to quantity demanded. Their three–equation system then consisted of an acreage–supply equation; a quantity–demand equation; and, from equation (27), an acreage–demand equation which is expressed as a linear approximation in terms of quantity demanded and and expected yield. Applying this specification to the present model would not affect the 2SLS estimates of the acreage–supply and quantity–demand equations since the third

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[1]There is actually a fourth equation; the identity which equates quantity purchased to quantity supplied (footnote *a*, Table 4, *infra*, p. 34).

equation is not taken into account in the estimation process. However, it would affect the parameter estimates under 3SLS, because the statistical specification of the third equation—an identity in this model and a linear approximation in the Chern–Just model—is incorporated into the estimation procedure.

Table 4 presents the estimation results for several hypotheses concerning the specific form of the grower–supply and processor–demand equations. In each case, the equations are expressed in linear form with all price and income variables in deflated terms (1967 dollars). Estimates in log form and nondeflated form were also explored. The log formulation provided parameter estimates that were consistent in sign with the linear model and which were about the same or slightly lower in statistical reliability. The linear formulation was selected primarily because of its greater convenience in the later model analysis. The model using undeflated values did not perform well.

In Table 4, equations (23.1a) and (26.1a) reflect the basic behavioral hypothesis discussed in section 3. Equation (26.1b) explores the effect of normalizing the processor demand equation on price rather than quantity. Equation set (23.2) and (26.2) is an attempt to evaluate the possibility of changes in short–run supply response as a result of the introduction of the mechanical harvester. Equation set (23.3) and (26.3) explores the possibility of a change in perceived processor demand slope after the adoption of mechanical harvesting.[1]

Supply

Equation (23.1) indicates that plantings of tomato acreage have responded significantly to changes in expected profit per acre as measured by $PRAR_t = PGCD_t \cdot YMAC_t - GCRD_{t-1}$. The coefficient of the PRAR variable measures short–run response. Referring to the 3SLS estimate, the coefficient .2551 indicates that, with all other variables constant, each dollar increase in return per acre or decrease in cost per acre has been associated with an average increase of 255 acres in that year. The long–run response, obtained by setting $AC_{t-1} = AC_t$ and solving for AC, is .6343. This indicates that, with all other factors constant, the final effect of each dollar increase in return per acre would be to increase acreage by about 634 acres.

The variable, TC (percent of acreage harvested mechanically), was introduced to account for a possible change in response level due to the different labor environment and perceptions of uncertainty with the shift to mechanized harvest. It was not strongly significant as indicated by the relatively low t ratio. However, it is of the expected sign, and retention of the variable improves the overall estimation results.

Chern and Just have argued that the increased fixed cost relative to variable cost associated with the change to mechanized harvesting would be expected to reduce the elasticity of supply. Moreover, their pooled county supply model generated results which supported that hypothesis. In the present analysis, this kind of change is expressed as a hypothesis that the partial adjustment coefficient may have declined with increased mechanization. This would reduce the short–run supply response while leaving long–run supply response unchanged.

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[1]For reasons noted in the discussion of results, this equation set does not provide a precise specification for purposes of testing the Chern–Just hypotheses as to the effects of changes in supply response on processor perceived demand.

To test this hypothesis, cross-product terms with TC were introduced to allow the value of the partial adjustment coefficient and, therefore, all other coefficients to change with the shift to mechanization [Table 4, equation (23.2)]. The estimation results with this formulation turned out to be statistically nonsignificant, primarily for two reasons. First, the cross-product specification necessary to allow supply slopes to change with harvest mechanization introduced substantial intercorrelation among the explanatory variables. Second, an examination of the acreage and price variation during the sample period (1954–1977) shows that relatively larger variations occurred during the period after the introduction of harvest mechanization. The statistical estimates, therefore, tend to be dominated by adjustment rates after mechanization so that possible response differences prior to mechanization are not revealed by the analysis of this data set. Thus, the analysis was not able to verify further or reject the Chern–Just hypothesis.

Demand

The basic demand equation is (26.1a) in Table 4 which was estimated jointly with equation (23.1a). All coefficients are of the expected sign, and most coefficients are reasonably large relative to their standard errors. The equation indicates that the quantity of tomatoes purchased by processors decreases with increases in grower price, PGCD; increases with increases in the average price of processed products in the previous year, $PRDW_{t-1}$; decreases with increases in levels of carry–in stocks, $S1T_t$; and shifted upward during the period 1974 to 1977 when growers began active group bargaining with processors over prices.

The bargaining association influence is suggested by the positive coefficient for the dummy variable, M, which by using the 3SLS result for the 1974 to 1977 period indicates that processors desired to purchase about 1.6 million tons more per year at the same real grower price than in earlier periods. Alternatively, as suggested by (26.1b) in Table 4, processors were willing to pay a higher price for a given quantity. Whether this reflects a change in processor attitudes as a consequence of activities of the grower bargaining association or was a result of changes in other factors, such as physical characteristics of the raw tomato, is not verifiable from the data. Possibly, it reflects some combination of these influences. In any case it seems evident that the processor demand function did shift upward during this period.

The lagged average processed product price variable, $PRDW_{t-1}$, introduced through the price expectation submodel (section 3), suggests a two–stage processor adjustment to changes in grower prices. First, if grower price were reduced by $1.00 per ton (say, as a result of a cost reduction), the expected initial increase in processor purchases would be 51,318 tons. If all other things remained constant, the added 51,318 tons, when processed and offered for sale, would reduce the average processed product price. This would reduce the processor demand level in the next period so that the final effect of the change in grower price would be something less than 51,318 tons. Conceptually, processors could take immediate account of the effect of raw product changes on processed product prices, thus eliminating $PRDW_{t-1}$ as a variable. However, explorations with alternative models suggest that the present format provides a better predictor of behavior. The dynamics of the adjustment process are explored further in a later section.

In Table 4, equation (26.1b) formulates the processor demand equation with grower price as the normalized variable. The statistical results are generally acceptable, but normalization on QCT [equation (26.1a)] gives parameter estimates with lower relative standard errors and is more consistent with the original behavioral hypothesis.

Table 4

Estimates of Grower Supply and Processor Raw Product Demand Relationships for California Processing Tomatoes, 1954–1977[a]

1. Grower Supply

Right-side variable	Equation number and normalized variable 23.1a AC^b	23.1b AC^b	23.2 AC^b	23.3 AC^b
		Two–stage least squares		
Constant term	49.5412 (20.6133)[c]	Same as (23.1a)	78.9362 (64.2766)	Same as (23.2)
$PRAR_t{}^d$	.2382 (.0689)	"	.0393 (.2595)	"
$TC_t{}^e$	.1542 (.1796)	"	– .0322 (.6689)	"
$AC_{t-1}{}^b$	.6574 (.1478)	"	.4200 (.5010)	"
$TC/(100) \cdot PRAR_t$			.2330 (.2915)	
$TC/(100) \cdot AC_{t-1}$			.1800 (.4968)	
		Three–stage least squares		
Constant terms	56.6968 (20.2973)	43.1118 (20.3325)	74.9137 (62.9033)	77.8701 (64.2484)
$PRAR_t{}^d$	.2551 (.0681)	.2250 (.0685)	.1377 (.2545)	.0543 (.2594)
$TC_t{}^e$	.1982 (.1767)	.0926 (.1767)	.0243 (.6562)	– .0231 (.6686)
$AC_{t-1}{}^b$	.5978 (.1445)	.7171 (.1449)	.4525 (.4900)	.4289 (.5008)
$TC/(100) \cdot PRAR_t$			.1268 (.2870)	.2165 (.2914)
$TC/(100) \cdot AC_{t-1}$			.1416 (.4858)	.1720 (.4965)

(Continued on next page.)

2. Processor Raw Product Demand

Right-side variable	Equation number and normalized variable 26.1a QCT^f	26.1b $PGCD^g$	26.2 QCT^f	26.3 QCT^f
		Two–stage least squares		
Constant term	– 1957.6260 (1319.8526)	10.6476 (12.7998)	– 1891.6870 (1315.9478)	– 3749.8752 (1946.7863)
$PGCD_t^g$	– 51.4228 (33.3757)		– 54.6720 (32.7309)	– 52.5944 (33.3821)
$PRDW_{t-1}^h$	21.3576 (9.1105)	.1264 (.0925)	21.5822 (9.1234)	28.0869 (10.5265)
YD_t^i	10.5590 (1.2812)	.0459 (.0264)	10.6055 (1.2809)	13.4678 (2.5359)
$S1T_t^j$	– 1.4156 (.4803)	– .0116 (.0043)	– 1.4431 (.4780)	– 1.5220 (.4906)
M_t^k	1570.9260 (372.9761)	8.9914 (4.5090)	1586.2711 (372.5683)	1498.0530 (385.4264)
$TC/(100) \cdot PGCD_t$				– 26.8199 (20.3746)
QCT_t^f		– .0032 (.0024)		
		Three–stage least squares		
Constant term	– 1625.8034 (1246.5239)	10.5464 (12.2223)	– 1597.5149 (1291.6239)	– 3590.7022 (1945.8478)
$PGCD_t^g$	– 51.3183 (31.3825)		– 52.7460 (31.8801)	– 52.2284 (33.3643)
$PRDW_{t-1}^h$	19.1082 (8.5379)	.1262 (.0876)	19.0791 (8.9785)	27.2408 (10.5223)
YD_t^i	10.3040 (1.2474)	.0406 (.0254)	10.3950 (1.2681)	13.2621 (2.5341)
$S1T_t^j$	– 1.3431 (.4651)	– .0120 (.0043)	– 1.3782 (.4722)	– 1.5055 (.4904)
M_t^k	1604.9538 (356.6679)	7.1676 (4.3405)	1621.6507 (368.0976)	1509.6829 (385.3249)
$TC/(100) \cdot PGCD_t$				– 25.2263 (20.3633)
QCT_t^f		– .0022 (.0023)		

(Continued on next page.)

TABLE 4—continued.

[a] Estimated as a four-equation system involving endogenous variables QCT^b, QCT^s, AC^s, and PGCD. Equation numbers refer to Table 1. Equation (26) is obtained by substituting (25) in (26) in Table 1.

(26) Demand: $QCT_t^b = f_1(PGCD_t, PRDW_{t-1}, YD_t, S1T_t, M_t)$

(23) Acreage supply: $AC_t^s = f_2(PGCD_t, YNAC_t, GRD_{t-1}, TC_t, AC_{t-1})$

(24) Tomato supply: $QCT_t^s = YLDCP_t \cdot AC_t^s$

Equilibrium identity: $QCT_t^b = QCT_t^s$.

[b] California acreage (1,000 acres).

[c] Figures in parentheses are standard errors.

[d] PRAR = deflated return per acre (price times expected yield less cost per acre) = $PGCD_t \cdot YMAC_t - GCRD_{t-1}$.

[e] Proportion of acreage harvested mechanically.

[f] California production (1,000 tons).

[g] Deflated California grower price.

[h] Weighted average f.o.b. processed product price expressed per ton of raw product equivalent.

[i] Deflated total income.

[j] California January 1 stocks of tomato products, farm weight equivalent.

[k] Zero for all years before 1974; one thereafter.

Chern and Just have noted that, under conditions of oligopsony in the purchase of the raw product, the slope of the perceived raw product demand curve would be affected by changes in the slope of the supply curve (section 3). Their statistical findings seem consistent with such a hypothesis. Since the present analysis was unable to measure shifts in short–run supply response after harvest mechanization, a test of the associated change in demand slope may not be very meaningful. However, it may be of some interest to explore possible changes in demand slope regardless of reason. Moreover, it is still possible that the short–run supply coefficient may have decreased, although it was not verified in the analysis. In Table 4, equation set (26.3) and (23.3) provides a formulation which allows for this kind of change in demand slope.[1]

The negative coefficient for the cross–product term, TC/(100) · PGCD in equation (26.3), suggests that the slope of the demand curve may have become a bit more negative after the adoption of the mechanical harvester. However, adding this variable tends to increase the coefficients and standard errors of the income and lagged price variables, and the standard error of its own coefficient is relatively large.

Equation Selection

Evaluations of the several alternative supply and demand formulations suggest that equations (26.1a) and (23.1a) provide the best estimates of raw product demand and supply relationships in the context of this study. With the focus on aggregate aspects of industry behavior, the analysis was unable to discriminate between alternative market structure hypotheses. Hence, equations (26.1a) and (23.1a) could be reflective of either competitive or oligopsonistic behavior.

Elasticities

Supply and demand elasticity values for selected years before and after harvest mechanization, using the 3SLS results, are given in Table 5. The values obtained are generally within the range of after–mechanization elasticity estimates obtained by Chern and Just (1978, pp. 78 and 80). With higher quantities and prices in recent periods, the linear equations suggest some decline in supply elasticity after mechanization, but the magnitude of the decline is less than that found by Chern and Just. Again, however, it should be noted that the results of the present study tend to be dominated by after–mechanization behavior.[2]

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[1]Equation (26.3) is incompletely specified for purposes of evaluating the possible effects of a change in supply slope on perceived demand. Just and Chern (1980) showed that the slope coefficients of all variables in the perceived demand equation would be affected by a change in the slope of the supply curve. To allow for this effect, cross–product terms with TC would be required for all explanatory demand variables rather than just with PGCD as in (26.3). However, this would create difficult intercorrelation and degrees–of–freedom problems that preclude the obtaining of meaningful results.

[2]Chern and Just also included three more years (1951, 1952, and 1953) in their premechanization data set.

TABLE 5

Grower Supply and Processor Raw Product Demand Elasticities
Before and After Harvest Mechanization
for Selected Years, 1960, 1970, 1975, and 1977

Values	1960	1970	1975	1977
Elasticities				
Short-run supply[a]	.833	.785	.681	.654
Long-run supply[b]	2.072	1.952	1.694	1.627
Demand[c]	− .602	− .331	− .243	− .238
Data				
YMAC[d]	16.100	20.070	23.670	23.130
$PGCD_t$[e]	26.380	21.670	34.490	30.910
AC_t[f]	130.000	141.300	305.600	278.800
QCT_t[g]	2249.000	3363.000	7271.000	6670.000

[a]Short-run supply elasticity = .2551 · YMAC · (PGCD)/AC.

[b]Long-run supply elasticity = .6343 · YMAC · (PGCD)/AC.

[c]Short-run elasticity of demand for raw product = −51.3183 · (PGCD)/QCT.

[d]Three-year average California yield per acre.

[e]Deflated California grower price.

[f]California acreage (1,000 acres).

[g]California production (1,000 tons).

Source: Computed from equations (26.1a) and (23.1a), three-stage least squares, Table 4, *supra*, p. 32.

The short–run supply elasticities show the immediate percentage change in acreage associated with a given percentage change in grower price. In 1970, for example, a 1 percent increase in grower price was associated with .785 percent increase in acreage. The long–run elasticities reveal the final percentage response of acreage to a given percentage change in grower price, with all other factors constant. The long–run elasticity is substantially greater than the corresponding short–run elasticity.

The processor raw product demand appears rather inelastic and also has declined, although the decline would be less if equation (26.3) in Table 4 were used. The values are in the same general range as obtained by Chern and Just (1978, p. 80) for the 1967–1975 period. The concept of a long–run elasticity is less clear in the case of the demand equation. When expressed within the framework of the complete system, the lagged average processed product price and the January 1 inventories are affected by lagged quantity. These dynamic effects are calculated in the later analysis of the complete system.

January 1 Stock Prediction

Since the industry model is formulated in terms of annual observations beginning July 1, it is necessary to have an equation to predict January 1 stocks, S1T, which appears as a variable in the California processor demand equation. The OLS estimate of this equation in Table 1 is

$$(28)\quad S1T_t = \underset{(85.8650)}{21.9220} + \underset{(.1491)}{.8464}\ SCT_{t-1} + \underset{(.0382)}{.3772}\ QCTR_{t-1}, \qquad R^2 = .863.$$

The values in parentheses are standard errors.

Other Region Production and Acreage

The Other Region Production and Acreage block consists of equations (31) through (42) in Table 1. Estimates of the four behavioral equations are given in Table 6. The equations are estimated by OLS since the explanatory variables are all regarded as predetermined in each equation. Grower price is determined by lagged values of price and quantity, by a trend factor, and by California grower prices which are usually established earlier in each year. The regional grower price then enters as a predetermined variable in the regional acreage equation.

As was indicated in section 3, these equations are partially descriptive but provide acceptable estimates of acreage adjustment processes in these regions. The signs of all coefficients are consistent with theoretical expectations, the standard errors are mostly low relative to the coefficient values, and the equations explain reasonably large proportions of variations in the endogenous variables. Alternative formulations, which were explored but gave less satisfactory results, are not reported.

6. THE COMPLETE MODEL

The empirically estimated counterpart of the model outlined in Table 1 is presented in Table 7. For ease of computer calculations, the equations are numbered consecutively rather than grouped as in Table 1. Equation (25) in Table 1 is eliminated by substitution, as

TABLE 6

Ordinary Least-Squares Estimates of Acreage and Grower Price Relationships for the Midwest and East, 1954–1977

Midwest			*East*		
	Equation number (Table 1) and dependent variable			Equation number (Table 1) and dependent variable	
Right-side variable	(31) $PGMD_t$ [a]	(32) AM_t [b]	Right-side variable	(34) $PGED_t$ [c]	(35) AE_t [d]
Constant term	18.5951 (5.8829)[e]	47.6922 (10.5384)	Constant term	19.2293 (8.0545)	51.6847 (11.4147)
$PGMD_t$ [a]		1.4612 (.4349)	$PGED_t$ [c]		1.0228 (.2981)
$PGMD_{t-1}$ [a]	.2948 (.1200)		$PGED_{t-1}$ [c]	.3724 (.1630)	
QMT_{t-1} [f]	– .0080 (.0026)		QET_{t-1} [g]	– .0066 (.0046)	
$PMSD_{t-1}$ [h]		– 8.8346 (2.3088)			
$PGCD_t$ [i]	.2707 (.0853)		$PGCD_t$ [i]	.3754 (.1253)	
T[j]	.2071 (.0665)	– 1.2518 (.1568)	T[j]	– .1306 (.1068)	– 2.9111 (.1565)
R^2 [k]	.769	.829	R^2 [k]	.510	.944
D.W.[l]	2.21	1.90	D.W.[l]	1.75	1.35

[a]Deflated grower price of tomatoes (Midwest).

[b]Planted tomato acreage (Midwest; 1,000 acres).

[c]Deflated grower price of tomatoes (East).

[d]Planted tomato acreage (East; 1,000 acres).

[e]Figures in parentheses are standard errors.

[f]Tomato production (Midwest; 1,000 tons).

[g]Tomato production (East; 1,000 tons).

[h]Deflated farm price of soybeans (Ohio; dollars per bushel).

[i]Deflated grower price of tomatoes (California).

[j]1 in 1954.

[k]Coefficient of determination.

[l]Durbin-Watson statistic.

(For further details of variable definitions, see Table 1, *supra*, p. 6.)

TABLE 7

U. S. Processing Tomato Industry Structural Equations

(1) $$S1T_t = 21.9220 + .8464\ SCT_{t-1} + .3772\ QCTR_{t-1}$$

(2) $$QCT_t = -1625.8034 - 51.3183\ PGCD_t + 19.1082\ PRDW_{t-1} + 10.3040\ YD_t - 1.3431\ S1T_t + 1604.9538\ M_t$$

(3) $$AC_t = 56.6968 + .2551\ YMAC \cdot PGCD_t - .2551\ GCRD_{t-1} + .1982\ TC + .5978\ AC_{t-1}$$

(4) $$QCT_t = YLDCP_t \cdot AC_t$$

(5) $$PGMD_t = 18.5951 + .2948\ PGMD_{t-1} + .2071\ T - .0080\ QMT_{t-1} + .2707\ PGCD_t$$

(6) $$AM_t = 47.6970 + 1.4612\ PGMD_t - 8.8346\ PMSD_{t-1} - 1.2518\ T$$

(7) $$QMT_t = YLDMP_t \cdot AM_t$$

(8) $$PGED_t = 19.2293 + .3724\ PGED_{t-1} - .1306\ T - .0066\ QET_{t-1} + .3754\ PGCD_t$$

(9) $$AE_t = 51.6850 + 1.0228\ PGED_t - 2.9111\ T$$

(10) $$QET_t = YLDEP_t \cdot AE_t$$

(11)[a] $$QRT_t = RR_t\ (QCT_t + QMT_t + QET_t)$$

(12) $$QOT_t = QMT_t + QET_t + QRT_t$$

(13)[b] $$AR_t = RA_t\ (AC_t + AM_t + AE_t)$$

(14) $$A_t = AC_t + AM_t + AE_t + AR_t$$

(15) $$QT_t = QCT_t + QOT_t$$

(16)[c] $$QWC_t = RWC_t \cdot QCT$$

(17)[c] $$QJC_t = RJC_t \cdot QCT$$

(18)[c] $$QCC_t = RCC_t \cdot QCT$$

(19)[c] $$QUC_t = RUC_t \cdot QCT$$

(20)[c] $$QPIC_t = RPC_t \cdot QCT$$

(21) $$QCTR_t = .014\ QWC_t + .014\ QJC_t + .030\ QCC_t + .035\ QUC_t + .066\ QPIC_t$$

(22)[d] $$QW_t = QWC_t + RWO_t \cdot QOT_t$$

(Continued on next page.)

TABLE 7—continued.

$$(23)^d \quad QJ_t = QJC_t + RJO_t \cdot QOT_t$$

$$(24)^d \quad QU_t = QUC_t + RUO_t \cdot QOT_t$$

$$(25) \quad SW_t = SW_{t-1} + QW_{t-1} - AW_{t-1} - EW_{t-1}$$

$$(26) \quad SJ_t = SJ_{t-1} + QJ_{t-1} - DJ_{t-1} - EJ_{t-1}$$

$$(27) \quad SCC_t = SCC_{t-1} + QCC_{t-1} - DCC_{t-1}$$

$$(28) \quad SU_t = SU_{t-1} + QU_{t-1} - DU_{t-1}$$

$$(29) \quad SPIC_t = SPIC_{t-1} + QPIC_{t-1} - DPIC_{t-1}$$

$$(30) \quad SWC_t = (QWC_{t-1} \div QW_{t-1})\ SW_t$$

$$(31) \quad SJC_t = (QJC_{t-1} \div QJ_{t-1})\ SJ_t$$

$$(32) \quad SUC_t = (QUC_{t-1} \div QU_{t-1})\ SU_t$$

$$(33) \quad SCT_t = .014\ SWC_t + .014\ SJC_t + .030\ SCC_t + .035\ SUC_t + .066\ SPIC_t$$

$$(34) \quad PWD_t = 7.0763 - 16.9024\ DWN_t - .0957\ DOVN_t + .0018\ YND_t$$

$$(35) \quad AWN_t = .0442 + .6354\ [(SW + QW)/N]_t + .0242\ PWD_t - .0242\ PWD_{t-1}$$

$$(36) \quad DWN_t = AWN_t + IWN_t$$

$$(37) \quad PJD_t = 7.1758 - 20.6285\ DJN_t + .6041\ VJ_t - .0503\ T$$

$$(38) \quad DJN_t = .0270 + .6877\ [(SJ + QJ)/N]_t + .0344\ PJD_t - .0344\ PJD_{t-1}$$

$$(39) \quad PCD_t = 5.3873 - 22.5035\ DCN_t - 11.6775\ [(SCC)/N]_t + .0009\ YND_t$$

$$(40) \quad DCN_t = .1025 + 1.2924\ [(SCC + QCC)/N]_t + .0452\ PCD_t - .0452\ PCD_{t-1}$$

$$(41) \quad PUD_t = 2.6699 - 30.1158\ [(SU + QU)/N]_t + .0013\ YND_t$$

$$(42) \quad DUN_t = -.0008 + .7896\ [(SU + QU)/N]_t + .0106\ PUD_t - .0106\ PUD_{t-1}$$

$$(43) \quad PPD_t = 2.5398 - 24.1768\ DPN_t - 147.8438\ [(SPIC)/N]_t + .0033\ YND_t$$

$$(44) \quad APN_t = .0173 + .9812\ [(SPIC + QPIC)/N]_t + .0037\ PPD_t - .0037\ PPD_{t-1}$$

(Continued on next page.)

TABLE 7—continued.

$$(45)\quad DPN_t = APN_t + IPN_t$$

$$(46)\quad AW_t = N_t \ (AWN_t)$$

$$(47)\quad DW_t = N_t \ (DWN_t)$$

$$(48)\quad DJ_t = N_t \ (DJN_t)$$

$$(49)\quad DC_t = N_t \ (DCN_t)$$

$$(50)\quad DU_t = N_t \ (DUN_t)$$

$$(51)\quad AP_t = N_t \ (APN_t)$$

$$(52)\quad DP_t = N_t \ (DPN_t)$$

$$(53)^e\quad DCC_t = KCC_t \ (DC_t)$$

$$(54)^f\quad DPIC_t = KPC_t \ (AP_t + EP_t)$$

$$(55)^g\quad PRDW_t = 9.9968 \ PWD_t + 4.2901 \ PJD_t + 10.2211 \ PCD_t + 1.3042 \ PUD_t + 4.2411 \ PPD_t$$

$$(56)\quad MRDW_t = PRDW_t - PGCD_t$$

[a]RR = three-year centered moving average of $QRT_t \div (QCT_t + QMT_t + QET_t)$.

[b]RA_t = three-year centered moving average of $AR_t \div (AC_t + AM_t + AC_t)$.

[c]RKC_t = three-year centered moving average of $QKC_t \div QCT_t$; K = W, J, C, U, and P.

[d]RKO_t = three-year centered moving average of $QKO_t \div QOT_t$; K = W, J, and U.

[e]KCC_t = three-year centered moving average of $DCC_t \div DC_t$.

[f]KPC_t = three-year centered moving average of $DPIC_t \div (AP_t + EP_t)$.

[g]Computed from the following: PWRD = 71 PWD_t; PJRD = 46.43 PJD; PCRD = 43.42 PCD; PURD = 17.89 PUD; PPRD = 9.25 PPD (Appendix Table A.17 for coefficient values); and PRDW = .1408 PWRD + .0924 PJRD + .2354 PCRD + .0729 PURD + .4585 PPRD where the weights are 1973–1977 average proportions of reported processed product sales in each product form, measured in farm-weight equivalents.

explained previously. The model consists of 56 behavioral equations, technical relationships, and identities—one equation for each endogenous variable in the system. It provides a means of predicting expected annual values of the endogenous price and quantity variables, given the values of the exogenous income, cost, population, yield, import, export, trend, and shift variables.

Model Components

In Table 7, equations (1) through (4) involve processor demand and grower supply relationships in California. Equations (5) through (10) pertain to grower price and production in the Midwest and East. The small amounts of production and acreage in regions other than California, the Midwest, and the East are calculated by equations (11) to (13). Equations (14) and (15) accumulate regional values into U. S. totals.

As noted in section 3, attempts to predict allocations of the raw product to processed forms according to economic criteria were unsuccessful. The raw product, therefore, was allocated according to historical moving average ratios of the reported processed product in each of the major forms to the quantity of the raw product produced. This is accomplished by equations (16) to (24). As was noted previously, because of data limitations the reported pack values do not account for all of the tomatoes delivered to canners. In California, the reported pack is about 55 percent of the equivalent raw product deliveries (compare QCTR and QCT).

Equations (25) to (29) compute carry–in stocks from previous year values of carry–in stocks, pack, sales, imports, and exports. Equations (30) to (32) predict California carry–in stocks of canned tomatoes, juice, and puree, using U. S. stocks and the lagged ratio of California pack to U. S. pack. Equation (33) aggregates the California stocks in terms of raw product equivalents.

Equations (34) to (45) are the f.o.b. processor demand functions and the processor market allocation equations for the five major processed product forms. Equations (46) to (52) compute total disappearance values by multiplying per capita quantities by population. Equations (53) and (54) provide estimates of California shipments of catsup and chili sauce and paste using historical moving average ratios to U. S. values. Equation (55) calculates a weighted average processed product price in the raw product weight, and (56) computes the residually determined processed product margin indicator.

Solution Procedures

If the values of the exogenous and lagged endogenous variables of the model are given, the equation set in Table 7 can be solved to obtain predicted values of all of the endogenous variables. Two solution approaches were used: (1) a modified Gauss-Seidel procedure for historical predictions and (2) an analytical solution (with nonlinear equations converted to linear approximations) which provides a basis for evaluating dynamic properties and calculating long–run multipliers.

The Gauss-Seidel solution is an iterative procedure that is particularly useful with nonlinear systems. The equations are ordered in a sequence, such as in Table 7, but with the equations structured so that every endogenous variable appears once on the left–hand side. To start the solution, initial values of the first endogenous variable in each jointly related set of equations are read in. For example, the initial values may be the values of the previous year. The predicted value of the left–hand endogenous variable in the first equation is computed, and that value is used to obtain the prediction for the next equation, and so on. After a complete iteration, the new predicted value of the first endogenous variable is applied to the first equation, and the process is repeated. A final solution is obtained when the changes in values of the endogenous variables from one iteration to the next are all less than some predetermined value such as, say, .1 percent.

Since the California grower–supply and processor demand submodel was estimated with quantity (acreage or production) as the normalized variable in both the supply and demand equations, it was necessary to transform the demand equation so as to make grower price the dependent variable. This caused a convergence problem.[1] The problem was solved by replacing equation (2) with the partial reduced–form solution for PGCD obtained from equations (2) and (3) and the identity, QCTD = AC · YMAC. The latter identity is appropriate at this point since, with the disturbance term set at zero, equation (2) predicts QCTD (quantity demanded) as well as quantity purchased, QCT. The efficiency of the solution procedure was further increased by replacing the structural equations of the processed product demand and market–allocation block [equations (34) through (45)] with partial reduced–form equations for each commodity subset. With these adjustments, a solution is obtained with a single pass for the values of the endogenous variables which satisfy the equation system, given the values of all exogenous variables and lagged endogenous variables. In the solution for year, t + 1, the solution values of endogenous variables for year t become the lagged endogenous variables in t + 1.

If the values of yields, population, and the technical coefficients of the model are specified, all the equations of the system are linear except for (30), (31), and (32). Linear approximations of these equations may be obtained by Taylor Series expansion around the mean values of the stock and pack variables.[2] With this modification, the complete model may be expressed in matrix form as

$$B_1 \; Y_t = B_2 \; Y_{t-1} + B_3 \; Z_t \qquad (6)$$

where

Y_t = 56 × 1 element vector of current endogenous variables

Y_{t-1} = 56 × 1 element vector of lagged endogenous variables

Z_t = 15 × 1 element vector of exogenous variables (including the constant term)

B_1 and B_2 = 56 × 56 element matrices of coefficients of current and lagged endogenous variables

and

B_3 = 56 × 15 element matrix of coefficients of the exogenous variables (Appendix Table D.1).

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[1]For a discussion of such convergence problems with the Gauss–Seidel procedure, see Heien, Matthews, and Womack (1973). When equation (2), Table 7, *supra*, p. 39, was replaced by the processor demand equation estimated with PGCD as the dependent variable, the solution converged readily.

[2]The linear approximations are given in Appendix Table D.1, footnote *a*, *infra*, p. 106.

The reduced—form solution for this system is obtained by multiplying by B_1^{-1}. That is,

$$B_1^{-1} \; B_1 \; Y_t = B_1^{-1} \; B_2 \; Y_{t-1} + B_1^{-1} \; B_3 \; Z_t$$

or (7)

$$Y_t = H_1 \; Y_{t-1} + H_2 \; Z_t.$$

A difficulty with this procedure is that a new inverse must be computed whenever values of yields, population, or the technical coefficients change (Appendix Table D.1). Thus, the modified Gauss—Seidel solution is more efficient for computing historical predictions of the model. On the other hand, the analytical solution provides a more convenient means of evaluating dynamic properties and computing long–run multipliers for use in projection analysis.[1]

Appraisal of the Model

The usefulness of the tomato industry model in further analysis is determined by the extent to which it is a valid representation of the system under study. This may be judged in accordance with (1) the logic of the basic behavioral equations, (2) the statistical tests applied to the estimates of equation parameters, (3) the ability of the model to track historical movements of key variables in the system, (4) the ability to predict values of variables in recent years beyond the observation period, (5) the stability properties of the model, and (6) the structural properties when viewed as a complete system.

Validity of the Behavioral Equations

The logical structure and the statistical properties of individual equations were discussed in sections 3 and 5. All of the equation specifications appear consistent with generally accepted theoretical concepts of firm and market behavior, and the coefficients of all equations have the theoretically expected sign. The standard errors are generally smaller than the values of their coefficients, and most coefficients are significantly different from zero at the 5 percent level of significance.

Goodness of Fit

The closeness with which the model is able to track or predict historical movements of the endogenous price and quantity variables may be evaluated in terms of (1) its ability

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[1]Note that stationary equilibrium values for given values of exogenous variables may be readily computed by either method. In the modified Gauss–Seidel solution, this is done by fixing the exogenous variables and technical coefficients and letting the model run for 20 or so periods into the future. The analytical solution computes the stationary equilibrium values by $Y^* = (I - H_1)^{-1} H_2 Z^*$ as explained more fully with the later presentation of long–run multipliers. The two estimates of stationary equilibrium values do not coincide precisely because of the linear approximations used in the analytical solution; however, they are very close. This provides an important means of checking for possible errors which may creep in as a result of accidentally entering wrong coefficient values in the computer model.

to predict one–period changes for given values of exogenous variables and lagged endogenous variables and (2) its ability to predict movements of endogenous variables over time, given some initial set of values of endogenous variables and the values of all exogenous variables. The sequential model (2) uses the past predicted values of lagged endogenous variables rather than actual values in generating current year predictions.

Table 8 presents several measures of the model's performance in predicting changes in the major endogenous variables one period ahead. Column 2 gives the average difference between the actual and predicted values of each variable. For unbiasedness, it would be desirable for these mean differences to be zero. While only one average difference is zero, most are very small relative to the mean values of the variables. Thus, the model does not appear to predict significantly too high or too low.

The mean absolute errors and the root mean square errors (RMSE) provide measures of how closely the model predictions associate with the actual values.[1] The RMSE may be used to obtain a rough indication of the distribution of the unexplained differences. If the differences are approximately normally distributed, about two–thirds of the predictions may be expected to fall within one RMSE of the actual values and about 95 percent between two RMSE. For most variables, the average percentage error is between about 5 and 8 percent. The higher average errors for the puree variables (DUN and PUD) reflect the previously noted difficulty in obtaining a good estimate of the demand for this commodity.

Another measure of forecast accuracy is given by Theil's U statistic or *inequality coefficient* (Theil, 1966). It is computed by dividing the RMSE (in relative terms) by the mean of the squared actual relative changes.[2] The denominator is the RMSE assuming zero forecasted change. If forecasts are perfect, U is zero. A value of U = 1 would indicate a *status quo* forecast. Values of U greater than unity suggest a forecast that is worse than simply projecting the *status quo*. The values of U given in Table 8 suggest that the model forecasts, while generally better than simply projecting the previous–year value, do not provide highly accurate forecasts of year–to–year changes. However, the total set of goodness–of–fit measures suggest that the model is a reasonable representation of the industry structure in longer run terms, although a considerable amount of year–to–year variation remains unexplained.

Table 9 presents measures of historical accuracy of predictions in which only the values of exogenous variables and the initial (1954) values of lagged endogenous

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[1]The RMSE is the square root of the mean of the squared differences between predicted and actual values.

[2]Let A be the actual value of a variable in period t and P_t the predicted value of the variable. Define $a_t = (A_t - A_{t-1})/A_{t-1}$ and $p_t = (P_t - P_{t-1})/P_{t-1}$. Then,

$$MSE = \frac{1}{n} \Sigma (p_t - a_t)^2$$

and

$$U = \frac{\sqrt{MSE}}{\sqrt{\frac{1}{n} \Sigma a_t^2}}.$$

TABLE

Goodness-of-Fit Measures, Processing Tomato Industry Model, One-Period-

Variable	Mean value, $\bar{X}_a$	Mean of differences, $\bar{X}_a - \bar{X}_p$	Mean absolute error: Actual units	Mean absolute error: Percent/100
AC	177.3	.26	14.06	.083
PGCD	29.11	- .45	3.04	.113
QCT	3,618.6	4.61	290.99	.085
AM	56.2	2.15	4.27	.078
PGMD	34.10	1.28	1.61	.047
QMT	814.3	25.03	61.07	.081
AE	52.3	- 1.21	4.30	.075
PGED	37.63	- 1.12	2.55	.071
QET	586.2	-18.8	48.62	.081
DWN	.211	- .005	.011	.051
PWD	3.20	- .130	.158	.048
DJN	.195	.000	.008	.043
PJD	2.84	.019	.136	.050
DCN	.164	- .001	.010	.060
PCD	3.92	.085	.266	.063
DUN	.038	.001	.005	.147
PUD	4.74	.128	.446	.095
DPN	.099	.002	.005	.057
PPD	7.90	.071	.925	.117
PGDW	123.9	.090	8.14	.065
MRDW	94.8	.536	7.10	.073

[a]Actual values of DCN and DPN were computed by supplementation from confidential survey data. These

Source: Calculated.

Change Predictions, 1955–1977, and 1978–79 and 1979–80 Prediction Errors

Root mean square error			1978 and 1979 prediction errors ($X_a - X_p$)	
Actual units	Percent / 100	Theil's U statistic	1978	1979
17.44	.101	.527	– 14.84	5.03
3.78	.138	.748	– 3.98	– 8.63
372.09	.105	.403	–331.3	124.63
4.97	.095	.940	– 10.02	– 4.27
2.45	.073	.796	– 3.01	– 6.42
70.72	.097	.411	199.8	– 71.68
5.51	.092	.828	1.93	2.35
3.47	.096	.970	– 5.32	– 8.56
62.20	.103	.365	23.79	31.04
.014	.064	.810	– .018	– .015
.213	.065	.816	– .114	– .659
.009	.052	.817	– .001	.006
.181	.065	.770	.149	– .254
.011	.069	1.174	*a*	*a*
.372	.093	.894	.202	– .282
.007	.185	2.259	– .013	– .013
.593	.119	.937	– 1.082	– 1.784
.008	.075	.598	*a*	*a*
1.247	.144	.799	1.332	– 1.151
10.17	.083	.773	5.78	– 19.12
8.68	.090	.784	9.76	– 10.50

data were not computed for 1978.

TABLE 9

Goodness-of-Fit Measures, Processing Tomato Industry Model
Sequential Predictions, 1955–1977

Variable	Mean value, $\bar{X}_a$	Mean of differences, $\bar{X}_a - \bar{X}_p$	Mean absolute error: Actual units	Mean absolute error: Percent/100	Root mean square error: Actual units	Root mean square error: Percent/100
AC	177.3	1.31	17.70	.105	22.80	.132
PGCD	29.11	- .38	3.45	.125	4.20	.150
QCT	3,618.6	27.36	366.03	.110	492.94	.141
AM	56.2	2.50	4.92	.091	5.82	.110
PGMD	34.1	1.52	1.97	.058	2.68	.080
QMT	814.3	30.69	71.65	.096	85.54	.117
AE	52.3	- 1.45	5.05	.088	6.42	.107
PCED	37.63	- 1.35	3.18	.089	3.90	.109
QET	586.2	-21.86	57.54	.095	73.22	.117
DWN	.211	- .002	.011	.053	.013	.064
PWD	3.20	- .184	.197	.060	.256	.078
DJN	.195	- .002	.010	.050	.011	.059
PJD	2.84	.065	.207	.077	.256	.094
DCN	.164	- .004	.012	.072	.014	.084
PCD	3.92	.167	.416	.103	.476	.119
DUN	.038	- .000	.003	.071	.003	.086
PUD	4.74	.081	.530	.114	.679	.139
DPN	.099	.001	.005	.049	.007	.063
PPD	7.90	.158	1.052	.131	1.286	.156
PRDW	123.9	.901	8.98	.071	11.02	.088
MRDW	94.8	1.29	7.36	.075	9.067	.093

Source: Calculated.

variables are given. The predictions following the first year use predicted values of lagged endogenous variables in further calculations rather than actual values. As would be expected, the overall fit is less close than for the one–period–change model, but the absolute percentage error still remains reasonably small. The U statistic was not calculated in this case since it appears to have limited applicability in the context of the sequential calculations.

Prediction Beyond the Observation Period

It may be recalled that the parameters of the behavioral equations of the model were estimated from data which extended through the 1977–78 crop year. As more recent data became available, the model's applicability to 1978–79 and 1979–80 conditions was tested by comparing model predictions with actual values for these later years. The differences between actual and predicted values of the key endogenous variables of the system are given in the last two columns of Table 8.

All of the predictions fall within three standard deviations (RMSE) of the actual values, with one exception; and most are within two standard deviations. This suggests that the model has continued to generate predictions within the general probability range of the observed data. The exception noted above is for the estimate of the puree price (PUD) where the predicted value for 1979–80 exceeded the actual value by slightly more than three times the RMSE. This larger than expected deviation is associated with a reduction in the reported (undeflated) 1979–80 price which, when deflated, yields a price below any observed during the previous 25 years. At this point, it is difficult to tell whether this reflects some difference in data reporting, a temporary aberration, or a more fundamental change in the structure of demand. In any case, it should be noted that puree accounts for only about 7 percent of the reported pack of tomato products, so the impact on the overall model predictions is not great.

Stability Properties

A dynamic model should have the property that, when all exogenous variables are held constant, the endogenous variables eventually converge to stationary equilibrium values or oscillate around stationary values rather than continually increasing or decreasing. To test for convergence using the modified Gauss–Seidel solution procedure, all exogenous variables are held constant at some specified level and the model allowed to generate values of the endogenous variables for a number of periods in the future. When this was done with the exogenous variables held at 1979–80 values, all endogenous variables appeared to be closely converging to stationary equilibrium values within a few years.

A more rigorous test for stability may be obtained from the analytical solution of the linearized model. For convergence, it is required that the absolute value of the largest characteristic root (or modulus) of H_1 [equation (7)] be less than one. As expected, this proved to be the case. The dominant root of H_1 is complex with modulus equal to .75, indicating a dampening cycle in the movement of the system. Inspection of the printout of time paths of the endogenous variables revealed the amplitude of the cycles to be very small, with each variable closely approaching the stationary equilibrium value within a few years.

Structural Properties

Sometimes when an apparently well–formulated dynamic model of a complete system is used to project beyond the range of observed values of the data set or when the model is manipulated to evaluate the impact of some policy or technical change, it may generate values for some variables that appear inconsistent with expected behavior. This may occur because the linear or other specific algebraic equation forms used can only approximate the substantially more complex actual relationships and because the model, of necessity, relegates the influence of some variables to a component of the unexplained residuals. When such problems are encountered, it may be necessary to reformulate the model or, if that does not appear feasible, to impose restrictions designed to keep any errant variable within acceptable bounds. The restrictions should, of course, be examined carefully to insure that they do not introduce other significant distortions into the model.

The model of the tomato industry appears generally well behaved in most applications. In a computer experiment to evaluate what might have happened without mechanical harvesting, it was found that processor margins, if left unconstrained, would change to levels which appear questionable as a permanent outcome. The source of the difficulty is in the manner in which margins are determined. The average processor margin (MRDW in the model) is determined residually as the difference between the realized average processed product price and grower price. These margins have varied considerably over time (Appendix Table A.13), and the model simulates the historical variation reasonably well. Since the average processed product price–quantity demand slope is less than the estimated raw product price–quantity demand slope, increases in quantity processed (with all other variables constant) are associated with increases in the margin. Historically, variations in income, production inventories, population, and unexplained disturbances have been such that the margin has fluctuated around an overall average level even though output has increased.

The positive association of margins and production could be considered to reflect an imperfectly competitive structure of demand and/or increasing marginal costs of processing. Note, however, that, if equation (26.1b) were used in place of (26.1a)—raw product demand normalized on grower price—the margin–production relationship would be reversed. That is, the price–quantity demand slope at the grower level would be less than at the f.o.b. processor level, and the margin would be a decreasing function of production. These inconsistencies are reflective of the problems associated with defining and estimating a *true* processor demand function for the raw product as noted in sections 3 and 5. If demand slopes were the same at both the f.o.b. processor and grower level (as would be expected if competition were perfect and marginal costs constant), margins would not change with output.

While the possibility of margin variation with output cannot be rejected on either logical or empirical grounds, such variation seems likely to be associated with variation around general trend levels of output. It seems unlikely that the average level of margins would change significantly with more permanent shifts in output levels.[1] However, the margin–predicting equation of the model is not able to distinguish between long– and short–run output variation. Thus, in a simulation experiment in which other margin–affecting variables remain constant and in which only the changes in general output level are examined, it seems reasonable to impose a restriction to allow the processor to shift the raw product demand curve so as to maintain whatever predetermined margin level is deemed appropriate. Results with and without the restriction and with possible alternative parameter values may be explored to define plausible ranges within which the expected output and price effects might be contained. This is discussed more specifically in the next two sections which utilize the model for issue analysis and projection.

7. IMPACT OF MECHANIZED HARVESTING ON OUTPUT, EMPLOYMENT, AND PRICES

The development of mechanical harvesting of processing tomatoes has generated substantial discussion and controversy concerning its impact on employment and prices of tomato products. Social welfare and sociological effects have been evaluated by Schmitz and Seckler (1970); Hightower (1972); Friedland and Barton (1975); Thompson and Scheuring (1978); and de Janvry, LeVeen, and Runsten (1980). Further calculations of effects on supply response and labor displacement are found in Chern (1976); Brandt, French, and Jesse (1978); and Chern and Just (1978). A limitation of all of these studies, with the partial exception of the Chern–Just study, is that the estimates of acreage change and labor displacement focus only on the growing side, without taking full account of the interaction of shifting supply functions with processor demand functions. This may result in an overestimation of supply impacts and underestimation or overlooking of important price influences.

To evaluate the impact of mechanical harvesting, we need to be able to estimate and compare expected differences in output, employment, and prices with and without this development. The industry model estimated in this study provides a framework for making such comparisons.

Supply Response with Continued Hand Harvest

It may be instructive first to note how the supply response function [equation (23.1a)] may be altered to reflect a continuation of hand–harvest conditions. The general function is:

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[1]Whether the marginal cost of processing is constant, increases or decreases with industry output is an empirical question which cannot be answered fully with the data at hand. However, in view of the modular nature of processing plant organization and the ability to vary output by length of run (number of shifts and number of days), it seems likely that marginal costs would not change much with variations in short–run industry output. Over longer periods, the modular structure noted above plus ability to vary plant numbers and locations may be such that long–run unit processing costs also are not greatly influenced by industry output levels.

$$AC_t = 56.70 + .2551\ YMAC_t\ (PGCD_t) - .2551\ GCRD_{t-1} + .1982TC_t + .5978AC_{t-1} \quad (23.1a)$$

where GCRD estimates the general trend of actual average cost per acre over time for whatever harvest method or combination of methods was in use each year. The equation for long–run response may be obtained by setting $AC_{t-1} = AC_t$ to obtain

$$AC_t = 140.97 + .6343\ YMAC_t\ (PGCD_t) - .6343\ GCRD_{t-1} + .4928\ TC_t. \quad (23.1a')$$

The supply equation assuming continued hand harvest is obtained by setting TC = 0 and replacing GCRD with GCRHD. The GCRHD series is identical to GCRD up to 1961. From 1961 to 1969, it is based on reported costs in hand harvest studies (Appendix B). Estimates from 1970 on were obtained by multiplying machine harvest costs by 1.21, the ratio of hand harvest to machine harvest in 1969.[1]

To illustrate the interpretation of the equations, consider the situation in 1970 in which hand harvest costs per acre were estimated at $110 above mechanical harvest cost. With grower price constant, growers would have been willing to plant 47.88 thousand acres less under hand harvest in the short run (.2551 x 110 + 19.82) and 119.05 thousand acres less in the long run (.6343 x 110 + 49.28). It is clear, however, that grower price would not remain constant. As growers reduced acreage, this would increase price, so the final reduction in acreage would be considerably less than indicated above.

To obtain the predicted differences in the equilibrium values of acreage, with and without mechanical harvest, it is necessary to solve the complete model. The procedure followed is first to generate predictions of historical variation in output and prices using the sequential model whose performance was evaluated in Table 9. The supply component of this model is then modified by using the production cost series based on the higher hand harvest costs and by setting the TC variable in the supply equation at zero and then generating sequential predictions of output and prices under these conditions. Differences in associated employment levels then are estimated, using estimates of labor requirements per acre or per ton as described in Appendix C.

With the termination of the Bracero Program in 1964, it seems very doubtful that the labor needed to hand harvest the volume of production required to satisfy increased demands for tomato products could have been obtained without substantial wage

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[1]The average ratio for 1967 to 1969 was also 1.21.

inducements. The uncertainties of the hand labor supply also made tomatoes so much less attractive to many growers that there was considerable speculation that much production might be shifted to Mexico. While there is no way to know what actually would have happened, the industry model provides a framework for evaluating the effects under alternative labor cost scenarios, thus suggesting some quantitative dimensions to the issue. Each scenario varies the assumed wage cost where the wage cost reflects the combined effects of wage rates, labor acquisition cost, and uncertainty cost.

Impacts on Output and Prices

Model predictions of changes in California acreage, production, and prices (if mechanical harvesting had not been developed) are presented in Table 10 for the period 1964 (when mechanized harvesting started gaining a significant portion of total harvest) until 1977. The latter date might be regarded as roughly the end of the first wave of mechanization and the start of the second wave involving electronic sorting. The impact of electronic sorting is considered in the next section. The acreage and price values were obtained by starting the model operating with actual values of the lagged endogenous variables for 1954 and then generating sequential predictions to 1977, the last year for which data were available when the model was estimated. The values of the exogenous variables are the same in each simulation run. Only the production cost series and the TC variable change.[1] In the hand–harvest simulation, the processor margin, MRDW, is constrained to be within ± 50 cents per ton of the margin predicted under mechanical–harvest development as explained in the previous section.

It should be stressed that what is being compared are *predictions of the model*, with and without harvest mechanization, rather than actual values. The objective is to isolate the effects of the harvest method. If the simulated hand–harvest results were compared with actual historical values of acreage and prices rather than with model predictions, an influence would be included in one series which is not included in the other.

The figures in Table 10 indicate that, without the development of the mechanical harvester, acreage and production would have been lower and grower and processed product prices higher. How much lower and higher depends on the assumptions made with regard to the labor market.[2] Model 1 assumes that labor would have continued to be fully available, with wage increases no greater than experienced under mechanical harvesting. Under these conditions, the model predicts that without mechanical harvesting there would have been 11,000–18,000 fewer acres in the early years, with the reduction reaching

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[1]Note that the production cost series used to simulate the historical development under mechanical harvesting, GCRD, is a TC weighted average of hand–harvest and mechanical–harvest costs from 1961 to 1970 when the harvester was fully adopted (Appendix B, *infra*, p. 98). The GCRD series does not include costs with electronic sorting.

[2]It is possible that higher processed product prices would have encouraged increased imports. If that happened, some U. S. production would have been displaced, so acreage declines with hand harvest would have been greater than indicated in Table 10. It is believed that this effect would have been minor within the range of projected price increases.

TABLE 10

Model Predictions of Changes in California Acreage, Production and Prices if Mechanical Harvesting Had Not Been Developed 1964–1977

Year	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]
	Predicted *decrease* in acreage (AC, 1,000 acres)			
1964	0.3	0.3	0.3	0.3
1965	1.3	1.3	1.3	1.3
1966	10.6	24.0	37.4	57.3
1967	18.3	30.7	42.1	56.8
1968	17.6	25.1	32.9	50.3
1969	14.2	20.3	27.6	42.4
1970	12.8	19.7	27.5	39.8
1971	12.1	18.6	27.7	38.8
1972	12.2	20.5	29.2	41.2
1973	14.9	23.5	31.8	44.5
1974	20.0	32.3	45.3	63.2
1975	21.0	33.9	47.5	65.5
1976	23.5	36.9	50.4	68.2
1977	29.5	46.1	62.8	85.1
	Predicted *decrease* in production (QCT, 1,000 tons)			
1964	8	8	8	8
1965	27	27	27	27
1966	204	464	723	1,103
1967	313	524	720	971
1968	372	532	696	1,066
1969	311	443	582	829
1970	306	470	655	947
1971	286	440	657	919
1972	302	506	722	1,017
1973	323	508	689	964
1974	462	749	1,049	1,463
1975	499	807	1,131	1,558
1976	450	705	963	1,303
1977	705	1,104	1,503	2,035

(Continued on next page.)

TABLE 10—continued.

Year	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]
		Predicted *increase* in grower price (PGCD)		
1964	.35	.35	.35	.35
1965	.80	.80	.80	.80
1966	2.02	4.15	6.27	8.75
1967	4.94	8.89	13.03	18.87
1968	7.45	12.62	17.65	22.78
1969	8.71	13.50	18.25	23.94
1970	8.40	12.57	16.60	22.47
1971	7.66	11.53	15.02	20.08
1972	7.28	10.66	14.22	18.81
1973	6.56	9.92	13.38	17.75
1974	6.49	9.65	12.70	16.82
1975	7.22	11.00	14.73	19.79
1976	7.21	11.21	15.26	20.67
1977	6.84	10.64	14.45	19.51
		Predicted *increase* in average processed product price (PRDW)		
1964	.31	*e*		
1965	.39			
1966	1.89			
1967	4.57			
1968	7.21			
1969	8.49			
1970	8.30			
1971	7.69			
1972	7.38			
1973	6.50			
1974	6.49			
1975	7.15			
1976	7.14			
1977	6.74			

[a] Assumes labor fully available at wage rates experienced with mechanical harvest development.

[b] Increases effective wage cost by 30 percent over Model 1.

[c] Increases effective wage cost by 60 percent over Model 1.

[d] Increases effective wage cost by 100 percent over Model 1.

[e] Blanks indicate that, with the marketing margin (MRDW) constrained to be approximately the same for both the mechanical harvesting and hand-harvest simulations, the average processed product price difference is approximately the same as the grower price difference.

about 30,000 by 1977. The reason for the widening gap is the continued growth in total demand and the fact that the difference between the hand–harvest and mechanical–harvest cost series continues to widen in an absolute sense, although not in percentage terms (compare series GCRD and GCRHD, Appendix B). With the continued gain in mechanical–harvesting efficiency, even without electronic sorting, it is possible that the estimated hand–harvest production cost series actually may be a bit too low relative to the mechanical–harvest costs. If so, the reductions in acreage and production with continued hand harvest would be calculated to be a bit larger.

Associated with the reduced production is a higher price to growers required to cover the higher production costs that would have been experienced with continued hand harvest. Under Model 1, the prices increase by around $7.00 per ton or roughly 20–25 percent at the grower level and 5–7 percent at the f.o.b. processor level.

Model 2 assumes that, starting in 1965, wage costs would have increased by 30 percent. With labor accounting for about half of the total costs for hand harvest, the production cost per acre is increased by about 15 percent (series GCRHD1 in Appendix B). Model 3 increases labor cost by 60 percent starting in 1965 (total production cost per acre increases by an additional 30 percent compared to GCRHD), and Model 4 doubles labor cost (series GCRHD2 and GCRHD3, respectively, in Appendix B).

As would be expected, the scenarios involving greater labor cost with continued hand harvest lead to greater reductions in acreage and production and larger increases in prices. In the most extreme scenario depicted (Model 4), acreage declines and price increases are about three times greater than for Model 1 which maintains the *status quo* with respect to the labor market.

If the estimates of hand–harvest production and prices had been made without imposing restrictions to maintain margins at the computed level under mechanical–harvest adoption, the predicted reduction in acreage and production would have been about half as great as indicated in Table 10. Grower prices would have increased slightly more, and final product price increases would have been about half as much as in Table 10, with the difference reflected in a reduced processing margin. Had processor demand equation (26.1b) been used (equation estimated with price as the normalized variable), the estimates of acreage reduction under hand harvest would have been a little larger and the grower price increase not quite as great as shown in Table 10. The average processed product price increase under hand harvest would have been predicted to be slightly larger than in Table 10, and the average processing margin would have been predicted to increase.

Although the present study was unable either to confirm or reject the Chern–Just conclusions concerning competitive behavior, the aggregate results presented in Table 10 are broadly consistent with the empirical findings of their eight–county study. Both studies conclude that grower prices were reduced as a result of the adoption of mechanical harvesting. On the supply side, Chern and Just concluded that, after allowing for the effects of other demand–shifting factors, production could be affected either positively or negatively. Their study suggested that in some counties the net impact of mechanical–harvest adoption on output was negative. In this study, mechanical harvesting is estimated to have had an overall positive net effect on output.

Impacts on Employment

Tables 11 and 12 present the results that were obtained by using the estimates of acreage and production change to predict changes in employment in the tomato industry

TABLE 11

Comparison of Model Predictions of California Processing Tomato Industry Employment With and Without Mechanical Harvesting Development, 1960-1977

Year	Mechanical harvest adoption	Hand harvest only			
		Model 1	Model 2	Model 3	Model 4
	million hours				
	Preharvest production labor				
1960	5.77	5.77	5.77	5.77	5.77
1965	5.75	5.70	5.70	5.70	5.70
1970	6.39	5.95	5.71	5.43	5.00
1975	8.15	7.48	7.07	6.63	6.06
1977	8.32	7.41	6.89	6.37	5.68
	Harvest season labor[a]				
1960	18.97	18.97	18.97	18.97	18.97
1965	16.88	21.69	21.69	21.69	21.69
1970	10.00	28.30	27.15	25.85	23.81
1975	10.61	38.93	36.78	34.51	31.52
1977	11.55	40.00	37.21	34.41	30.69
	Assembly labor				
1960	.30	.30	.30	.30	.30
1965	.53	.53	.53	.53	.53
1970	.96	.89	.85	.81	.75
1975	1.64	1.50	1.42	1.33	1.22
1977	1.73	1.54	1.44	1.33	1.18
	Seasonal cannery labor				
1960	9.61	9.61	9.61	9.61	9.61
1965	12.03	11.93	11.93	11.93	11.93
1970	16.74	15.57	14.93	14.22	13.09
1975	23.33	21.41	20.23	18.98	17.34
1977	24.71	22.00	20.46	18.93	16.88
	Off-season cannery labor				
1960	4.19	4.19	4.19	4.19	4.19
1965	5.25	5.20	5.20	5.20	5.20
1970	7.30	6.79	6.52	6.20	5.71
1975	10.18	9.34	8.83	8.28	7.57
1977	10.78	9.60	8.93	8.26	7.37
	Total tomato industry labor				
1960	38.85	38.85	38.85	38.85	38.85
1965	40.44	45.05	45.05	45.05	45.05
1970	41.39	57.50	55.16	52.51	48.36
1975	53.91	78.66	74.33	69.73	63.71
1977	57.09	80.55	74.93	69.30	61.80

[a]From 1965 on, hand-harvest labor estimates are based on the 1960–1963 average of 7.0 labor hours per ton. (For a further explanation, see Appendix C, *infra*, p. 101.)

Source: Calculated from data in Table 10, *supra*, p. 54, and Appendix Table C.1, *infra*, p. 103.

TABLE 12

Model Predictions of Changes in California Tomato Industry Employment If Mechanical Harvesting Had Not Been Adopted, 1964-1977

Year	Model 1	Model 2	Model 3	Model 4
	million labor hours[a]			
	Decrease in preharvest production labor			
1964	.01	.01	.01	.01
1965	.05	.05	.05	.05
1966	.38	.86	1.35	2.06
1967	.66	1.11	1.52	2.04
1968	.62	.88	1.15	1.76
1969	.50	.71	.97	1.49
1970	.44	.68	.96	1.39
1971	.41	.63	.94	1.32
1972	.41	.70	.99	1.40
1973	.49	.78	1.05	1.47
1974	.66	1.07	1.49	2.08
1975	.67	1.08	1.52	2.09
1976	.75	1.18	1.61	2.18
1977	.91	1.43	1.95	2.64
	Increase in harvest season labor			
1964	2.15	2.15	2.15	2.15
1965	4.81	4.81	4.81	4.81
1966	6.18	4.36	2.54	0.12
1967	7.16	5.68	4.31	2.56
1968	13.64	12.52	11.37	8.78
1969	15.58	14.66	13.69	11.26
1970	18.30	17.15	15.85	13.81
1971	17.53	16.45	14.94	13.10
1972	19.15	17.72	16.21	14.14
1973	18.04	16.74	15.47	13.55
1974	25.44	23.42	21.32	18.42
1975	28.32	26.17	23.90	20.91
1976	21.25	19.47	17.66	15.28
1977	28.45	25.66	22.86	19.14
	Decrease in off-season cannery labor			
1964	.01	.01	.01	.01
1965	.05	.05	.05	.05
1966	.34	.78	1.21	1.85
1967	.53	.88	1.21	1.63
1968	.62	.89	1.17	1.79
1969	.52	.74	.98	1.39
1970	.51	.78	1.10	1.59
1971	.48	.74	1.10	1.54
1972	.51	.85	1.21	1.71
1973	.54	.85	1.16	1.62
1974	.78	1.26	.76	2.46
1975	.84	1.35	1.90	2.61
1976	.76	1.18	1.62	2.19
1977	1.18	1.85	2.52	3.41

(Continued on next page.)

TABLE 12–continued.

Year	Model 1	Model 2	Model 3	Model 4
	million labor hours[a]			
		Decrease in assembly labor		
1964	*b*			
1965				
1966	.04	.08	.13	.20
1967	.06	.10	.14	.18
1968	.07	.11	.14	.21
1969	.07	.09	.12	.17
1970	.07	.11	.15	.21
1971	.07	.10	.15	.22
1972	.07	.12	.17	.24
1973	.08	.13	.17	.24
1974	.12	.19	.27	.38
1975	.14	.22	.31	.42
1976	.12	.19	.26	.35
1977	.19	.29	.40	.55
		Decrease in seasonal cannery labor		
1964	.03	.03	.03	.03
1965	.10	.10	.10	.10
1966	.79	1.79	2.78	4.25
1967	1.21	2.02	2.77	3.74
1968	1.43	2.05	2.68	4.10
1969	1.20	1.71	2.24	3.19
1970	1.17	1.81	2.52	3.65
1971	1.10	1.69	2.53	3.54
1972	1.16	1.95	2.78	3.92
1973	1.24	1.96	2.65	3.71
1974	1.78	2.88	4.04	5.63
1975	1.92	3.10	4.35	5.99
1976	1.73	2.71	3.71	5.02
1977	2.71	4.25	5.78	7.83
		Change in total tomato industry labor		
1964	2.10	2.10	2.10	2.10
1965	4.61	4.61	4.61	4.61
1966	4.63	0.85	- 2.93	- 8.48
1967	4.70	1.57	- 1.33	- 5.03
1968	10.90	8.59	6.23	0.92
1969	13.29	11.41	9.38	5.02
1970	16.11	13.77	11.12	6.97
1971	15.47	13.29	10.22	6.48
1972	17.00	14.10	11.06	6.87
1973	15.69	13.02	10.44	6.51
1974	22.10	18.02	13.76	7.87
1975	24.75	20.42	15.82	9.80
1976	17.88	14.21	10.46	5.54
1977	23.46	17.84	12.21	4.71

[a]Models 1 to 4 vary the effective level of labor wage rates under hand harvest compared to wage rates experienced with mechanical harvest (Table 10, *supra*, p. 54, and text).

[b]Blanks indicate less than .005.

under hand harvest compared to mechanical harvest. Table 11 gives predictions of preharvest, harvest, assembly, and cannery employment levels for selected years in order to provide benchmarks for comparative purposes. Table 12 gives the estimated changes in labor requirements if mechanical harvesting had not been developed, *i.e.*, if hand harvest had continued. The estimates of labor requirements per ton or per acre used to calculate the total employment values in each labor category are described in Appendix C.

Tables 11 and 12 refer only to employment in the tomato industry and do not take into account the effects on other employment as land is shifted from producing tomatoes to other crops, or vice versa. If cultural labor requirements per acre for crops alternative to tomatoes were similar to tomatoes, reduced acreage of tomatoes under hand harvest would have little effect on total employment in activities such as land tillage and irrigation. In that case the predicted differences in preharvest labor, which are small in any case, could be ignored. Similarly, the model does not take into account the additional labor that might have been used to harvest alternative crops grown on land not used for tomatoes under the higher cost, hand–harvest scenarios. For the major alternatives, such as corn, wheat, sugar beets, and alfalfa hay, the amount would be very small relative to tomato hand–harvest labor requirements.

Table 11 indicates that, with the adoption of mechanical harvesting, estimated harvest season labor declined sharply and then increased somewhat with industry growth but still remained well below hand–harvest levels. At the same time, industry employment in all other labor categories increased with the higher industry output resulting from higher demand and lower costs. The net impact was that, following a small initial decline, total industry employment increased substantially above premechanization levels.

While these figures provide impressive evidence of an expanded total industry employment opportunity after the adoption of mechanical harvesting, the model results suggest that, if hand harvest had continued, total industry employment would have been still greater under all scenarios. However, the job distribution would have been quite different from that under mechanization. For example, in 1977 harvest season labor was estimated to have accounted for about 20 percent of the tomato industry employment under mechanization but would have been about 50 percent with continued hand harvest.

Turning to Table 12, the various scenarios suggest that continued hand harvest would have provided between 23,450,000 and 4,690,000 more total hours of labor in 1977. Since the conditions of Model 1 seem very unlikely, a more plausible range would be 17,820,000 to 4,690,000, or possibly even the narrower range defined by Models 3 and 4.

Many discussions of the effects of mechanized harvesting have been in terms of lost jobs. However, a job is not a precisely defined unit of measure. It may consist of a worker employed one day, one week, or one month or, more precisely, some specified number of hours. Since the primary harvest season for tomatoes in the major areas extends from late July to early October, it seems reasonable to define a job as about 10 weeks of work at 50 hours per week, or 500 hours. In these terms the 12,180,000 hours of labor displaced under Model 3 in 1977, for example, would account for 24,360 jobs. If 12 weeks were used to define a job, the job displacement would be 20,300.

Schmitz and Seckler estimated total harvest season labor displacement for 1973 at about 19,477,100 hours which exceeds the estimated values in Table 12 for that year. The difference is due to the fact that the present study draws on additional information in estimating labor requirements; takes more explicit account of supply and demand functions and the price effects of output change; and, through the several scenarios, considers possible shifts in the labor supply curve.

While the estimates of seasonal labor displacement developed in this study are less than indicated by Schmitz and Seckler, it is clear that, even under scenarios which substantially increase hand–harvest labor costs, the increased nonharvest labor employment after mechanization has not been sufficient to offset fully the displaced harvest labor. However, balanced against the reduced total employment is an estimated increase in f.o.b. processor prices of from 5 to 15 percent (roughly $7.00 to $20 per raw product ton in Table 10) under hand harvest and a change in the distribution of labor activity under mechanization toward work of higher skill and pay rates. The welfare aspects of these trade–offs have been discussed by Schmitz and Seckler; Brandt, French, and Jesse; and Thompson and Scheuring and need not be repeated here. While the findings of the present analysis would not greatly alter the general conclusions of these earlier studies, the model provides a stronger and more rigorously developed empirical base. Further estimates of the impact of the adoption of electronic sorting on production, prices, and employment are presented in the next section.

8. LONG-RUN MULTIPLIERS AND ECONOMIC PROJECTIONS

In section 6 it was explained how the industry model may be solved to obtain year–to–year predictions of each endogenous price and quantity variable for given values of exogenous variables and the lagged endogenous variables. This section applies the model in order to explore the effects of possible future changes in exogenous factors such as population, technology, and income on longer term average values of acreage, prices, and production.

The accuracy of the future projections depends on (1) the accuracy of estimates of the model parameters, (2) the stability of the model's structural relationships in future periods, (3) the flexibility of the model in measuring substitution and allocation adjustments, and (4) the accuracy with which the exogenous variables can be predicted.

The stochastic properties of the estimated parameters of the model are indicated by the standard error terms given with the estimation results. In making projections it is assumed that the equations estimated for the historical period will hold at least approximately in the future. However, it is possible that conditions affecting slopes and levels of the equations may change. For example, a change in the competitive environment might affect the slope and level of the processor raw product demand equation, and unmeasured changes in consumer tastes might affect the relationship between per capita income and per capita consumption.

It may be recalled that the model allocates total output among product forms in accordance with historical ratios. This can distort some aspects of the projections. Such distortions do not appear serious in this model, but they require explanation and special interpretation.

Regardless of how well a model represents the behavior of a system, projections of future levels of price and quantity variables can be no more accurate than the projections of the exogenous variables. Changes in some exogenous variables, such as population, can be projected for a decade or so with a reasonable degree of accuracy. Others, such as changes in technology, are much more speculative.

From the previous discussion, it is evident that the probability distributions of the projected values of acreage, prices, and production are complex functions of the error distribution associated with the estimates of equation parameters, the possible changes in structure, the possible specification errors, and the probability distributions of projections of the future values of the exogenous variables. This compound distribution is unknown. Hence, it is not possible to compute meaningful confidence intervals for the acreage, price, and production projections. The projections should be viewed, therefore, as conditional solutions of the model rather than specific forecasts.

While the difficulties noted above are present in almost any type of economic projection, they are particularly apparent when a model is used to project specific *levels* of price and quantity variables. The accuracy in such cases is influenced by the levels of all exogenous variables, including such things as trend relationships which are representative of past adjustments but which may not hold in future periods. The procedure here will be first to compute the *changes* in final long–run equilibrium values of the endogenous variables for a one–unit *change* in each exogenous variable, holding other exogenous variables constant. Coefficients which measure these relationships are called long–run multipliers. The multipliers then may be used to calculate likely total changes in production and prices for possible alternative projections of total change in exogenous factors over some future period.

Multiplier Analysis

Estimates of long–run impacts may be obtained by extending either (or both) the modified Gauss–Seidel solution procedure or the analytical solution of the linearized model. With the modified Gauss–Seidel procedure, future values of the exogenous variables are projected over some chosen time interval and the model solved sequentially to generate future predictions of the endogenous variables for the same period. By varying the exogenous variables one at a time, it is possible to compute approximations of the long–run multipliers.

When the model is specified completely in linear terms, a more direct and general alternative is to compute the long–run multipliers by further manipulation of the reduced–form matrix solution [equation (7)]. This may be accomplished by solving the reduced–form system to obtain the *final form*. The final form then may be used to obtain both interim–period and long–term multipliers.[1] However, if only the long–term multipliers are of interest, they may be obtained more simply by setting $Y_t = Y_{t-1}$ since, in long–run equilibrium, there are no changes in the endogenous variables. Equation 7 thus may be written as

$$Y_t = H_1 Y_t + H_2 Z_t. \tag{8}$$

Solving for Y_t gives:

$$Y_t = (I - H_1)^{-1} H_2 Z_t = M Z_t. \tag{9}$$

The elements of the matrix $(I - H_1)^{-1} H_2 = M$ are the long–run multipliers. The values of the endogenous variables (vector Y_t) obtained by solving (9) for given values of the vector

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[1]Discussions of dynamic model analysis may be found in most econometric texts as well as in other publications [see, for example, Intriligator (1978), pp. 490–507].

of exogenous variables, Z, are called long–run stationary equilibrium values. In the tomato industry model, the endogenous variables tend to converge quickly to values near the final equilibrium values, so the interim period multipliers and interim values of endogenous variables tend to be near the long–run values.[1]

While the emphasis in this analysis is on change relationships rather than levels, it may be instructive first to note the recent values of the major endogenous variables of the system and to examine the relation of these values to their final stationary equilibrium values. The first column of Table 13 gives reported values for 1979. The next two columns give the 1979 predictions of the linearized version of the model summarized in Table 7 (see Appendix D) for two sets of grower cost conditions. Condition I sets grower cost at the 1978 level ($GCRD_{t-1}$) and pertains only to harvest cost with hand sorting. Condition II reduces growing cost by $94 per acre to take account of recent gains in general harvest efficiency (1979 cost value, Appendix Table B.1) and the lowered costs with electronic sorting. These cost adjustments are explained more fully in the later section which evaluates effects of technological change. The remaining columns under Model I give the final equilibrium values predicted by the model after all dynamic adjustments have run their course, *i.e.*, if the exogenous variables remain at the 1979 level. *They are not forecasts of the future.*

An evident feature of the model predictions for 1979 is that they generally overestimate prices. This is modified a bit under the more likely cost levels of Condition II, but the price predictions still remain too high. A factor accounting for part of the differences is the higher than average yields experienced in 1979 which produced greater output from about the same total acreage as predicted by the model. Note also that the reported (deflated) prices for 1979 are well below values experienced in more recent years (Appendix Tables A.12 and A.13). At the grower level, this may reflect some shift in the processor derived demand due to escalating interest rates and the higher costs of holding inventories. The reduced prices for processed products are more difficult to explain, especially for puree and paste. This could indicate some change in demand structure or possibly some change in price reporting. However, the differences between predicted and actual values for 1979 are generally within the range of maximum historical prediction error. Further observation would be required to ascertain whether or not structural changes have occurred.

It may be recalled that estimation of the processor raw product demand equation with price rather than quantity as the normalized variable resulted in a substantial change in the estimated price elasticity (Table 4). The model presented in Table 7 (referred to as Model I) uses equation (26.1a) which was estimated with quantity as the normalized variable. While this result is regarded as superior, the alternative price–dependent formulation (equation 26.1b) cannot be rejected entirely. Model II replaces equations (2) and (3) in Table 7 with the simultaneously estimated equation set (23.1b) and (26.1b) in Table 4.[2] Since this formulation leads to some differences in long–run multipliers for grower cost, GCRD, and per capita income, YND, it is appropriate to evaluate the effects of using the alternative Model II equation system.

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[1]Interim period values are cumulative effects obtained after the elapse of some specified period shorter than required to achieve approximate stationary equilibrium.

[2]With the price–dependent formulation, the 2SLS estimates seemed subjectively superior to the 3SLS estimates and so were used. However, the modeling results would not differ significantly if the 3SLS estimates had been used.

TABLE 13

Base Conditions for Economic Projections

Endogenous variable[a]	1979 reported value	Model I: 1979 model prediction, Condition I	Model I: 1979 model prediction, Condition II	Model I: 1979 long-run equilibrium, Condition I	Model I: 1979 long-run equilibrium, Condition II
PGCD	26.08	33.97	31.08	33.42	29.75
AC	256.0	253.5	260.0	269.8	274.3
QCT	6,350	5,778	5,926	6,147	6,249
PGMD	31.77	37.99	37.21	38.51	37.42
AM	36.1	40.2	39.1	40.9	39.3
QMT	607	719	699	733	704
PGED	31.09	39.27	38.22	42.25	40.35
AE	18.9	16.2	15.1	19.2	17.3
QET	250	225	210	267	240
A	321.4	321.8	326.2	342.5	343.0
QT	7,331	6,853	6,968	7,287	7,335
PWD	2.78	3.46	3.43	3.43	3.41
DWN	.240[b]	.247	.249	.249	.250
PJD	2.69	2.97	2.97	2.95	2.95
DJN	.145[b]	.141	.141	.142	.142
PCD	3.50	3.99	3.97	4.50	4.42
DCN	.165[c]	.189	.189	.172	.175
PUD	3.58	5.45	5.42	5.37	5.35
DUN	.044[b]	.055	.055	.044	.045
PPD	6.60	8.06	7.99	7.63	7.47
DPN	.170[c]	.162	.165	.170	.173
PRDW	106.5	129.4	128.6	132.28	130.68
MRDW	80.4	95.5	97.6	98.86	100.93

(Continued on next page.)

TABLE 13—continued.

Endogenous variable[a]	Model II 1979 model prediction Condition I	Condition II	1979 long-run equilibrium Condition I	Condition II
PGCD	30.06	28.93	30.81	27.80
AC	243.75	259.3	269.8	282.2
QCT	5,555	5,909	6,150	6,433
PGMD	36.93	36.62	37.7	36.8
AM	38.7	38.3	39.8	38.5
QMT	692	684	713	690
PGED	37.82	37.40	40.9	39.3
AE	14.7	14.3	17.8	16.2
QET	204	198	248	226
A	308	323	340	350
QT	6,577	6,924	7,249	7,490
PWD	3.53	3.44	3.45	3.32
DWN	.243	.248	.248	.256
PJD	3.02	2.99	2.99	2.96
DJN	.138	.140	.139	.140
PCD	4.02	3.98	4.49	4.27
DCN	.188	.190	.172	.180
PUD	5.50	5.43	5.38	5.34
DUN	.054	.055	.044	.046
PPD	8.16	8.00	7.62	7.18
DPN	.158	.165	.170	.162
PRDW	131.09	128.9	132.7	127.0
MRDW	101.03	99.94	101.8	99.2

[a]PGCD, PGMD, and PGED are deflated grower prices for California, the Midwest, and the East; AC, AM, and AE are acreage (1,000 acres) for California, the Midwest, and the East; QCT, QMT, and QET are total production for California, the Midwest, and the East (1,000 tons); A and QT are U. S. acreage and production; PWD, PJD, PCD, PUD, and PPD are deflated California f.o.b. processed product prices for principal canned, juice, catsup and chili sauce, puree, and paste forms; DWN, DJN, DCN, DUN, and DPN are per capita consumption of the processed products in cases; PRDW is the weighted average processed product price (in farm weight); and MRDW = PGCD − PRDW.

[b]1978 value (later value not available when table was prepared).

[c]1977 value (later value not available).

The Model II predictions given in the last four columns of Table 13 are similar overall to the results obtained with Model I.

Model II gives slightly lower price predictions: acreage predictions are lower for the short run and above the Model I predictions in the long run, especially for the lower cost Condition II. The magnitudes of deviations between actual and predicted values are of the same general order for both models, suggesting that the general results are at least consistent. Some differences in estimated long–run multipliers between the two models and their effects on economic projections are noted in the later discussion.

The long–run multipliers for the major endogenous and exogenous variables of the tomato model, obtained as in (9), are given in Table 14. They are based on the linearized version of the model presented in Table 7, as given in Appendix D. The values apply strictly to a situation in which population and the allocation coefficients are held at 1979 values, and yields are 1975-1979 averages.[1] However, moderate variation in population and yield levels would not have much effect on the coefficient values.

In computing the coefficients, account was taken of the fact that population, total income, and per capita income are not independent; that is, it is not possible to hold both total income and population constant and vary per capita income. The long–run multiplier for YND thus incorporates an associated variation in total income, YD.[2] The effect of a change in population is not shown in Table 14. It is evaluated later by obtaining solutions over future time periods with population held at different levels.

The YND column shows how a change in per capita income would affect each of the endogenous variables, assuming a continuation of past relationships between income and demand levels. It shows, for example, that a \$100–per–year increase in average deflated income per person would increase California acreage by 6,310 acres and increase the

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[1]Allocation coefficients are given in Appendix Table A.15, *infra*, p. 95.

[2]Both YD and YND appear as separate variables in the exogenous set. Express endogenous variable y^i as $y^i = f\,(YD, YND)$. Then,

$$dy^i = \frac{\partial y^i}{\partial YD}\, dYD + \frac{\partial y^i}{\partial YND}\, dYND$$

and

$$\frac{dy^i}{dYND} = \frac{\partial y^i}{\partial YD} \cdot \frac{dYD}{dYND} + \frac{\partial y^i}{\partial YND}.$$

Since

$$YD = \frac{N(YND)}{1{,}000{,}000}, \qquad \frac{dYD}{dYND} = \frac{N}{1{,}000{,}000}$$

Thus,

$$\frac{dy^i}{dYND} = \frac{N}{1{,}000{,}000}\,\frac{\partial y^i}{\partial YD} + \frac{\partial y^i}{\partial YND}.$$

TABLE 14

Long-Run Multipliers for the Processing Tomato Industry Model[a]

Endogenous variable[b]	Per capita income, YND	Production cost per acre, GCRD	Exports canned, EW	Exports juice, EJ	Exports paste, EP
PGCD	.004204	.039084	.000048	.000028	.000190
AC	.063097	– .047743	.00727	.000425	.002854
QCT	1.437935	–1.088065	016571	.009681	.065036
PGMD	.001245	.011570	.000014	.000008	.000056
AM	.001819	.016906	.000021	.000012	.000082
QMT	.032555	.302616	.000375	.000219	.001472
PGED	.002170	.020171	.000025	.000015	.000098
AE	.002219	.020631	.000026	.000015	.000100
QET	.030894	.287185	.000356	.000208	.001397
A	.069709	– .010598	.000803	.000469	.003153
QT	1.530744	– .508008	.017641	–.010305	.069233
PWD	.000952	.000264	.000066	–000006	–.000038
DWN	.000050	– .000016	–.000004	.0000003	.000002
PJD	– .000500	– .000404	–.000006	.000090	–.000023
DJN	.000024	.000020	.0000003	–.000004	.000001
PCD	– .000237	.000860	–.000013	–.000008	–.000051
DCN	.000040	– .000031	.0000005	.0000003	.000002
PUD	.000930	.000203	–.000004	–.000002	–.000017
DUN	.000010	– .000005	.0000001	.0000001	.0000004
PPD	.001085	.001676	–.000026	–.000015	.000689
DPN	.000038	– .000029	.0000004	.0000003	–.000003
PRDW	.010767	.017070	.000392	.000183	.001892
MRDW	.006563	– .022014	.000344	.000155	.001702

(Continued on next page.)

TABLE 14–continued.

Endogenous variable[b]	Imports canned, IW	Imports paste, IP	Competing vegetables, DOVN	Shift variable,[c] M
PGCD	–.000020	–.000012	– .024763	2.1741
AC	–.000296	–.000180	– .371611	32.6256
QCT	–.006747	–.004094	–8.46902	743.5373
PGMD	–.000006	–.000004	– .007331	.6436
AM	–.000009	–.000005	.010711	.9404
QMT	–.000153	–.000093	– .191734	16.8333
PGED	–.000010	–.000006	– .01278	1.1220
AE	–.000010	–.000006	– .013072	1.1476
QET	–.000145	–.000088	– .181957	15.9749
A	–.000327	–.000198	– .410564	36.0454
QT	–.007182	–.004358	–9.015632	791.5274
PWD	–.000072	.000002	– .090704	– .4387
DWN	.000004	–.0000001	– .000296	.0260
PJD	.000002	.000001	.002943	– .2584
DJN	–.0000001	–.0000001	– .000143	.0125
PCD	.000005	.000003	.006694	– .5877
DCN	–.0000002	–.0000001	– .000238	.0209
PUD	.000002	.000001	.002177	– .1911
DUN	–.0000001	–.00000003	– .000057	.0050
PPD	.000010	–.000103	.013045	– 1.1452
DPN	–.0000002	.000004	– .000227	.0199
PRDW	–.000611	–.000371	– .767535	– 16.6072
MRDW	–.000592	–.000359	– .742771	– 18.7813

[a]Coefficients indicate the final effect on the indicated endogenous variable of a one–unit change in each exogenous variable. Computed for the following conditions: Population held at 1979 level of 221,700 (1,000's); all allocation coefficients held at 1979 (1977–1979 average) levels (Appendix Table A.15); yields specified at 1975–1979 average values (YMAC = 23.66, YLDPC = 22.79, YLDMP = 17.90, and YLDEP = 13.92; and trend set at 1979 value (T = 26).

[b]For a short definition of the endogenous variables, see Table 13, footnote *a*, *supra*, p. 64; for a more complete definition, see Table 1, *supra*, p. 6.

[c]M = 0 for years before 1974; 1 thereafter.

grower price by about $0.42 per ton in 1967 dollars. It would also increase the average processed product price by $1.08 per farm weight ton and lead to a margin increase of $0.66 per ton.

The negative YND coefficients for PJD and PCD (deflated juice and catsup prices) would not ordinarily be expected. They are largely a consequence of the fixed allocation coefficients for quantities distributed to each product form.[1] When *total* output increases as a result of an increase in income, increased quantities are allocated to juice and catsup. Since income does not appear directly as a variable in the juice demand equation, there is no compensating shift in demand level and the juice price falls. In the case of catsup, the income coefficient in the demand equation is small so that the increase in demand level is insufficient to offset the price–decreasing effect of greater quantities of catsup processed.

In practice, shares allocated to each product form would not necessarily remain constant. Increased quantities likely would be allocated to the forms showing greater price increases and less to the juice and catsup forms. Thus, the long–run income multipliers for commodities other than catsup and juice tend to overstate the effect on price and understate the effects on quantity, while the catsup and juice coefficients allocate too much pack to those commodities.

The coefficients in the GCRD column indicate how changes in farm production costs affect each endogenous variable. A cost increase of $100 per acre in 1967 dollars, for example, would lead to a 4,774–acre reduction in California acreage and to a $3.91 per ton increase in the California grower price. This price increase would approximately reflect the added cost per ton. Reverse conclusions would be reached for a $100 reduction in cost per acre. As would be expected, increases in California cost (with cost in other regions constant) would lead to some increase in other regions' acreage and production. The net effect is a decline in U.S. acreage (A) of 1,060 acres for each $100 increase in California production costs. Concurrent with the reduced production, all processed product per capita quantities would be reduced (except for juice) and the price increased. The seemingly perverse behavior of the juice component may be explained by the fact that reduced California production and associated increases in other regions' production might actually lead to an increase in juice output since the other regions allocate higher proportions of output to juice. Whether the shares in other regions would remain at historical levels might be questioned, but the model tends to capture the basic influence.

The economic effects of varying levels of exports are shown by the multipliers in the EW, EJ and EP columns.[2] The figures indicate, for example, that a 1,000,000–case increase in canned tomato exports would lead to increases of about $.07 in the per case price of canned tomatoes, PWD; about $.39 per ton in the average processed product price, PRDW; about $.34 per ton in the processor margin, MRDW; and about $.05 per ton in the deflated California grower price, PGCD. Correspondingly, California production, QCT, would increase by 16,571 tons. The multiplier coefficients for juice and paste exports are interpreted in a similar manner.

Because of the constant product form allocation ratios, the export multipliers for the processed products require careful interpretation. In the case of canned exports, EW,

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[1]Recall that in the earlier discussion it was noted that efforts to relate the allocations of product forms to price and cost variables were unsuccessful.

[2]The small quantities of catsup and chili sauce exported were not included in the model calculation.

for example, the canned tomato price increases with increases in exports as might be expected. However, the prices of other processed products are shown to decline slightly. The reason is that, when total production increases in response to the increased exports, the model allocates constant shares to each product, thus slightly increasing the pack of commodities other than canned tomatoes. The U. S. per capita disappearance of canned tomatoes is reduced by the increased exports. In practice, it would be expected that the share of production allocated to canned tomatoes would increase. Thus, the positive effect on PWD and the negative effects on other prices would be less than indicated. In any case, the canned tomato export multiplier coefficients for the other commodities would remain very small. Although holding allocation shares constant slightly distorts the multiplier effects, the model nevertheless appears to capture the major influence of exports on the commodity exported and on the farm price and production.

A similar interpretation applies to the multiplier coefficients for juice, EJ, and paste, EP. Changes in paste exports have a somewhat greater effect on prices and output than the other commodities, reflecting the more concentrated nature of the product. Overall, if exports of canned, juice, and paste products were expanded to twice their recent (1978) values (EW_{78} = 1211, EJ_{78} = 1170, and EP_{78} = 1325), the multipliers suggest that the California grower price would increase by about $.34 per ton (more than double that in 1979 dollars), and California production would increase by about 118,000 tons. Thus, rather large relative increases in export levels would be required to have much impact on grower returns, although it clearly would provide a market for more tomatoes.

The long-run effects of changed *imports* are given in the IW and IP columns of Table 14. Increasing imports of canned tomatoes by 1,000,000 cases, for example, would be expected to decrease the average price of canned tomatoes by about $.07 per case. This is similar in effect to a 1,000,000–case increase in U. S. production if sold in the U. S. market [Table 2, equation (1)].[1] Much of the decrease in price is absorbed by a reduction in the average processing margin, PRDW, so the net effect on California grower price, PGCD, is only about $.02 per ton.

The constant share allocation again results in some distortion of the multipliers for the processed product prices and pack. An increase in IW increases DWN and, as would be expected, decreases PWD. However, with shares of all processed forms remaining constant, the reduced total production slightly reduces quantities for all commodities except canned tomatoes, so the model predicts a slight price increase for those commodities. Actually, lesser quantities likely would be allocated to canned tomatoes and more to the other commodities, thus preventing a price increase for other commodities. These cross– effects are very small in any case, so the main effects of increased IW on PWD and DWN and the overall effects on acreage and production seem likely to be reasonably close approximations, given the other properties of the model.

The DOVN column of Table 14 gives the effects of changes in per capita consumption of competing vegetables. This variable appears only in the demand equation for canned tomatoes and has not varied widely in recent years. Its effect is more to capture a historical trend influence rather than to serve as a basis for further projection. The coefficients are interpreted similarly to those in the other columns.

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[1] *Supra*, p. 26. Dividing the coefficient for DWN (16.9024) by the 1979 U. S. population (221,700,000) gives .000076.

The final column shows the effect of the shift variable, M, which was introduced in the processor raw product demand equation in association with the initiation of price bargaining by the California Tomato Growers in 1974. As noted earlier, the positive coefficient for M indicates that processor demand apparently shifted upward during that period, although it is not clear whether it was a result of the influence of the CTGA or other factors, or some combination of both. The coefficients in the M column of Table 14 provide estimates of the effects if processor demand conditions were to revert to pre–1974 levels with respect to this particular shift influence. The coefficients suggest, for example, that grower price would be reduced by $2.17 per ton (in 1967 dollars), California acreage would decrease by 32,626 acres, and the average processed product price, PRDW, would increase by $16.61 per raw product ton.

If industry Model II is used (processor demand estimated with price as the normalized variable), the estimates of long–run multipliers for income and grower cost are somewhat altered. The multipliers for GCRD become .0320 for PGCD, –.1320 for AC, .0602 for PRDW, and .0282 for MRDW. For YND, the values would become .0029 for PGCD, .0506 for AC, .0172 for PRDW, and .0143 for MRDW.[1]

Economic Projections

Among the exogenous factors likely to impact heavily on the processing tomato industry during the next decade are (1) further technological developments which affect costs and input requirements, (2) population growth which expands market size, and (3) possible further shifts in consumer incomes, tastes, and other factors affecting the derived demands facing processors and growers. The long–run multipliers and the simulation model provide a framework for evaluating likely effects of these probable developments on output, employment, and prices in the tomato industry.

Technological Change

During the past 15 years, the processing tomato industry has drastically changed its harvest and assembly technology and has introduced changes in processing methods such as aseptic bulk storage. Other developments have included improvements in cultural efficiency and better yielding varieties. Many of these developments are likely to continue during the next decade.

The recent change of greatest significance, at least insofar as it affects employment, has been the development of electronic sorting as a further innovation in mechanical harvesting. This section presents an evaluation of the impact that electronic sorting has had and will have on output and employment in the industry. It also presents some conditional projections of possible impacts of other less spectacular changes.

Impact of the Electronic Sorter.—All of the cost figures and analysis presented to this point have been based on mechanical harvest with hand sorting only. A study by Zobel (1979) shows a reduction in cost with electronic sorting of $2.94 per ton or $73.50 per acre (25–ton yield). Dividing by the CPI value for 1978 of 1.954 gives a deflated cost saving of

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[1]The effects of these variations are considered in the development of economic projections in the next section.

$1.50 per ton or $37.62 per acre.[1] Multiplying the cost saving by the long–run grower price and acreage multipliers for GCRD in Table 14 (.0391 and –.0477) gives a decrease in price of $1.47 per ton and an increase of 1,794 acres. If the long–run multipliers based on Model II are used (.0320 and –.1320), the price decrease is $1.20, and the acreage increase is 4,966.[2]

The magnitude of the cost saving clearly is not large enough in either case to have a great impact on final output. However, the reduction in labor requirements suggests a much greater impact on employment. The Zobel study estimated harvest labor at approximately 35.7 labor hours per acre with manual sorting and 19 labor hours per acre with electronic sorting—a reduction of 16.7 hours per acre. The total reduction in labor hours depends on the magnitude of industry output. Using the 1979 stationary equilibrium value of California acreage given in Table 13 for Condition I and the Model I projection, the reduction in harvest labor is calculated as:

$$35.7(269.8) - 19(269.8 + 1.794) = 4{,}471.574$$

or a reduction of 4,471,574 harvest labor hours. The estimates based on Model II are only slightly smaller: $35.7(269.8) - 19(269.8 + 4.960) = 4{,}411.420$. The figures would be expanded a bit more with further projected increases in acreage due to expansion of population and demand. These aspects are explored subsequently. While this is a substantial reduction in labor requirements, it is considerably less than the estimated reduction due to the initial adoption of mechanical harvesting (Table 12).

Other Efficiency Gains.—Continued research on improved tomato varieties and further experience with mechanical harvesting techniques may result in further cost reductions when measured in constant dollars, although such gains may be offset to some extent by increased energy costs. Unfortunately, there are no studies which provide a basis for projecting the potential net magnitude of such efficiency gains. A figure of 10 percent over the next 10 years does not seem unreasonable. A gain of this magnitude would amount to about $60 per acre (in 1967 dollars) which, when multiplied by the Table 14 GCRD multiplier, suggests a potential farm price reduction of $2.35 and a further increase in California production of 2,865 acres. If Model II is used, the values are $1.92 and

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[1]The 1978 CPI value was used since the Zobel study was published early in 1979 and, thus, seems likely to reflect the 1978 average price experience more than later 1979 values.

[2]The supply response equation [Table 3, equation (7)] includes a variable TC which increased the level of supply in association with the transition from hand harvest to mechanical harvest. This adjustment, which was in addition to the cost effect, is interpreted as mainly a response to changed perceptions of labor uncertainty. It seems unlikely that further substitutions of capital for labor, such as the electronic sorter, would have the psychological impact of the original transition from hand harvest. Therefore, no attempt was made to include any alteration in future response not accounted for by cost changes.

7,920 acres. A 10 percent cost increase would, of course, have opposite price and production effects. These figures are speculative, but the calculations illustrate how the long–run multipliers may be used to make conditional projections based on the user's subjective estimates of technological potential.[1]

In formulating the processing tomato industry model, it was assumed implicitly that most of the change in processing cost had been closely associated with changes in the movement of the general price level as measured by the CPI. Unfortunately, there are no cost studies available which would confirm or reject that assumption. In recent years the introduction of new technology, such as aseptic bulk storage and handling and some consolidation of plants, may have had and may continue to have some impact on average processing cost. While there are no studies which might suggest the magnitude of potential gains in processing efficiency, some useful insights may be gained by utilizing the tomato industry model to delineate likely production and price effects of plausible assumptions concerning efficiency improvement.

To evaluate the effects of a change in the unit cost of processing, it is assumed that processors would regard such a cost increase or decrease as equivalent to an increase or decrease in grower price, PGCD. Therefore, PGCD in the processor demand equation [(Table 7, equation (2)] is replaced by PGCD + C, where C is a change in processing cost per unit of the raw product from the initial equilibrium solution such as in Table 13, column 1. The variable, C, is added to the set of exogenous variables, and the system is solved as before. When C = 0, the solutions are identical to those in columns 2 to 8 in Table 13. However, this process yields long–run multipliers for C. Using Model I, processing cost multiplier values for California grower price, acreage, average processed price, and average margin are $\Delta PGCD/\Delta C = -.070$, $\Delta AC/\Delta C = -1.043$, $\Delta QCT/\Delta C = -23.77$, $\Delta PRDW/\Delta C = .531$, and $\Delta MRDW/\Delta C = .601$, respectively. Comparable values based on Model II are –.184, –3.244, –73.94, 1.646, and 1.830, respectively.

To illustrate the use of these multipliers, assume that gains in processing efficiency result in a $10–per–ton (farm weight) reduction in processing cost. This would be approximately a 10 percent reduction. The Model I multipliers suggest that California acreage would increase by 1,043 acres, the grower price would increase by $.70 per ton, the average processed product price would decrease by $5.31, and the average margin would decrease by $6.01 per ton. Thus, $3.99 of the $10 gain would be retained by processors, $5.31 passed on to consumers (wholesale buyers), and $.70 to farmers. Model II yields the somewhat implausible result that the average processor margin, MRDW, would decrease by $18.30 which is considerably more than the cost reduction. This would involve a reduction in PRDW of $16.46 due to an increase in QCT of 73,940 tons and a $1.84 per ton increase in the grower price.

It is possible, of course, that bargaining by the Tomato Growers Association would permit growers to obtain some of the $3.99 retained by processors under the Model I calculations. However, without supply control, increased grower shares of the processing–cost reduction would lead to increased production which, in turn, would reduce the average processed product price, thus shifting an even greater portion to consumers. In an alternative Model I formulation in which none of the gains in processing efficiency were

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[1]These calculations are based on constant average yields set here at the 1975–1979 average level. If efficiency gains involve further increases in yields, this would slightly reduce the GCRD long–run multiplier for acreage. Hence, acreage increases would be slightly less than suggested above.

retained by processors, the $10–per–ton cost saving was allocated—$8.43 to consumers (wholesale buyers) and $1.56 to growers—with AC increasing by 2,270 acres rather than the 1,043 in the solution above. In either case, the model results suggest that gains in processing–cost efficiency up to about 10 percent would not lead to large increases in production and that, while all participants would gain to some extent, consumers would be the primary benefactors.

Shifts in Demand

The most predictable exogenous variable affecting the processing tomato industry is growth of population. Since population appears as a variable affecting matrix coefficients rather than as a linearly related exogenous variable (Appendix D), its effect could not be computed in the same way as were the long–run multipliers for the other variables. The procedure followed was first to compute stationary equilibrium values for all endogenous variables as in Table 13, column 2. Then population was increased, with all other factors except total income held constant. With per capita income constant, total income necessarily increases proportional to population. The change in the stationary equilibrium value of each variable then was divided by the change in population to obtain approximate long–run multipliers.

Estimates of long–run population multipliers for the major production and price variables are given in Table 15 for Model I. The figures indicate, for example, that an increase in U. S. population of 1,000,000 (1,000 units of N) is associated with an expected increase in the California acreage of 1,059 acres and an expected increase in average grower price of $.07 per ton. U. S. Census projections indicate that population will increase by about 10 percent from 1980 to 1990, from 221,651 to 243,004, and to 259,869 by the year 2000.[1] Applying these estimated increases to the population multipliers suggests that, with other factors constant, the growth in U. S. population would lead to increases of 22,613 acres in California by 1990 and 40,473 acres by 2000. This would, of course, involve reductions of the same amount in the total acreage of other alternative crops.

During the past 15 years, the total demand for processed tomato products has increased more rapidly than population. This is reflected in the significance of the per capita income coefficients, with deflated per capita income increasing from about $2,000 in 1954–55 to $2,500 in 1964–65 and to $3,400 by 1978. Whether real per capita income will continue that growth rate and whether the rate of growth in demand for tomato products will be sustained during the next decade is by no means clear. If the growth pattern of the 1970s is maintained through the 1980s, per capita income in 1990 will be increased by roughly $500 in 1967 dollars.[2] If the past association between per capita income and demand for tomato products were to continue, the per capita income multipliers in Table 14 (YND column) suggest that California production would expand by 31,549 acres (.063097 · 500) in 1990 to meet that demand. Associated would be an increase of 3,306 acres in other regions, an increase in California grower price of $2.10 per ton and an increase in the average processed product price, PRDW, of $5.38 per farm weight ton, all in 1967 dollars as measured by the CPI. If Model II multipliers for YND are used, the estimated California

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[1] U. S. Department of Commerce (1979).

[2] The amount would be roughly doubled in 1978–1979 dollars (see Appendix Table A.14, *infra*, p. 94, for CPI values).

TABLE 15

Approximations of Long-Run Population Multipliers for the Processing Tomato Industry

Endogenous variable[a]	Population multiplier	Endogenous variable[a]	Population multiplier
PGCD	.000070	PWD	.0000034
AC	.001059	DWN	−.0000002
QCT	.024037	PJD	.0000044
PGMD	.000021	DJN	−.0000002
AM	.000030	PCD	.0000027
QMT	.000544	DCN	−.0000001
PGED	.000036	PUD	.0000012
AE	.000037	DUN	−.0000003
QET	.000516	PPD	.0000009
A	.001165	DPN	−.0000001
QT	.025589	PRDW	.0000849
		MRDW	.0000146

[a]PGCD, PGMD, and PGED are deflated grower prices for California, the Midwest, and the East; AC, AM, AE and QCT, QMT, QET are corresponding acreage and production; A and QT are U.S. acreage and production; PWD, PJD, PCD, PUD, and PPD are deflated f.o.b. California prices for the five product forms; DWN, DJN, DCN, DUN, and DPN are corresponding U.S. per capita disappearance values; PRDW is the weighted average processed product price (farm weight); and MRDW = PRDW − PGCD. (For further details, see Table 1, *supra*, p. 6.)

Source: Calculated.

acreage increase by 1990 would be 25,300, and the grower price increase would be $1.45. In view of present uncertainties about the continued growth rate in real per capita income and the likelihood of some tapering off of the rate of growth of demand for tomato products in excess of population growth, it seems reasonable at this time to view the projections above as *optimistic* from an industry perspective. The realized growth may be somewhat less.[1]

Total Change Projections

Table 16 summarizes the several types of industry–growth projections developed above. The projections are optimistic in the sense of evaluating the effects of changes that would be favorable for growers and processors. The figures reflect possible values rather than forecasts. This is especially applicable to the evaluation of the impact of further per capita income growth and the associated continued upward shift in demand. The changes due to this influence could easily be very small. However, even with these words of caution, the table provides some interesting figures.

Perhaps the most striking thing is the indication that the industry expansion may be influenced substantially more by increases in population and other demand shifts than by improvements in efficiency. The calculated influence of the electronic sorter on output is surprisingly low. While the other possible efficiency gains are based on hypothetical and speculative assumptions, the magnitudes of the resulting output calculations are such that the impact seems clearly to be small relative to possible demand shifts, even if only population growth is considered.

Also of interest is the fact that the price effects of efficiency gains and demand increases tend to be offsetting. Thus, it would be possible to achieve gains in efficiency which, along with population growth and demand shifts, would substantially expand output, with relatively little net change in prices. Presumably, producers and processors would at the same time be better off.

If the labor reduction per acre with the electronic sorter is now applied to the acreage projections, the estimated labor displacement is substantially increased. If output increased in accordance with the most extreme projections of Table 16, the 1990 long–run equilibrium acreage would be $269.8 + 59.9 = 329.7$. The labor displacement due to the adoption of the electronic sorter then would be

$$35.7(329.7 - 1.79) - 19(329.7) = 5{,}442{,}087$$

or 5,442,087 harvest season labor hours. Thus, the potential displacement by 1990 should be between a value based on 269,800 acres and the 329,700 acres, or roughly between

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[1]Recall that in all these projections, yields are held constant at 1977–1979 average levels (for values, see Table 14, footnote *a*, *supra*, p. 67). It is likely that average yields will show further increases in the future. This would have both positive and negative influences on the acreage projections. Higher yields increase grower returns per acre which is an output–expanding influence. Increased yields would also reduce the acreage required to achieve given levels of output. The net result, compared to the constant yield results presented, would be a slight increase in acreage, a small increase in production, and small decreases in prices.

TABLE 16

Summary of "Optimistic" Tomato Industry Growth Projections for California Acreage, Production, and Price Variables 1980 to 1990[a]

Influencing factor	California acreage, ΔAC	California production, ΔQCT	California grower price, ΔPGCD	Average processed product price, ΔPRDW
	Change in:			
	1,000 acres	1,000 tons	dollars	
Cost decreasing factors				
Adoption of electronic sorter[b]	1.794	40.9	−1.47	−0.64
Other production efficiencies	2.865	65.3	−2.35	−1.02
Processing efficiency	1.043	23.8	0.70	−5.31
Demand increasing factors				
Population increase	22.613	513.0	1.50	1.81
Per capita income growth[c]	31.549	719.0	2.10	5.38
Optimistic total	59.864	1,362.0	0.48	0.22

[a]Based on long-run multiplier coefficients of Model I.

[b]Reflects difference between all hand sorting and all electronic sorting.

[c]Assumes continuation of historical trend in demand growth.

4,472,000 and 5,442,000 hours. This reduction would be offset to some extent by the addition of up to 237,000 hours of cannery and tomato assembly labor.[1]

9. MODEL EVALUATION

While the model formulated in this study appears to be a reasonable representation of industry behavior, it potentially could have been improved had better and more complete data been available. A major limitation is the fact that published industry pack statistics do not account for all of the raw product delivered to canners. Particularly notable is the lack of data series on pack of catsup and paste in retail–size containers. The use of market survey data as a supplement to calculate per capita disappearance of these products improved the estimates, but it is not a fully satisfactory procedure.

Since a data series pertaining to canning costs was not available, it was necessary to reflect the influence of that variable by assuming a close correlation with movements of the general price level as measured by the CPI. However, if a representative cost series could be obtained, it might be possible to include the average processed product margin as something other than a residually determined variable. Such cost data might also aid in estimating equations which would allocate the raw product to various product forms.

Prices of processed products are represented in the model by reported prices for the dominant container size. These reported prices may not always reflect actual transaction prices, although they probably reflect general movements over time. Some further study of the relationships among prices in various container types could be fruitful.

Regardless of the quality of data, it is likely that efforts to estimate processor raw product demand slopes will continue to be difficult. The difficulty is inherent in the imperfectly competitive structure of the industry. Chern and Just have noted that, under conditions of monopsony or oligopsony, the observed market–price and quantity values may define some relationship other than that of an industry marginal revenue product curve (industry demand curve). If demand and supply curve slopes remain stable and the supply curve shifts systematically, the market observations may define what Chern and Just call a *perceived demand curve*. In practice, however, the structure of competition may well have varied over time and may continue to vary with changes in the degree of imperfection and the variable influence of bargaining activities such as by the CTGA. Thus, it may not always be clear as to exactly what is being measured by a statistically estimated processor raw product demand function. If the actual departures from pure competition are small, the estimated function may be reasonably stable. Where they are large, this adds to the uncertainty of the estimate.

In the present study the estimated demand coefficient in the processor raw product demand equation is of the expected sign and, while the ratio of the coefficient to its standard error is not large, it is at least greater than one. However, the fact that the demand slope estimate is greatly affected by the choice of normalized variables in the 2SLS and 3SLS estimation process makes it difficult to reach firm conclusions concerning the magnitudes of processor price elasticity or flexibility values. Where the value of the

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[1] If the calculations had been based on Model II results, the projected acreage increases due to the electronic sorter development would have been a bit larger and the effects of population and income changes a little lower.

elasticity estimates may significantly influence the outcome in further applications of the model, it is important, as was done here, to consider the effects of using the alternative estimators.

An earlier study of supply response by Chern and Just concluded that supply elasticity was greatly reduced after adoption of the mechanical harvester. The results of this study neither confirm nor reject the Chern–Just conclusions. This may be due in substantial part to the fact that the largest price and acreage variations during the sample period used here occurred after mechanization, so the estimates are dominated by, and tend to reflect, behavior after mechanization. The supply model estimated here also differs from the Chern–Just model in that it applies a partial adjustment hypothesis, uses a representative grower cost series, and, for results presented, uses linear rather than logarithmic functions. Furthermore, Chern and Just estimated their model for an eight-county region, using pooled cross–section data rather than an aggregate model as was done here. If the grower cost series used in this study could be partitioned into fixed and variable components, it would be possible to explore more directly the possible influence of changed proportions of fixed costs on short–run and long–run responses.

A weakness of the supply function estimated here is that it does not take into account the effects of returns to alternative crops as a factor influencing supply. While this aspect needs more future study, it should be noted that Chern and Just were only marginally successful in this regard and that estimation of the effects of returns to alternative crops has been difficult in nearly all supply response models. In other respects the supply model developed here shows relatively good statistical significance and appears reasonable in the uses made of it in this analysis.

Recent changes in the bargaining status of the California Tomato Growers Association, continued growth in the share of tomatoes processed by farmer cooperatives, high inventory costs, and some indication of a slackening of processed product prices relative to previous actual and predicted values are all suggestive of some possible further changes in the structure of the industry. Continued high inflation rates may present another forecasting problem. While the CPI provided a satisfactory price deflator for the sample period of the study, it is possible that the association of tomato product prices and the CPI may vary in future periods. Thus, alternative deflators might be considered. As additional years of data become available and, hopefully, as the data base is improved, it will be interesting to reexamine the model and explore further possible extensions of the model formulation.

APPENDIX A

APPENDIX TABLE A.1

Processing Tomato Production Statistics for California, 1954-1980

Year	Acreage		Yield		Production	Grower Price[a/]	
	Planted AC	Harvested ACH	Planted acres YLDCP	Harvested acres YLDC	QCT	Field PGC	Processor door PGPC
	1000 acres		tons per acre		1000 tons	dollars per ton	
1954	79.5	79.50	16.90	16.90	1343.55	20.40	20.40
1955	116.3	116.30	17.10	17.10	1988.73	22.80	22.80
1956	151.5	151.50	18.30	18.30	2772.45	22.70	22.70
1957	129.6	128.70	15.59	15.70	2020.59	21.90	21.90
1958	152.9	152.90	17.20	17.20	2629.88	22.70	22.70
1959	129.7	129.70	15.40	15.40	1997.38	21.80	21.80
1960	130.0	130.00	17.30	17.30	2249.00	23.40	23.40
1961	146.8	146.80	15.80	15.80	2319.44	30.10	30.10
1962	177.2	177.20	18.20	18.20	3225.04	27.60	27.60
1963	129.0	129.00	19.10	19.10	2463.90	25.40	25.40
1964	143.0	143.00	21.00	21.00	3003.00	25.30	31.30
1965	122.8	122.80	20.10	20.10	2468.28	35.40	41.60
1966	162.5	162.50	19.30	19.30	3136.25	30.00	36.10
1967	186.7	186.70	17.10	17.10	3192.57	38.70	44.90
1968	231.3	231.30	21.20	21.20	4903.56	35.20	41.40
1969	154.0	154.00	2..90	21.90	3372.60	27.20	33.50
1970	141.3	141.30	23.80	23.80	3362.94	25.20	31.60
1971	163.7	163.70	23.70	23.70	3879.69	28.00	34.00
1972	183.4	178.90	24.68	25.30	4526.15	28.00	34.00
1973	224.4	218.00	21.66	22.30	4861.40	35.00	41.10
1974	252.4	249.90	23.17	23.40	5847.65	56.80	63.80
1975	305.6	299.20	23.79	24.30	7270.55	55.60	62.50
1976	265.0	233.80	19.12	21.70	5066.45	47.40	56.20
1977	278.8	276.40	23.92	24.10	6669.60	56.10	63.90
1978	237.0	231.90	22.32	22.80	5289.65	53.80	63.70
1979	256.0	250.00	24.80	25.40	6350.00	56.70	67.50
1980	211.2	208.30	26.23	26.60	5540.78	47.70	59.00

a/ Prior to 1964, prices were reported only at the first receiving point (field price). In 1964 the USDA began reporting prices only as delivered at the processor door. However, the California Crop Reporting Service has continued to report both a field and processor door price. The field price is used in the analysis to preserve continuity.

Sources: U. S. Statistical Reporting Service, Crop Reporting Board (1954-1980) and the California Crop and Livestock Reporting Service, 1954-1979.

APPENDIX TABLE A.2

Processing Tomato Production Statistics for the East, 1954-1980[a/]

Year	Acreage		Yield		Production	Grower[b/] price
	Planted AE	Harvested AEH	Planted acres YLDEP	Harvested acres YLDE	QET	PGE
	1000 acres		tons per acre		1000 tons	$/ton
1954	89.9	87.7	6.83	7.00	613.84	31.15
1955	96.2	93.5	4.69	4.82	451.06	31.97
1956	92.9	90.7	8.81	9.02	818.19	34.08
1957	76.4	74.8	6.86	7.01	524.15	34.92
1958	78.0	76.5	9.88	10.08	770.75	32.16
1959	64.8	63.9	8.68	8.81	562.65	30.87
1960	58.7	57.6	12.00	12.22	704.11	31.86
1961	61.0	60.6	13.05	13.14	796.23	32.13
1962	60.9	60.4	14.24	14.36	867.47	31.58
1963	48.8	48.5	12.12	12.19	591.23	31.75
1964	51.5	51.1	12.17	12.26	626.72	31.42
1965	54.6	54.1	14.25	14.38	777.90	33.56
1966	59.3	58.4	10.29	10.45	610.34	37.94
1967	56.4	55.4	12.71	12.94	716.74	42.35
1968	53.7	52.5	14.24	14.57	764.72	38.77
1969	42.0	40.9	12.64	12.98	530.87	39.00
1970	37.2	36.5	15.87	16.17	590.21	40.55
1971	35.2	34.6	13.27	13.50	467.11	41.41
1972	33.9	31.3	10.51	11.41	356.56	43.73
1973	31.3	30.3	12.64	13.06	395.71	48.36
1974	33.9	33.1	13.66	13.99	462.96	72.39
1975	29.5	28.6	13.21	13.62	389.55	70.46
1976	23.8	23.3	16.64	17.00	396.10	63.19
1977	21.9	21.4	14.18	14.50	310.45	63.54
1978	20.5	18.8	12.34	13.45	252.90	65.39
1979	18.9	17.8	13.23	14.05	250.11	67.59
1980	14.5	14.3	10.15	10.30	147.24	c/

a/ East includes New Jersey, Pennsylvania, Maryland, Virginia, New York (prior to 1976), and Delaware (prior to 1975).

b/ Field price prior to 1964; processor door price from 1964 on.

c/ Data not available when the table was prepared.

Source: U. S. Statistical Reporting Service, Crop Reporting Board, 1954-1980.

APPENDIX TABLE A.3

Processing Tomato Production Statistics for the Midwest, 1954-1980[a/]

Year	Acreage		Yield		Production	Grower[b/] price
	Planted AM	Harvested AMH	Planted acres YLDMP	Harvested acres YLDM	QMT	PGM
	1000 acres		tons per acres		1000 tons	$/ton
1954	58.0	56.9	9.57	9.76	555.14	27.04
1955	62.6	61.3	9.26	9.46	579.83	27.54
1956	70.6	69.3	11.12	11.33	785.27	27.88
1957	69.2	64.9	8.06	8.59	557.64	28.17
1958	75.5	69.3	8.87	9.66	669.50	28.36
1959	66.6	65.3	11.41	11.64	759.99	26.93
1960	64.9	64.0	13.68	13.87	887.92	28.35
1961	65.3	64.1	13.62	13.87	889.29	27.56
1962	63.5	62.9	16.47	16.63	1046.13	28.87
1963	48.6	48.1	16.92	17.09	822.22	27.53
1964	52.5	51.4	14.12	14.42	741.22	28.98
1965	59.0	58.0	18.33	18.64	1081.21	30.61
1966	58.1	56.1	12.36	12.80	718.19	33.12
1967	61.0	60.1	17.05	17.31	1040.15	38.00
1968	63.9	62.8	17.10	17.40	1092.94	36.77
1969	56.7	54.2	14.79	15.47	838.45	37.19
1970	50.0	49.3	19.36	19.63	967.89	38.12
1971	48.1	47.8	21.85	21.99	1051.00	38.26
1972	46.6	45.2	17.64	18.19	822.22	38.13
1973	39.4	37.9	15.03	15.62	592.37	44.51
1974	46.6	45.5	12.90	13.21	601.08	66.55
1975	45.3	44.3	15.36	15.70	695.60	66.10
1976	41.0	39.0	20.21	21.25	828.80	65.79
1977	38.3	37.8	17.22	17.44	659.35	66.17
1978	34.1	33.7	19.93	20.17	679.60	67.95
1979	36.2	34.6	16.78	17.55	607.39	69.06
1980	34.9	34.1	12.39	12.68	432.24	c/

a/ Midwest includes Ohio, Indiana, Michigan, and Illinois (prior to 1974).
b/ Field price prior to 1964; processor door price from 1964 on.
c/ Data not available when the table was prepared.

Source: U. S. Statistical Reporting Service, Crop Reporting Board, 1954-1980.

APPENDIX TABLE A.4

Processing Tomato Production Statistics for the United States 1954-1980a/

Year	Acreage: Planted A	Acreage: Harvested AH	Yield: YLD	Production: QT	Grower price b/ PG
	1000 acres	1000 acres	tons/harvested acre	1000 tons	$/ton
1954	270.40	262.95	10.30	2708.39	24.30
1955	335.60	330.50	9.90	3271.95	24.90
1956	359.00	354.48	13.10	4643.69	25.70
1957	312.67	304.32	10.90	3317.09	25.20
1958	357.50	343.65	12.50	4295.63	25.40
1959	300.33	296.93	11.90	3533.47	24.46
1960	282.90	279.95	14.50	4059.28	26.12
1961	307.45	304.55	14.00	4263.70	29.65
1962	330.10	327.90	16.40	5377.56	28.42
1963	252.57	250.46	16.40	4107.54	26.74
1964	276.11	273.35	16.80	4592.28	30.72
1965	260.99	257.36	17.50	4503.80	37.16
1966	306.05	300.13	15.50	4652.02	35.69
1967	333.43	327.56	15.80	5175.45	42.80
1968	373.76	370.15	18.80	6958.82	40.20
1969	272.35	266.94	18.35	4098.35	34.70
1970	248.60	245.09	20.64	5058.95	34.00
1971	256.86	254.73	21.65	5515.55	35.50
1972	276.31	265.02	21.90	5803.70	35.20
1973	305.94	295.10	20.11	5934.55	42.00
1974	343.69	337.70	20.79	7019.85	64.50
1975	393.93	384.25	22.13	8503.44	63.20
1976	346.82	308.96	20.95	6471.75	58.00
1977	352.31	346.66	22.44	7779.15	64.10
1978	304.06	295.56	21.54	6366.40	64.20
1979	321.40	311.73	23.52	7331.40	67.60
1980	267.38	263.03	23.61	6210.60	60.40

a/ Includes California, the East, the Midwest, and Other Regions (QT = QCT + QET + QMT + QRT).

b/ Field price prior to 1964; processor door price from 1964 on.

Source: U. S. Statistical Reporting Service, Crop Reporting Board, 1954-1980.

APPENDIX TABLE A.5

Canned Tomatoes: Supply and Disposition Statistics, 1954-1979

Year	Stocks			Pack			Imports[a]	Exports[a]	U.S. consumption[b]	Sales in U.S.[c]
	U.S. July 1	California July 1	California Jan 1	U.S.	California	Other				
	SW	SWC	S1W	QW	QWC	QWO	IW	EW	DW	AW
	1000 case equivalent, 24 No. 303 cans									
1954	5834	3412	8015	26629	10100	16529	3334	404	32148	28814
1955	3245	997	5632	30167	13058	17109	3558	358	33623	30065
1956	2989	1603	6070	36457	15996	20461	4068	1014	35512	31444
1957	6988	3680	10071	26446	13340	13106	3848	279	33699	29851
1958	3304	1366	8793	37152	18387	18765	5104	352	37282	32178
1959	7926	4259	11536	29422	14116	15306	4123	474	37013	32890
1960	3984	2355	9906	30991	15141	15850	5419	299	34805	29386
1961	5290	2611	9845	34034	14828	19206	6357	174	39805	33448
1962	5702	3052	9562	35541	17511	18030	5383	141	39707	34324
1963	6778	4098	12738	33041	17308	15733	3447	345	36168	32721
1964	6753	4250	12355	36431	20149	16282	3557	798	40799	37242
1965	5144	3430	13458	36015	19878	16137	4408	500	38799	34391
1966	6268	4397	13887	32662	20703	11959	4788	461	39561	34773
1967	3696	2231	12422	39127	23442	15685	6782	284	41702	34920
1968	7619	4310	14128	48422	34921	13501	5029	434	47038	42009
1969	13598	10771	22868	32036	23038	8998	4792	765	41291	36499
1970	8370	6520	20300	39017	29380	9637	6144	788	44105	37961
1971	8638	7017	21279	38027	29024	9003	5928	738	46178	40250
1972	5677	4778	19897	43301	34921	8380	5420	974	47784	42364
1973	5640	4246	18824	45347	38302	7045	3107	1090	49906	46799
1974	3098	2405	20288	43774	38170	5604	2780	987	43367	40587
1975	5318	4033	18805	53510	46603	6907	3285	1472	48575	45290
1976	12066	10240	28727	42805	35043	7762	3198	1089	47358	44160
1977	9431	7800	24763	54124	46486	7638	3256	1136	48813	45557
1978	16043	14493	33630	49241	40924	8317	3183	1211	52638	49455
1979	14618	12626	33386	52896	44781	8115	d/	d/	d/	d/

a/ Imports and exports converted from pounds to cases at 23.3 pounds per case.

b/ $DW_t = SW_t + QW_t + IW_t - EW_t - SW_{t+1}$.

c/ $AW_t = DW_t - IW_t$.

d/ Data not available when table was prepared.

Sources: U. S. stocks: U. S. Economic Research Service (1954b-1979b).
California stocks: Canners League of California (1954a-1979a) and (1954e-1979e).
Pack: National Canners Association (1954-1979); Canners League of California (1954i-1979i).
Imports and exports: U. S. Economic Research Service (1954a-1979a).

APPENDIX TABLE A.6

Tomato Juice: Supply and Disposition Statistics, 1954-1979

Year	Stocks U.S. July 1 SJ	Stocks California July 1 SJC	Stocks California Jan 1 S1J	Pack U.S. QJ	Pack California QJC[a/]	Pack Other QJO	Exports EJ	U.S. consumption DJ
	1000 case equivalents, 24 No. 303 cans							
1954	13975	4380	11472	32981	11937	21044	1563	37919
1955	7474	2012	9485	32844	15318	17526	1730	35950
1956	2638	1690	9562	53133	21768	31365	2484	40861
1957	12426	5773	15462	39760	18524	21236	2217	38529
1958	11440	6700	14972	45710	18657	27053	1538	42533
1959	13079	6440	15256	37962	14462	23500	1160	39211
1960	10670	4183	12336	40282	15094	25188	1187	39439
1961	10326	3931	10758	38545	14068	24477	1119	40754
1962	6998	2891	9908	48993	21283	27710	1113	42230
1963	12648	6813	15725	42114	15617	26497	1339	43467
1964	9956	5351	14091	43067	17853	25214	1289	41749
1965	9985	5783	14584	40047	13573	26474	884	40792
1966	8356	3448	10762	38907	18539	20368	807	39560
1967	6896	3212	11859	42815	16510	26305	726	40446
1968	8539	2696	11251	40169	19830	20339	572	37457
1969	10679	5919	15665	33653	16295	17358	494	36212
1970	7626	4265	14016	35952	16261	19691	618	36146
1971	6814	3447	12200	38411	18483	19928	454	36748
1972	8023	3942	12403	31074	17301	13773	770	35680
1973	2647	1330	10656	37936	19967	17969	900	34817
1974	4866	2218	11708	36133	20083	16050	985	34308
1975	5706	2615	10584	35358	21371	13987	1600	32929
1976	6535	3208	12235	32154	18152	14002	2038	27856
1977	8795	3462	11869	27844	18263	9581	1579	29516
1978	5544	3258	12227	33928	17286	16642	1170	31903
1979	5999	2381	9922	31517	17119	14398	b/	b/

a/ For 1967 and prior years, the California pack includes vegetable juice consisting of .70 percent or more tomato juice and tomato juice concentrate. From 1968, it includes only tomato juice and tomato juice concentrate.

b/ Data not available at the time the table was prepared.

Sources: U. S. stocks: U. S. Economic Research Service (1954b-1979b).

California stocks: Canners League of California (1954a-1979a) and (1954e-1979e).
Pack: National Canners Association (1954-1979); Canners League of California (1954l-1979l).
Imports and exports: U. S. Economic Research Service 1954a-1979a).

APPENDIX TABLE A.7

Tomato Catsup and Chili Sauce: California Supply and Disposition Statistics
U. S. Exports, 1954-1979

	Catsup[a/]				Chili Sauce				Catsup plus Chili Sauce				
	Stocks July 1 SCIC	Stocks Jan 1 SIC	Pack QCIC	Shipments[b/] DCIC	Stocks July 1 SCSC	Stocks Jan 1 SISC	Pack QCSC	Shipments[c/] DCSC	Stocks July 1 SCC	Stocks Jan 1 SICC	Pack QCC	Shipments DCC	U.S. exports EC
	1000 case equivalents, 24 No. 303 cans												
1954	703	1756	1976	2645	199	384	472	627	902	2140	2448	3272	1247
1955	34	1021	3700	3577	44	371	715	646	78	1392	4415	4223	954
1956	157	1471	5626	4066	113	382	821	650	270	1853	6447	4716	1203
1957	1717	3210	3208	3772	284	571	693	696	2001	3781	3901	4468	1278
1958	1153	2973	4625	4071	281	615	683	749	1434	3588	5308	4820	926
1959	1707	3573	3665	4772	215	547	770	798	1922	4120	4435	5570	738
1960	600	2794	4303	4020	187	549	847	812	787	3343	5150	4832	628
1961	883	2475	3678	3814	222	560	779	818	1105	3035	4457	4632	517
1962	747	2380	6501	4643	183	586	1139	875	930	2966	7640	5518	566
1963	2605	4967	3730	4268	447	840	751	881	3052	5807	4481	5149	616
1964	2067	4083	5184	5983	317	824	910	1050	2384	4907	6094	7033	746
1965	1268	4340	5224	5753	177	692	939	1006	1445	5032	6163	6759	632
1966	739	3242	7965	8082	110	569	1457	1281	849	3811	9422	9363	471
1967	622	3712	7398	6418	286	791	1007	1043	908	4503	8405	7461	355
1968	1602	4048	10998	7848	250	747	1459	1170	1852	4795	12457	9018	398
1969	4752	8550	6053	7518	539	1059	899	993	5291	9609	6952	8511	465
1970	3287	7613	5980	7762	445	938	880	943	3732	8551	6860	8705	381
1971	1505	5281	7503	8042	302	877	884	1083	1807	6158	8387	9125	459
1972	966	3904	7586	7597	175	709	1023	988	1141	4613	8609	8585	563
1973	955	4515	9086	9723	210	760	1246	1297	1165	5275	10332	11020	613
1974	318	4045	10329	9684	159	775	1116	958	477	4820	11445	10642	705
1975	963	4287	14552	11073	317	738	1274	1240	1280	5025	15826	12313	930
1976	4442	9068	6192	8461	351	983	1309	1329	4793	10051	7501	9790	829
1977	2173	5220	11126	8696	331	1003	1449	1294	2504	6223	12575	9990	918
1978	4603	8928	9086	10587	486	1210	1532	1688	5089	10138	10618	12275	786
1979	3323	7331	9307	d/	330	2397	d/	d/	3653	9728	9307	d/	d/

a/ Institutional-size containers only (No. 10 and larger).

b/ $DCIC_t = SCIC_t + QCIC_t - SCIC_{t+1}$.

c/ $DCSC_t = SCSC_t + QCSC_t - SCSC_{t+1}$.

d/ Data not available when the table was prepared.

Sources: Canners League of California (1954b-1979b), (1954f-1979f), and (1954i-1979i; for exports, see U. S. Economic Research Service (1954a-1979a).

APPENDIX TABLE A.8

Tomato Puree: Supply and Disposition Statistics, 1954-1979

Year	Stocks			Pack			Shipments[b/]
	U.S.[a/] July 1	California July 1	California Jan 1	U.S.	California	Other	
	SU	SUC	S1U	QU	QUC	QUO	DU
	1000 case equivalent, 24 No. 303 cans						
1954	1676	705	2180	3855	2069	1786	5350
1955	181	97	1078	5222	3489	1733	5113
1956	290	194	1429	7500	4732	2768	5645
1957	2145	1353	3003	5520	3792	1728	5762
1958	1903	1307	3049	5269	3675	1594	5317
1959	1855	1294	3185	4299	2910	1389	5674
1960	480	325	1944	5393	4063	1330	5550
1961	323	243	1909	6957	5300	1657	5810
1962	1470	1120	2910	8137	6006	2131	5972
1963	3635	2683	4919	5422	4058	1364	6149
1964	2908	2191	4456	5929	4788	1141	7370
1965	1467	1185	3826	6484	5263	1221	6678
1966	1273	1033	3772	7349	6249	1100	7846
1967	776	660	3211	8775	7126	1649	7779
1968	1772	1436	3690	13837	11744	2093	8435
1969	7174	6089	9026	7014	5757	1257	9217
1970	4971	4080	7764	5947	4920	1027	8192
1971	2726	2255	5290	7844	6567	1277	9000
1972	1570	1314	4899	9705	8820	885	10256
1973	1019	926	4954	9895	9003	892	10357
1974	557	513	4368	10282	9472	810	9763
1975	1076	991	3847	13807	12949	858	10171
1976	4712	4419	8330	8377	7495	882	9202
1977	3887	3478	6875	9824	9112	712	9585
1978	4126	3827	8001	8425	7788	637	9730
1979	2821	2599	7357	10395	9600	795	c/

a/ Estimated as $SU_t = SUC_t \cdot QU_{t-1} \div QUC_{t-1}$.

b/ $DU_t = SU_t + QU_t - SU_{t+1}$

c/ Data not available when the table was prepared.

Sources: For U. S. stocks, see U. S. Economic Research Service (1954b-1979b); for California stocks, see Canners League of California (1954d-1979d) and (1954h-1979h); and for Pack, see National Canners Association (1954-1979) and Canners League of California (1954i-1979i).

APPENDIX TABLE A.9

Tomato Paste: California Supply and Disposition Statistics U. S. Imports and Exports, 1954-1979[a/]

Year	Stocks July 1 SPIC	Stocks Jan 1 SIP	Pack QPIC	Shipments[b/] DPIC	U.S. Imports IP	U.S. Exports EP
	1000 case equivalents, 24 No. 303 cans					
1954	1158	2322	3179	4121	250	792
1955	216	1504	6187	6252	351	433
1956	151	1460	10115	8948	219	1058
1957	1318	2995	5482	5912	178	1071
1958	888	2590	8117	6991	361	666
1959	2014	3588	5103	6484	232	831
1960	633	2358	6756	7273	577	614
1961	116	1427	7972	7294	1836	471
1962	794	2082	11008	9096	914	406
1963	2706	4886	8173	9140	594	535
1964	1739	3726	9817	10437	586	518
1965	1119	4436	7152	8028	1469	438
1966	243	2926	10093	10125	3003	321
1967	211	1892	10239	9480	6654	246
1968	970	2350	16340	12426	4875	302
1969	4884	7637	11399	13487	3198	649
1970	2796	7966	11196	12866	4352	315
1971	1126	4961	13881	14236	4069	257
1972	771	4080	16843	17076	4864	404
1973	538	4721	20097	20242	3145	1722
1974	393	4945	25289	24519	981	1693
1975	1163	5486	32543	29985	1176	948
1976	3721	10979	20938	22890	2812	796
1977	1769	6382	32175	28778	2342	1307
1978	5166	10955	22977	25545	2400	1325
1979	2598	8780	31631	c/	c/	c/

a/ California data use for institutional-size containers only (No. 10 and larger).

b/ $DPIC_t = SPIC_t + QPIC_t - SPIC_{t+1}$.

c/ Data not available when the table was prepared

Sources: For stocks and pack, see Canners League of California (1954d-1979d), (1954h-1979h), and 1954i-1979i); for imports and exports, see U. S. Economic Research Service (1954a-1979a).

APPENDIX TABLE A.10

U. S. Per Capita Disappearance and Aggregate California Pack and Stocks of Processed Tomato Products, 1954-1979

Year	Per Capita Disappearance					Stocks[b/]		Pack[b/]
	Canned	Juice	Catsup and chili sauce	Puree	Paste	July 1	Jan 1	
	DWN	DJN	DCN[a/]	DUN	DPN[a/]	SCT	S1T	QCTR
	cases of 24 No. 303 equivalent per person					1000 tons farm weight equivalent		
1954	0.196	0.231	0.118	0.033	0.044	237	567	664
1955	0.202	0.216	0.127	0.031	0.060	73	390	1060
1956	0.209	0.241	0.141	0.033	0.071	71	420	1555
1957	0.195	0.223	0.125	0.033	0.058	327	774	1058
1958	0.212	0.242	0.133	0.030	0.066	260	718	1342
1959	0.206	0.219	0.144	0.032	0.063	386	847	972
1960	0.191	0.216	0.152	0.030	0.063	168	636	1166
1961	0.215	0.220	0.155	0.031	0.070	141	541	1250
1962	0.211	0.225	0.167	0.032	0.074	203	601	1709
1963	0.190	0.228	0.168	0.033	0.072	517	1067	1277
1964	0.211	0.216	0.187	0.038	0.078	397	1020	1530
1965	0.198	0.207	0.184	0.034	0.071	288	974	1309
1966	0.200	0.200	0.178	0.040	0.090	187	781	1717
1967	0.209	0.202	0.185	0.039	0.106	140	713	1737
1968	0.233	0.186	0.177	0.042	0.111	268	783	2630
1969	0.203	0.178	0.170	0.045	0.107	928	1648	1713
1970	0.214	0.175	0.172	0.040	0.111	590	1534	1756
1971	0.222	0.177	0.180	0.043	0.115	356	1166	2063
1972	0.228	0.170	0.168	0.049	0.132	253	1031	2410
1973	0.236	0.165	0.173	0.049	0.133	181	1056	2767
1974	0.204	0.161	0.172	0.046	0.143	123	1072	3159
1975	0.226	0.154	0.176	0.047	0.173	243	1060	4027
1976	0.219	0.129	0.175	0.043	0.148	732	1892	2614
1977	0.224	0.136	0.165	0.044	0.170	471	1406	3726
1978	0.240	0.145	c/	0.044		876	1949	2923
1979						582	1735	3568

a/ Estimated values obtained by supplementing California institutional sales data with confidential survey data. Figures for 1974 on are approximations based on extensions of the survey data.

b/ Converted to farm weight as follows:

SCT = .014SWC + .014SJC + .035SCC + .035SUC + .066SP1C

S1T = .014S1W + 014S1J + .03S1CC + .035S1U + .066S1P

QCTR = .014QWC + .014QJC + .03QCC + .035QUC + .066QP1C.

c/ Blanks indicate data not available at the time the report was prepared.

Source: Calculated.

APPENDIX TABLE A.11

Season Average F.O.B. Processor Prices of Tomato Products, 1954-1979[a/]

Year	Canned Tomatoes			Juice			Catsup		Puree	Paste
	24/303 cases, standard			12/46 oz. cans, fancy			24/14 oz. glass fancy		6/10 cans, 1.06 sp. gr.	6/10 cans, 26 percent
	East	Midwest	California	East	Midwest	California	Midwest	California	--California--	
	PWE	PWM	PWC	PJE	PJM	PJC	PCM	PCC	PUC	PPC
	dollars per case									
1954	2.52	2.73	2.60	2.42	2.37	2.37	3.52	3.39	3.15	5.80
1955	2.72	2.86	2.57	2.60	2.59	2.54	3.75	3.75	3.61	7.32
1956	2.57	2.67	2.48	2.64	2.46	2.38	3.53	3.55	3.41	6.99
1957	3.04	3.24	2.76	2.69	2.66	2.48	3.42	3.32	3.17	5.74
1958	2.44	2.68	2.54	2.51	2.42	2.36	3.36	3.16	3.27	5.05
1959	2.64	2.72	2.68	2.45	2.47	2.38	3.42	3.20	3.56	5.53
1960	2.68	2.81	2.72	2.59	2.46	2.51	3.55	3.34	4.08	6.63
1961	2.46	2.73	2.95	2.57	2.42	2.56	3.62	3.44	4.49	7.75
1962	2.54	2.68	2.54	2.38	2.33	2.24	3.27	2.98	3.86	6.00
1963	2.81	2.79	2.86	2.53	2.51	2.39	3.23	3.13	3.93	6.11
1964	2.66	2.84	2.86	2.59	2.56	2.51	3.36	3.36	4.18	6.53
1965	2.99	3.14	3.12	2.75	2.66	2.83	3.68	3.75	5.34	8.75
1966	3.48	3.66	3.39	2.96	2.94	2.94	4.04	3.86	5.70	9.63
1967	3.59	3.68	3.51	2.93	2.78	2.99	3.97	4.14	6.29	10.88
1968	3.10	3.22	3.06	2.56	2.55	2.65	3.99	3.98	4.99	8.31
1969	3.78	3.55	3.42	2.83	2.93	2.75	4.11	4.09	4.50	6.68
1970	3.77	3.91	3.64	3.15	3.04	3.05	4.30	4.30	4.93	7.53
1971	3.86	4.04	3.80	3.15	3.10	3.13	4.34	4.39	5.39	8.49
1972	4.40	4.43	3.96	3.49	3.64	3.47	4.78	4.60	5.79	8.59
1973	5.14	4.96	4.28	4.26	4.26	3.86	5.28	4.69	6.75	10.99
1974	5.88	5.94	5.43	5.68	5.59	5.15	7.84	7.00	9.31	16.98
1975	5.63	5.75	5.29	5.36	5.41	4.83	7.85	7.39	8.25	13.63
1976	5.78	6.00	6.13	5.36	5.53	5.48	7.95	8.05	8.75	14.19
1977	5.93	6.20	5.78	5.56	5.59	5.09	7.50	6.74	7.88	13.83
1978	6.35	6.12	6.11	6.37	6.47	5.89	7.56	7.50	8.27	14.82
1979	6.07	6.12	6.04	6.38	6.46	5.85	7.36	7.60	7.78	14.34

a/ Prices are simple averages of monthly or quarterly reported values.

Sources: Judge (1954-1979) and Pacific Fruit News (various issues).

APPENDIX TABLE A.12

Season Average Prices of Tomatoes and Tomato Products Deflated by the Consumer Price Index, 1954-1979

Year	Deflated Regional Tomato Grower Price			Deflated Season Average F.o.b. Price Per Case in California				
	California PGCD	Midwest PGMD	East PGED	Canned tomatoes (24/303 cans, standard) PWD	Tomato juice (12/46 oz., cans, fancy) PJD	Catsup (24/14 oz., glass, fancy) PCD	Puree (6/10 cans, 1.06 sp. gr.) PUD	Paste (6/10 cans, 26 percent) PPD
	dollars per ton			dollars per case				
1954	25.34	33.59	38.70	3.23	2.94	4.21	3.91	7.20
1955	28.43	34.34	39.86	3.20	3.17	4.68	4.50	9.13
1956	27.89	34.25	41.87	3.05	2.92	4.36	4.19	8.59
1957	25.90	33.42	41.42	3.27	2.94	3.94	3.78	6.81
1958	26.21	32.75	37.14	2.93	2.73	3.65	3.78	5.83
1959	24.97	30.85	35.36	3.07	2.73	3.67	4.08	6.33
1960	26.38	31.96	35.92	3.07	2.83	3.77	4.60	7.47
1961	33.59	30.76	35.86	3.29	2.86	3.84	5.01	8.65
1962	30.46	31.87	34.86	2.80	2.47	3.29	4.26	6.62
1963	27.70	30.02	34.62	3.12	2.61	3.41	4.29	6.66
1964	27.23	31.19	33.82	3.08	2.70	3.62	4.50	7.03
1965	37.46	32.39	35.51	3.30	2.99	3.97	5.65	9.26
1966	30.86	34.07	39.03	3.49	3.02	3.97	5.86	9.91
1967	38.70	38.00	42.35	3.51	2.99	4.14	6.29	10.08
1968	33.78	35.29	37.21	2.94	2.54	3.82	4.79	7.98
1969	24.77	33.87	35.52	3.11	2.50	3.72	4.10	6.08
1970	21.67	32.78	34.87	3.13	2.62	3.70	4.24	6.47
1971	23.08	31.54	34.14	3.13	2.58	3.62	4.44	7.00
1972	22.35	30.43	34.90	3.16	2.77	3.67	4.62	6.86
1973	26.30	33.44	36.33	3.22	2.90	3.52	5.07	8.26
1974	38.46	45.06	49.01	3.68	3.49	4.74	6.30	11.50
1975	34.49	41.00	43.71	3.28	3.00	4.58	5.12	8.46
1976	27.88	38.59	37.06	3.60	3.21	4.72	5.13	8.32
1977	30.91	36.46	35.01	3.18	2.80	3.71	4.34	7.62
1978	27.53	34.77	33.46	3.34	3.01	3.84	4.23	7.58
1979	26.08	31.77	31.09	2.78	2.67	3.50	3.58	6.60

Source: Calculated from data in Appendix Tables A.1, A.2, A.3, A.11 and A.14.

APPENDIX TABLE A.13

Processed Tomato Product Prices Per Unit of Raw Product and Average Processor-Grower Margin Indicators, 1954-1979[a]

Year	Processed Product Prices[b]					Weighted average[c]	Margin indicator[d]
	Canned PWRD	Juice PJRD	Catsup PCRD	Puree PURD	Paste PPRD	PRDW	MRDW
	dollars per ton of raw product						
1954	229.33	136.24	182.80	69.95	66.60	123.59	98.25
1955	227.20	146.90	203.21	80.51	84.45	130.03	109.60
1956	216.55	135.31	189.31	74.96	79.46	129.50	101.61
1957	232.17	136.24	171.07	67.62	62.99	119.41	93.43
1958	208.03	126.51	158.48	67.62	53.93	107.98	81.77
1959	217.97	126.51	159.35	72.99	58.55	112.10	87.13
1960	217.97	131.14	163.69	82.29	69.10	119.07	92.69
1961	233.59	132.53	166.73	87.63	80.01	127.65	94.06
1962	198.80	114.46	142.85	76.21	61.24	105.87	75.41
1963	221.52	120.95	148.06	76.75	61.61	111.10	83.40
1964	218.68	125.12	157.18	80.51	65.03	115.08	87.85
1965	234.30	138.56	172.38	101.08	85.66	133.06	95.60
1966	247.79	139.95	172.38	104.84	91.67	138.12	107.26
1967	249.21	138.56	179.76	112.53	100.64	144.60	105.90
1968	208.74	117.70	165.86	85.69	73.82	119.44	85.66
1969	220.81	115.85	161.52	73.35	56.24	110.99	86.22
1970	222.23	121.41	160.65	75.85	59.85	113.34	91.67
1971	222.23	119.56	157.18	79.43	64.75	114.86	91.78
1972	224.36	128.36	159.35	82.65	63.46	116.13	93.78
1973	228.62	134.39	152.84	90.70	76.41	122.27	95.97
1974	261.28	161.73	205.81	112.71	106.38	157.22	118.76
1975	232.88	139.02	198.86	91.60	78.26	135.05	100.56
1976	255.60	148.75	204.94	91.78	76.96	140.00	112.12
1977	225.78	129.75	161.09	77.64	70.49	119.72	88.81
1978	237.14	139.48	166.73	75.67	70.12	123.24	95.71
1979	197.38	124.65	151.97	64.05	61.05	106.46	80.38

a/ Values deflated by CPI.

b/ Processed product prices in Appendix Table A.12 converted to raw product basis using the following conversion factors (see Appendix Table A.17): PWRD = 71PWD, PJRD = 46.34PJD, PCRD = 43.42PCD, PURD = 17.89PUD, PPRD = 9.25PPD.

c/ Weighted average of PWRD, PJRD, PCRD, PURD, PPRD. Weights are proportions of sales (farm weight) in each of the measured processed product categories during 1973-1977. Weights are: W = .141, J = .092, C = .235, U = .073, P = .459.

d/ MRDW = PRDW - PGCD.

Source: Calculated as indicated in footnotes.

APPENDIX TABLE A.14

Values of Selected Exogenous Variables Affecting Demand and Supply of Tomatoes and Tomato Products, 1954-1979

Year	U.S. Population[a/] July 1 NM	U.S. Population[a/] Jan 1 t+1 N	U.S. Deflated Disposable Income Total YD	U.S. Deflated Disposable Income Per Capita YND	Consumer price index[b/] CPI	DOVN[c/]	Price of soybeans, Ohio[d/] PMSD	YMAC[e/]	Grower cost indicator[f/] GCRD	TC[g/]
	thousands		billion dollars	dollars	1967 = 100	pounds	dollars per bushel	tons per acre	dollars per acre	percent
1954	162400	164000	320	1969	80.5	41.91	3.07	16.00	381.70	0.00
1955	165300	166800	343	2077	80.2	43.56	2.84	16.67	416.60	0.00
1956	168200	169800	360	2141	81.4	44.14	2.70	17.00	443.00	0.00
1957	171300	172700	366	2136	84.3	44.54	2.49	17.43	459.30	0.00
1958	174100	175700	368	2114	86.6	45.50	2.33	17.03	477.80	0.00
1959	177100	179400	386	2182	87.3	45.81	2.26	17.07	504.60	0.00
1960	180700	182300	395	2184	88.7	45.75	2.46	16.10	526.60	0.00
1961	183700	185300	407	2214	89.6	45.60	2.51	16.63	550.30	0.50
1962	186500	188000	425	2280	90.6	48.02	2.57	16.17	572.70	1.30
1963	189200	190600	441	2332	91.7	48.65	2.77	17.10	594.90	1.30
1964	191900	193200	472	2457	92.9	48.88	2.86	17.70	613.20	3.50
1965	194300	195500	501	2577	94.5	50.55	2.74	19.43	610.70	20.00
1966	196600	197700	527	2679	97.2	51.70	2.84	20.07	560.50	70.00
1967	198700	199800	546	2749	100.0	53.33	2.52	20.13	558.80	80.00
1968	200700	201800	567	2826	104.2	55.18	2.30	18.83	547.20	92.00
1969	202700	203800	578	2850	109.8	55.76	2.15	19.20	536.00	98.00
1970	204900	206100	595	2903	116.3	55.91	2.44	20.07	526.00	100.00
1971	207000	208100	615	2973	121.3	55.98	2.54	22.30	525.30	100.00
1972	208800	209700	640	3067	125.3	57.03	3.45	23.13	528.90	100.00
1973	210400	211200	679	3227	133.1	59.13	4.29	24.27	571.00	100.00
1974	211900	212800	663	3130	147.7	58.64	4.56	23.77	612.70	100.00
1975	213600	214500	671	3139	161.2	56.81	3.10	23.67	635.90	100.00
1976	215100	216000	693	3222	170.5	58.65	4.10	23.33	671.60	100.00
1977	216800	217700	721	3327	181.5	59.24	3.11	23.13	702.50	100.00
1978	218500	219700	746	3416	195.4	57.77	3.45	23.37	665.30	100.00
1979	220600	221700	747	3384	217.4	h/	h/	22.87	609.50	100.00

a/ Total including armed forces overseas.
b/ All commodities.
c/ Total per capita disappearance of frozen and canned vegetables excluding potatoes, sweet potatoes, and canned tomatoes.
d/ Deflated price received by growers.
e/ Three-year average of California yield per harvested acre ending in year t - 1 (Appendix Table A.1 data).
f/ Deflated cost per acre. (For an explanation, see Appendix B, *infra*, p. 98.)
g/ Percent of California tomato acreage harvested mechanically [Brandt, French, and Jesse (1978)].
h/ Data not available when the table was prepared.

Sources: Population, income, consumer price index, and DOVN: U. S. Economic Research Service (1968-1979). Soybeans and processed vegetables: *idem* (1954d-1979d).

APPENDIX TABLE A.15

Processed Tomato Product and Minor Region Allocation Ratios, 1954-1979[a/]

Year	Allocation of California production					Allocation of other region production[b/]			California catsup chili sauce, and paste sale		Allocation of minor region production	
	RWC	RJC	RCC	RUC	RPC	RWO	RJO	RUO	KCC	KPCE	RR	RA
1954	7.040	8.868	2.017	1.540	3.224	11.591	15.425	1.350	0.177	0.583	0.081	0.199
1955	6.618	8.146	2.122	1.667	3.042	12.126	15.279	1.377	0.189	0.617	0.074	0.183
1956	6.313	8.241	2.159	1.779	3.157	11.459	15.600	1.388	0.202	0.620	0.071	0.165
1957	6.454	8.038	2.071	1.660	3.147	10.769	16.461	1.256	0.204	0.609	0.062	0.148
1958	6.887	7.834	2.056	1.577	2.785	10.446	15.973	1.065	0.210	0.557	0.063	0.151
1959	6.930	7.015	2.176	1.554	2.882	9.995	15.151	0.865	0.199	0.587	0.059	0.144
1960	6.731	6.672	2.144	1.850	2.999	9.533	13.934	0.830	0.183	0.602	0.062	0.131
1961	6.105	6.457	2.193	1.785	3.285	9.003	13.126	0.859	0.170	0.645	0.056	0.112
1962	6.282	6.334	2.036	1.931	3.389	9.276	13.861	0.891	0.168	0.658	0.057	0.112
1963	6.388	6.294	2.072	1.701	3.333	9.398	14.953	0.846	0.179	0.679	0.052	0.109
1964	7.263	5.927	2.115	1.791	3.161	9.248	14.997	0.716	0.183	0.623	0.050	0.112
1965	7.121	5.785	2.510	1.906	3.128	8.687	14.103	0.681	0.216	0.662	0.044	0.105
1966	7.332	5.527	2.711	2.119	3.108	7.909	13.236	0.719	0.218	0.645	0.043	0.098
1967	7.022	5.042	2.726	2.207	3.253	7.456	12.200	0.859	0.240	0.669	0.039	0.087
1968	7.098	4.682	2.411	2.111	3.306	6.792	11.513	0.891	0.233	0.679	0.036	0.082
1969	7.563	4.570	2.214	1.855	3.347	6.050	10.961	0.816	0.248	0.693	0.030	0.079
1970	7.683	4.810	2.088	1.621	3.429	5.694	11.723	0.737	0.245	0.696	0.028	0.069
1971	7.978	4.474	2.035	1.701	3.543	5.915	11.524	0.693	0.245	0.707	0.022	0.058
1972	7.692	4.231	2.063	1.831	3.811	6.209	13.236	0.768	0.263	0.732	0.018	0.041
1973	7.374	3.788	1.995	1.807	4.060	5.968	13.739	0.738	0.279	0.760	0.016	0.039
1974	6.939	3.494	2.086	1.751	4.312	5.649	13.927	0.739	0.306	0.786	0.016	0.035
1975	6.617	3.319	1.871	1.627	4.311	5.302	11.667	0.672	0.292	0.789	0.021	0.040
1976	6.764	3.087	1.848	1.542	4.478	6.003	9.981	0.655	0.287	0.794	0.022	0.042
1977	7.207	3.196	1.791	1.437	4.434	6.710	11.352	0.620	b/	b/	0.023	0.045
1978	7.246	2.901	1.786	1.450	4.716	7.626	12.921	0.681	b/	b/	0.020	0.038
1979	7.246	2.901	1.786	1.450	4.716	7.626	12.921	0.681	b/	b/	0.020	0.032

a/ Each number is a three-year centered moving average of the following ratios:

RWC: $\frac{QWC}{QCT}$, RJC: $\frac{QJC}{QCT}$, RCC: $\frac{QCC}{QCT}$, RUC: $\frac{QUC}{QCT}$, RPC: $\frac{QPIC}{QCT}$, RWO: $\frac{QWO}{QOT}$, RJO: $\frac{QJO}{QOT}$, RUO: $\frac{QUO}{QOT}$, KCC: $\frac{DCC}{DC}$, KPC: $\frac{DPIC}{AP + EP}$

RR: QRT ÷ (QCT + QMT + QET), RA: AR ÷ (AC + AM + AE). Note that QCT is in tons farm weight and QKC is cases. The coefficients are used to allocate raw production to processed product pack forms.

b/ Not calculated for years after 1976 because data to compute DC and DP were not available. Latest year average values were used in all further projections of model values.

Source: Calculated as indicated in footnote a/.

APPENDIX TABLE A.16

Conversion Factors for Containers to No. 303 Cans and to Cases of 24/303 Can Equivalent

Container designation	Container conversion factor to No. 303	Case conversion: Number of containers per case	Case conversion: Factor to 24/303
Tin containers			
6 oz.	.360	48	.720
8 oz. short	.470	48	.940
8 oz. tall (buffet)	.514	48	1.028
No. 1 flat	.527	48	1.296
No. 1 picnic	.648	48	1.296
No. 211 cylinder	.803	24	.803
No. 2 vacuum (12 oz. vacuum)	.871	24	.871
No. 300	.902	24	.902
No. 1 tall	.989	24	.989
No. 303	1.000	24	1.000
No. 300 cylinder	1.149	24	1.149
No. 2	1.217	24	1.217
No. 303 cylinder	1.295	--	--
No. 3 vacuum	1.416	24	1.416
Jumbo	1.531	--	--
No. 2 cylinder	1.564	24	1.564
No. 2-1/2	1.765	24	1.765
29 oz.	1.925	12	.962
32 oz. (quart)	2.103	12	1.052
No. 3 cylinder (46 oz.)	3.063	12	1.532
No. 5 squat	4.034	6	1.008
No. 10	6.483	6	1.621
No. 12 (gallon)[a/]	8.207	6	2.052
5 gallon	41.035	1	1.710
Glass containers			
12 oz. bottles	.680	24	.680
14 oz. bottles	.906	24	.906
18/20/24 oz. bottles	.515	12	1.130

a/ No. 12 gallon = 6.744 No. 2 can equivalent; No. 2 can = 1.217; and No. 303 can equivalent (6.744 • 1.217 = 8.207).

Sources: Judge (1976) and King, Jesse, and French (1973).

APPENDIX TABLE A.17

Conversion Factors for Processing Tomato Products, Cases, and Prices

	Product				
	Canned tomatoes	Tomato juice	Catsup and chili sauce	Puree	Paste
Pounds farm weight per case of 24/303					
United States	36.36	36.36	66.67	80.00	142.86
California[a]	28	28	60	70[b]	132[c]
24/303 cases per ton farm weight					
United States	55	55	30	25	14
California	71	71	33	29	15
F.o.b. product price per ton farm weight					
Case unit	24/303 can, standard	12/46 oz. can, fancy	24/14 oz. glass, fancy	6/10	6.10
Conversion factor[d]	71.00	46.34	43.42	17.89[e]	9.25[f]

a/ Estimates based on industry data and Hoos (1956).
b/ 11 percent solids.
c/ 33 percent solids.
d/ Conversion factors calculated using column 4 and appropriate conversions from Appendix Table A.16.
e/ 1.06 sp. gr.
f/ 26 percent solids.

Sources:

For farm weight, United States: U. S. Economic Research Service (1972).
For farm weight, California: Hoos (1956) and King, Jesse, and French (1973).

APPENDIX B

Appendix B

Appendix Table B.1 contains trend values of California processing tomato production costs per acre used in the supply response analysis and the assumed production–cost values for the alternative hand–harvest scenarios. The trend values were derived from sample cost of production studies compiled by the California Agricultural Extension Service in a number of counties during the period 1956 to 1979. The values of GCRH and GCRM were obtained as predictions of equation (8) in King, Jesse, and French (1973) for the period 1954 to 1972, assuming one–half of the land rented and one–half owned. After 1973, reported costs began increasing at a much more rapid rate than had been maintained during the previous two decades. Thus, the trend equation used in earlier periods was no longer appropriate. Trend values from 1973 to 1979 were obtained by a free–hand fit to available sample cost of production studies.[1] The GCR series is a TC/100 weighted average of the hand– and machine–harvest trend series.

The GCRD series divides the GCR series by the CPI (CPI/100). The GCRHD series attempts to approximate production costs with hand harvest as it was and as it would have been had it continued past 1969. The series is simply GCRH ÷ CPI/100 up to 1970. In 1969 the hand–harvest costs were estimated to be 1.21 times the machine–harvest cost. This figure was used to extend the hand–harvest cost through later years. The ratio rather than a constant difference was chosen to reflect proportionate increases in hand–harvest costs as costs increased generally and to allow in an absolute sense for some further improvement in relative efficiency of mechanical harvest with added experience. The GCRHD series assumes that hand–harvest wage rates would have increased no more than wage rates under mechanical harvest.

The GCRHD1, GCRHD2, and GCRHD3 series provides three alternative scenarios with respect to possible increases in labor costs required to obtain the added hand–harvest labor. GCRHD1 increases wage costs by 30 percent. Since labor accounts for about half of total cost with hand harvest, this increases per acre total cost by 15 percent. GCRHD2 increases wage costs by 60 percent, and GCRHD3 doubles wage costs.

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[1]Observed values of cost studies for the period 1956–1973 are given in King, Jesse, and French (1973, pp. 70 and 71). Cost study values obtained for the period 1974 to 1979 are as follows (dollars per acre):

For 1974, San Joaquin, Contra Costa, and Stanislaus Counties, $1,084; Sacramento County, $990; and Merced County, $913.

For 1975, San Joaquin County, $941.

For 1976, San Joaquin, Contra Costa, and Stanislaus Counties, $1,164; and Yolo County, $1,194.

For 1977, Yolo County, $1,285.

For 1979, Yolo County, $1,339.

These figures are for machine harvest with manual sort.

APPENDIX TABLE B.1

Trend Values of California Processing Tomato Production Costs, 1953-1979

Year	Proportion of acres harvested mechanically	Current dollar values (dollars per acre)			Deflated values (dollars per acre)				
		Hand harvest	Machine harvest	Weighted average	Weighted average	Alternative hand harvest scenarios			
	TC/100	GCRH	GCRM	GCR	GCRD	GCRHD	GCRHD1	GCRHD2	GCRHD3
1953	0	280.8	a/	280.8	350.6	350.6	b/	b/	b/
1954	0	307.3		307.3	381.7	381.7			
1955	0	334.1		334.1	416.6	416.6			
1956	0	360.6		360.6	443.0	443.0			
1957	0	387.2		387.2	459.3	459.3			
1958	0	413.8		413.8	477.8	477.8			
1959	0	440.5		440.5	504.6	504.6			
1960	0	467.1		467.1	526.6	526.6			
1961	.005	493.7	382.0	493.1	550.3	551.0			
1962	.013	530.4	407.5	528.8	583.6	585.4			
1963	.013	547.0	433.0	545.5	594.9	596.5			
1964	.035	573.7	458.6	569.7	613.2	617.5			
1965	.200	600.3	484.1	577.1	610.7	635.2	730.5	825.8	952.8
1966	.700	626.9	509.6	544.8	560.5	644.6	741.3	838.0	966.9
1967	.800	653.6	535.1	558.8	558.8	653.6	751.6	849.7	980.4
1968	.920	680.2	560.6	570.2	547.2	652.8	750.7	848.6	979.2
1969	.980	706.9	586.1	588.5	536.0	643.8	740.4	836.9	965.7
1970	1.00	a/	611.7	611.7	526.0	636.5	732.0	827.5	954.8
1971	1.00		637.2	637.2	525.3	635.6	730.9	826.3	953.4
1972	1.00		662.7	662.7	528.9	640.0	736.0	832.0	960.0
1973	1.00		760.0	760.0	571.0	690.9	794.5	898.2	1036.4
1974	1.00		905.0	905.0	612.7	741.4	852.6	963.8	1112.1
1975	1.00		1025.0	1025.0	635.9	769.4	884.8	1000.2	1154.1
1976	1.00		1145.0	1145.0	671.6	812.6	934.5	1056.4	1218.9
1977	1.00		1275.0	1275.0	702.5	850.0	978.2	1105.0	1275.0
1978	1.00		1300.0	1300.0	665.3	a/	a/	a/	a/
1979	1.00		1325.0	1325.0	609.5				

a/ Blanks indicate series not computed for that period.

b/ Prior to 1965, the series is identical to GCRHD.

Source: For an explanation, see Appendix B, *supra*, p. 98.

APPENDIX C

Appendix C

Estimates of Conversion Ratios Between Output and Employment in the California Processing Tomato Industry

The estimates of total employment in the processing tomato industry presented in section 6 were computed from the estimates of labor requirements per acre or per ton in Appendix Table C.1. They were obtained as follows.

Preharvest Production Labor

Estimates of preharvest production labor requirements per acre were constructed from inputs specified in 28 Cooperative Extension sample cost–of–product studies in 14 different California counties covering the period 1958 to 1979. While varying somewhat, the studies revealed a general downward trend in cultural labor requirements. The numbers given in Appendix Table C.1 are representative of the values in the various studies and reflect the downtrend. The numbers do not necessarily represent actual average values.

Harvest Season Labor

Estimates of harvest season labor per ton were computed from data reported in Brandt, French, and Jesse (1978, p. 33) assuming a 50–hour work week. The values for later years compare well with reported hours per ton in Cooperative Extension studies of mechanical harvesting. The earlier Extension studies did not report labor hour requirements for hand harvest since the workers were paid by the box. The work week totals during the period of hand harvest (early 1960s) are consistent with fresh tomato harvest studies which would suggest picking rates of about five to six 50–pound lugs per hour. The declining average labor hour values reflect the shift from strictly hand harvest to strictly mechanical harvest and then a small further decline as mechanical harvest efficiency improved with experience. The estimates exclude mechanical harvesting with electronic sorting.

Assembly

Estimates of labor required to transport tomatoes from fields to processing plants were computed from values suggested in Brandt, French, and Jesse (1979, p. 53). They estimated assembly labor at .12 hours per ton in 1960 and .27 hours per ton in 1975, the higher figure attributed to increased hauling distances. The values in Appendix Table C.1 for the years between were obtained by interpolation.

Cannery Labor

Emerson (1976) reported that 7.7 seasonal workers and 2.1 other season workers were required per 1,000 tons canned. Unfortunately, there is no specification as to how many days or hours each worker worked. While California canneries may operate for up to 16 weeks, it seems doubtful that many would operate with full crews for that length of time. For the purposes of this study, it was assumed that the average seasonal job was 500 hours. This yields an average value of 3.85 seasonal workers per ton ($7.7 \times 500 \div 1{,}000$).

APPENDIX TABLE C.1

Labor Conversion Coefficients for the Processing Tomato Industry, 1960-1979[a/]

Year	Preharvest production labor	Harvest season labor	Assembly labor
	labor hours per acre	labor hours per ton	
1960	40	7.60	.12
1961	40	7.90	.13
1962	38	6.25	.14
1963	38	6.25	.15
1964	37	6.30	.16
1965	37	5.40	.17
1966	36	4.60	.18
1967	36	3.90	.19
1968	35	3.00	.20
1969	35	2.70	.21
1970	35	2.30	.22
1971	34	2.35	.23
1972	34	2.30	.24
1973	33	2.15	.25
1974	33	2.10	.26
1975	32	1.75	.27
1976	32	1.95	.27
1977	31	1.80	.27
1978	31	1.80	.27
1979	30	1.80	.27

a/ Estimates of cannery labor coefficients are 3.85 hours per ton for canning season labor and 1.68 hours per ton for off-season labor.

Source: For an explanation, see Appendix C, *supra*, p. 101.

The hours of off-season work are even more difficult to estimate. It is assumed here that, while some workers are retained year-round, the average off-season job consisted of twenty 40-hour weeks. The average off-season labor requirement per ton is $2.1 \times 500 \div 1{,}000 = 1.68$, and total cannery labor is estimated at 5.53 hours per ton. While these are very crude values, substantial variations above or below would not greatly alter the estimates of *comparative employment* under conditions of mechanical harvest adoption and continued hand harvest.

APPENDIX D

APPENDIX TABLE D.1

Matrix Representation of the U.S. Processing Tomato Industry Model[a/]

$$B_1 \; Y_t = B_2 \; Y_{t-1} + B_3 \; Z_t$$

Column vector of endogenous variables (Y)	B1 Matrix (56 x 56)					
	Row column i,j	Values of non-zero elements	Row column i,j	Values of non-zero elements	Row column i,j	Values of non-zero elements
1 S1TT	1, 1	1	20, 20	1	39, 40	22.5035
2 PGCD	2, 1	1.3431	21, 16	-.014	40, 18	-1.2924/N
3 AC	2, 2	51.3183	21, 17	-.014	40, 27	-1.2924/N
4 QCT	2, 4	1	21, 18	-.030	40, 39	-.0452
5 PGMD	3, 2	-.2551 YMAC	21, 19	-.035	40, 40	1
6 AM	3, 3	1	21, 20	-.066	41, 24	30.1158/N
7 QMT	4, 3	-YLDCP	21, 21	1	41, 28	30.1158/N
8 PGED	4, 4	1	22, 12	-RWO	41, 41	1
9 AE	5, 2	-.2707	22, 16	-1	42, 24	-.7896/N
10 QET	5, 5	1	22, 22	1	42, 28	-.7896/N
11 QRT	6, 5	-1.4612	23, 12	-RJO	42, 41	-.0106
12 QOT	6, 6	1	23, 17	-1	42, 42	1
13 AR	7, 6	-YLDMP	23, 23	1	43, 29	147.8438/N
14 A	7, 7	1	24, 12	-RUO	43, 43	1
15 QT	8, 2	-.3724	24, 19	-1	43, 45	24.1768
16 QWC	8, 8	1	24, 24	1	44, 20	-.9812/N
17 QJC	9, 8	-1.0228	25, 25	1	44, 29	-.9812/N
18 QCC	9, 9	1	26, 26	1	44, 43	-.0037
19 QUL	10, 9	-YLDEP	27, 27	1	44, 44	1
20 QPIC	10, 10	1	28, 28	1	45, 44	-1
21 QCTR	11, 4	-RR	29, 29	1	45, 45	1
22 QW	11, 7	-RR	30, 25	-.8466	46, 35	-N
23 QJ	11, 10	-RR	30, 30	1	46, 46	1
24 QU	11, 11	1	31, 26	-.5733	47, 36	-N
25 SW	12, 7	-1	31, 31	1	47, 47	1
26 SJ	12, 10	-1	32, 28	-.9236	48, 38	-N
27 SCC	12, 11	-1	32, 32	1	48, 48	1
28 SU	12, 12	1	33, 27	-.030	49, 40	-N
29 SPIC	13, 3	-RA	33, 29	-.066	49, 49	1
30 SWC	13, 6	-RA	33, 30	-.014	50, 42	-N
31 SJC	13, 9	-RA	33, 31	-.014	50, 50	1
32 SUC	13, 13	1	33, 32	-.035	51, 44	-N
33 SCTT	14, 3	-1	33, 33	1	51, 51	1
34 PWD	14, 6	-1	34, 34	1	52, 45	-N
35 AWN	14, 9	-1	34, 36	16.9024	52, 52	1
36 DWN	14, 13	-1	35, 22	-.6354/N	53, 49	-KCC
37 PJD	14, 14	1	35, 25	-.6354/N	53, 53	1
38 DJN	15, 4	-1	35, 34	-.0242	54, 51	-KPCE
39 PCD	15, 12	-1	35, 35	1	54, 54	1
40 PCN	15, 15	1	36, 35	-1	55, 34	-9.9968
41 PUD	16, 4	-RWC	36, 36	1	55, 37	-4.2901
42 DUN	16, 16	1	37, 37	1	55, 39	-10.2211
43 PPD	17, 4	-RJC	37, 38	20.6285	55, 41	-1.3042
44 APN	17, 17	1	38, 23	-.6877/N	55, 43	-4.2411
45 DPN	18, 4	-RCC	38, 26	-.6877/N	55, 55	1
46 AW	18, 18	1	38, 37	-.0344	56, 2	1
47 DW	19, 4	-RUC	38, 38	1	56, 55	-1
48 DJ	19, 19	1	39, 27	11.6775/N	56, 56	1
49 DC	20, 4	-RPC	39, 39	1		
50 DU						
51 AP						
52 DP						
53 DCC						
54 DPIC						
55 PROW						
56 MRDW						

(Continued)

Appendix TABLE D.1 (Continued)

Column vector of endogenous variables (Y)		B2 Matrix (56 x 56) Row column i, j	B2 Matrix (56 x 56) Values of non-zero elements	Column vector of exogenous variables (Z)	B3 Matrix (56 x 15) Row column i, j	B3 Matrix (56 x 15) Values of non-zero elements
1 S1TT	40 PCN	1, 21	.3772	1. 1.0	1, 1	21.9220
2 PGCD	41 PUD	1, 33	.8464	2. YD	2, 1	-1625.8034
3 AC	42 DUN	2, 55	19.1082	3. M	2, 2	10.3040
4 QCT	43 PPD	3, 3	.5978	4. $GCRD_{t-1}$	2, 3	1604.9538
5 PGMD	44 APN	5, 5	.2948	5. TC	3, 1	56.6968
6 AM	45 DPN	5, 7	-.0080	6. T	3, 4	-.2551
7 QMT	46 AW	8, 8	.3724	7. $PMSD_{t-1}$	3, 5	.1982
8 PGED	47 DW	8, 10	-.0066	8. EW_{t-1}	5, 1	18.5951
9 AE	48 DJ	25, 22	1	9. EJ_{t-1}	5, 6	.2071
10 QET	49 DC	25, 25	1	10. DOVN	6, 1	47.6970
11 QRT	50 DU	25, 46	-1	11. YND	6, 6	-1.2518
12 QOT	51 AP	26, 23	1	12. IWN	6, 7	-8.8346
13 AR	52 DP	26, 26	1	13. VJ	8, 1	19.2293
14 A	53 DCC	26, 48	-1	14. IPN	8, 6	-.1306
15 QT	54 DPIC	27, 18	1	15. EP	9, 1	51.6850
16 QWC	55 PROW	27, 27	1		9, 6	-2.9111
17 QJC	56 MRDW	27, 53	-1		25, 8	-1
18 QCC		28, 24	1		26, 9	-1
19 QUL		28, 28	1		34, 1	7.0763
20 QPIC		28, 50	-1		34, 10	-.0957
21 QCTR		29, 20	1		34, 11	.0018
22 QW		29, 29	1		35, 1	.0442
23 QJ		29, 54	-1		36, 12	1
24 QU		30, 16	.2258		37, 1	7.1758
25 SW		30, 22	-.1927		37, 6	-.0503
26 SJ		31, 17	.2026		37, 13	.6041
27 SCC		31, 23	-.1162		38, 1	.0270
28 SU		32, 19	.3270		39, 1	5.3873
29 SPIC		32, 24	-.3020		39, 11	.0009
30 SWC		35, 34	-.0242		40, 1	.1025
31 SJC		38, 37	-.0344		41, 1	2.6699
32 SUC		40, 39	-.0452		41, 11	.0013
33 SCTT		42, 41	-.0106		42, 1	-.0008
34 PWD		44, 43	-.0037		43, 1	2.5398
35 AWN					43, 11	.0033
36 DWN					44, 1	.0173
37 PJD					54, 14	1
38 DJN					54, 15	KPCE
39 PCD						

a/ Equations 30, 31 and 32 in Table 7 were converted to linear approximations by Taylor series expansion around the 1975-79 average values of pack and stocks to obtain

30. $SWC_t = .8466\ SW_t + .2258\ QWC_{t-1} - .1927\ QW_{t-1}$

31. $SJC_t = .5733\ SJ_t + .2026\ QJC_{t-1} - .1162\ QJ_{t-1}$

32. $SUC_t = .9236\ SU_t + .3270\ SUC_{t-1} - .3020\ QU_{t-1}$

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