

AN ANALYSIS OF THE DEMAND AND PRICE STRUCTURE
OF THE TOMATO PROCESSING INDUSTRY
1950 - 1965

by *JPS*

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CHAPTER I

INTRODUCTION

Statement of the Economic Problem

Even though the vegetable processing industry is of minor importance to the U.S. agriculture -- it contributes only five per cent to the national farm income -- it exhibits numerous characteristics which make a study of its economic relationships valuable to farmers as well as to processors.

The change in the eating pattern of the population, observed since the end of World War II, consisted, in the case of the vegetable consumption, in a substitution of processed for fresh vegetables. As is evidenced by Table 1, the increased per capita consumption of tomatoes in processed form during the period 1950 to 1965 was not due only to the substitution for fresh tomatoes but also to an absolute increase in the per capita consumption of processed tomatoes. The increase in per capita consumption was greatest for the more concentrated products like catsup and sauce, whereas the per capita consumption of canned whole tomatoes, puree and juice remained relatively constant from 1950 to 1965.

The increased demand for processed tomato products and the changing structure of retail markets - characterized by the increased importance of chain stores and their demand for large quantities of uniform products - brought about significant changes in the tomato processing industry. The most important changes in this industry, which ranks first within the vegetable processing industry, are (1) a reduction of the number of processing plants, (2) increased plant capacity, (3) increased output per plant, (4)

increased grower-processor integration, and (5) increased product differentiation for the firms remaining in business.^{1/}

At the farm level the increased utilization of tomatoes for processing appears to be the stimulating factor toward concentration and specialization in the production of processing tomatoes. Increased concentration has been brought about, on the one hand, by a shift of the production into the most favored production regions (California) and, on the other hand, by a decrease of the number of vegetable farms accompanied by an increase in the average size of these farms.^{2/}

Given the considerable increase in the total demand for processed tomato products^{3/} and assuming that the tomato processing industry operates under conditions of perfect competition^{4/}, one expects to observe, according to the theoretical concept of an increasing cost industry, existing plants increasing their capacity of production, new firms entering the industry, and rising product prices, assuming of course that all other things remain constant.

It is obvious, however, that this last assumption does not hold if one recalls the summary given above of the structural changes experienced by the industry.

^{1/}Organization and Competition in the Fruit and Vegetable Industry. Technical Study 4. National Commission on Food Marketing. June, 1966, p. 33. See also Tables 7-3 and 7-4 on p. 76.

^{2/}Ibid., p. 13. See also Table 1-12, p. 11.

^{3/}Total civilian consumption increased by 60 per cent from 1950 to 1965.

^{4/}To what extent the assumption of perfect competition is justified for the tomato processing industry will be discussed in the following section.

The shift of processing tomato production into more favored production regions combined with the application of new technology leads to either an absolute or at least a relative decrease, in the price paid by the processors in these regions for the raw product. Since long distance shipments do not occur in this industry^{5/} firms located in marginal production areas with higher raw product prices will have a competitive disadvantage relative to their concurrents enjoying lower prices for processing tomatoes. Consequently the former firms will have to leave the industry; a situation which is not compatible with the theoretical concept of an expanding industry.

In aggregating the prices for processing tomatoes over the main production regions, as was done in this study, one realizes that the relative decrease of raw product prices in some areas holds the increase of the aggregated raw product price below the theoretically expected increase. The theoretical concept, however, does not take into account any structural shifts at all.

From the discussion in this section we can still derive another characteristic of the industry, namely:

"...that the firms are less concerned with market proximity for finished products than with the capability of producing areas to provide adequate supplies of low cost raw materials."^{6/}

Three reasons among others can be given for the firms decision to locate their processing plants in the production areas:

- (1) Transportation of processed tomatoes involves neither major

^{5/}Shipments of processing tomatoes over distances exceeding 200 miles do generally not occur. loc. cit., p. 190, Table 7-17.

^{6/}"National Commission on Food Marketing." op. cit., p. 13.

costs nor problems.^{7/} This leaves the firms with considerable freedom in selecting plant location.

- (2) In order to secure a high quality product, the highly perishable crop has to be processed as soon as possible after harvesting.
- (3) Shorter hauling distances reduce the transportation costs of the highly watery tomatoes.

Practically all processing tomatoes are produced under contract. The industry has therefore the possibility to influence the supply of the raw product by setting its price. In trying to maximize profits the firms under assumed perfect competition will bid up the prices for processing tomatoes up to the point where it is equal to the value of the marginal product; in mathematical terms up to the point where

$$p_a = p_x \cdot MPP_a$$

where p_a = contract price for processing tomatoes

p_x = aggregated product price for processed tomato products

MPP_a = marginal physical product for tomato processing.

The effect of contract production is that the quantity produced does not determine the farm price but that the contract price offered determines to a considerable extent the quantity produced.

The market for the finished products is less complex than the raw product market; quantity consumed and quantity supplied determines the going retail price.

^{7/} "National Commission on Food Marketing". op. cit., p. 13.

As can be seen from Figure 1, supply fluctuates considerably, while demand for processed tomatoes is increasing rather continuously. Stocks therefore, play an important role in balancing out supply and demand.

Since the processors have the possibility of influencing the supply of the raw product considerably, they will do so in attempting to equalize demand and supply. Supply, however, consists not only in current production but also in carryover stocks.

The hypothesis of this report, therefore, is that demand and supply at the farm level as well as demand and supply at the retail level are determined simultaneously.

Structural Characteristics of the Tomato Processing Industry.

The climatic conditions in the United States are such that tomatoes could be grown practically all over the United States. There are, however, few important producing areas, among which California ranks first, supplying over 50 per cent of total U.S. output. Following California are Ohio, New Jersey, and Indiana, which in 1965 supplied 12, 7, and 7 per cent of total U.S. output respectively.^{8/}

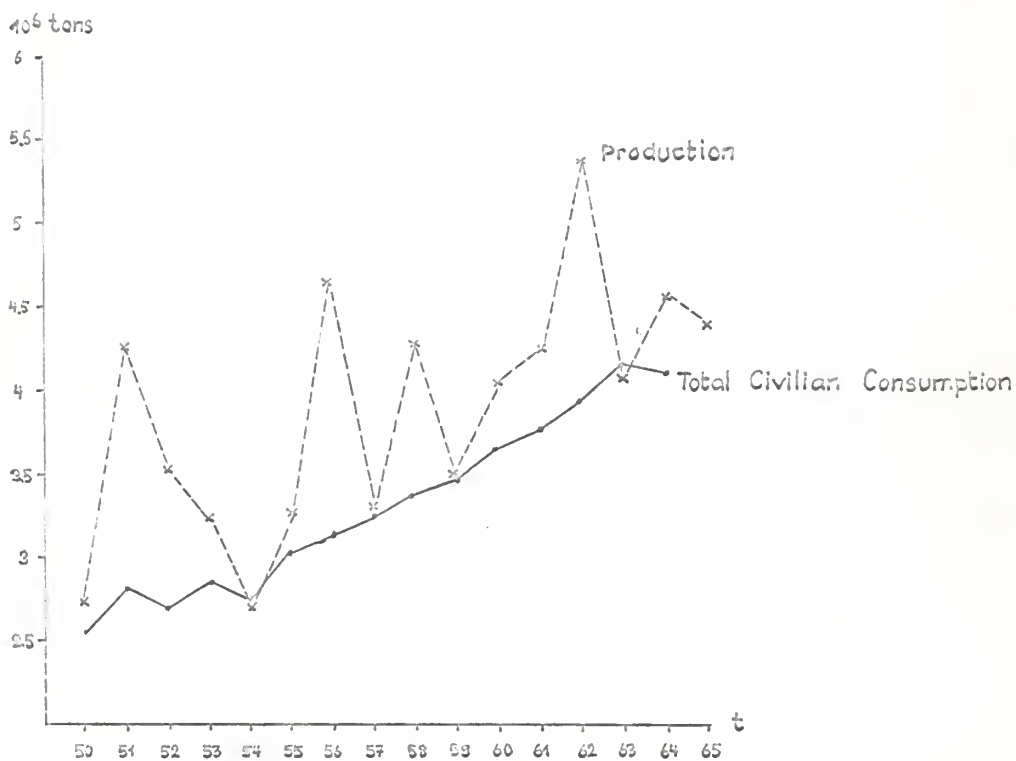
As we pointed out already, the firms locate their processing plants in areas of highest product concentration, procuring virtually all of the processing crop within a 30 mile radius of the plant. The buyer concentration in the local market for processing tomatoes is therefore relatively high.

As P.G. Helmberger and S. Hoos specify,^{9/} this situation does not lead

^{8/}American Tomato Yearbook, 1966. p. 21.

^{9/}P.G. Helmberger and S. Hoos: "The Vegetable Processing Industry" in J.R. Moore and R.G. Walsh: Market Structure of the Agricultural Industries, 1966.

Figure 1. Production of Processing Tomatoes and Consumption of Processed Tomatoes (Fresh Equivalent Basis), 1950 - 1965.



Source: Compiled from Tables 1 and 9.

to monopsonistic market conduct. On the contrary the authors show that the industry's conduct is of the type of "competitive barometric price leadership", which means that the farmers get prices comparable to those they would probably obtain if they sold their products in a competitive market. On the other hand, the processors sell the different tomato products in a market which is essentially national in scope. According to Helmberger and Hoos this market is a competitive one as well. From this we can draw the conclusion, that the assumption of perfect competition in the tomato canning industry which we made in the previous section can be justified.

Prior to turning our attention to the development of the economic model, a brief discussion of grower-processor integration is needed. By definition grower-processor integration is "... the linking -- by contract or otherwise -- of certain activities and decisions of growers and processors, so that either or both relinquish some of their rights in producing and marketing their products."^{10/} The effect of this is that certain production and marketing activities on which individual firms would otherwise make independent managerial decisions become integrated under single or eventually joint decision-making. Thus, each firm does not strive directly for its own profit objectives; its actions are constrained by a new profit goal which must compromise the income objectives of all the participants.

In the case of the tomato processing industry grower-processor integration takes the form of forward buying. The major advantage of contract production is that it reduces uncertainty of supply and demand at harvest time.^{11/}

^{10/} N. Collins, W.F. Mueller, E.M. Birch: "Grower-Processor Integration. A Study of Vertical Integration Between Growers and Processors of Tomatoes in California". Calif. Agr. Expt. Stat. Bul. 768, October 1959, p. 4.

^{11/} For a more detailed discussion of grower-processor integration see N. Collins et al. *ibid.*, pp. 54-60. See also Helmberger & Hoos *op. cit.*, pp. 170-172.

Since the assumption will be made that all tomatoes for processing are procured through forward buying, this paragraph investigates to what extent this assumption is justified. In their article, Collins et al. estimate, that since World War II less than 10 per cent of the tonnage each year has been grown on open acreage.^{12/} They also show that as soon as contract production is introduced in a production area, "open market" production declines rapidly to an insignificant amount. For this latter statement empirical evidence can be found in J. V. Cain and M. E. Hutchinson's analysis.^{13/} From Table 4 in that publication it can be seen that contract production in Maryland and Delaware increased from 33 per cent in 1950 to 50 per cent in 1962, whereas open market purchases accounted for approximately 12 per cent during this period.

Except for Texas, Virginia, and Maryland, states in which the fresh market is competing with the processing outlet, open market purchases do not exceed 10 per cent of total tomato purchases.^{14/} Considering the fact that these three states provide less than five per cent of the total U.S. pack of canned tomatoes one can say that the assumption concerning forward buying is

^{12/}National Commission on Food Marketing showed that in 1964 canners obtained only 15 per cent of their raw product supplies of fruits and vegetables from the open market; op. cit., p. 185, Table 7-12.

^{13/}J.V. Cain and M.E. Hutchinson: An Analysis of Structural Changes in the Maryland-Delaware Fruit and Vegetable Industry 1950-1962. Maryland Agr. Expt. Stat. Misc. Pub. 550, October 1965, p. 8.

^{14/}For Illinois, R.A. Kelly indicates that in 1953, 85 per cent of total tomato acreage was contracted, and only 3 per cent grown for open market. "The Vegetable Canning Industry in Illinois". Ill. Agr. Expt. Stat. Bul. 612, 1957, pp. 4-5.

reasonably well met.

With this sketchy information about the tomato canning industry in mind, we shall develop an econometric model of this industry in the next chapter.

Objectives and Procedures of this Report

As mentioned earlier the objective of this study is to support - through econometric analysis - the hypothesis that the quantity demanded and supplied as well as the respective prices at the farm and at the retail level are simultaneously determined in the tomato processing industry.

A five equation model of the relationships at work in this industry will be developed but since no data were available for one of the variables included in this model, a reduced four equation model will be estimated. The four equations consist of the respective supply and demand equations for the farm and retail level.

In order to test the hypothesis, the four equation model will be estimated first, whereas in a second step the quantity demanded, the quantity supplied, and the prices will be considered as being determined simultaneously at their respective level. The assumption in this case is that no relationships exist between the raw product market and the market of the finished products. The correlation and regression coefficients obtained by the two approaches will then be compared. A better fit for the four equation model would support our hypothesis that simultaneous relationships exist between the raw product market and the market for processed tomatoes.

Since all equations are overidentified in either case, they have to be estimated by the two stage least square method using reduced form equations

for the first stage. The statistical results will be interpreted for both stages and for both cases under investigation, also, a check will be made to see if the assumption concerning serial correlation of the residuals is met or not.

Finally, suggestions will be made as to how the results may be improved by using a somewhat modified model.

Literature Review

The present report is based mainly on Shuffet's article, "The Demand and Price Structure for Selected Vegetables."^{15/} in which the demand for canned tomatoes at the retail level was estimated by a single equation model. Shuffet also describes an eight equation model which he believes would explain the relevant relationships at work in the tomato processing industry. The statistical fitting of this model, however, was impossible because of the lack of necessary data. The flow charts for tomatoes and green peas developed in this article were of considerable value to the author of the present report. The chart shown in Figure 2 is a modification of the charts presented in Shuffet's article.

The author found no other studies dealing with a similar econometric analysis of the tomato processing industry. Most available studies are descriptive studies of the market structure. A few studies, however, estimated demand, income or price elasticities. Among the latter, a study cited by Helmberger and Hoos^{16/} which estimates supply relationships for processed

^{15/}M. Shuffet: "The Demand and Price Structure for Selected Vegetables." USDA Techn. Bul. 1105, December 1954.

^{16/}Helmberger & Hoos op. cit., p. 166.

tomatoes in Wisconsin, should be mentioned.

There are a number of publications concerned with the description of the structural changes in the vegetable processing industry during the post-war period. Much useful information about the tomato processing industry can be found in these publications. The most recent among these is the study of the National Commission on Food Marketing on the "Organization and Competition in the Fruit and Vegetable Industry". Collins et al.^{17/} present a very detailed analysis of the market structure of the Californian tomato canning industry. A host of minor publications deal with the market structure in various tomato producing states. Reference is made at this point to the bibliography which contains not only the publications cited in this report but also those which are closely related to the subject matter, but which were not available to the author at this time.

^{17/}See footnote 10.

CHAPTER II

ECONOMIC MODEL OF THE TOMATO PROCESSING INDUSTRY

The model which will be developed in this chapter is one of the aggregated tomato processing industry. Since data are available only for some of the included variables, it will be reformulated so that it can be estimated approximately by using proxy variables. As a result, what is said in developing the economic model may not always seem consistent with what will be done when setting up the statistic model.

The model is based on the flow chart which is shown in Figure 2 and which is believed to indicate the most relevant variables affecting the industry under investigation.

The Economic Model of the Aggregated Industry

The Demand for Processing Tomatoes. There exists only one major source of demand for processing tomatoes: the processing industry itself. This demand, however, originates from some other, external sources of demand. Hence, the demand for processing tomatoes has to be considered as a derived demand. According to Collins, et al.,^{18/}

"The demand for processing tomatoes at the farm level is far removed in complexity from the simple demand function of elementary economic theory. The latter concept is a simple reversible relation between the price of the product and the quantity the buyer is

^{18/}K. Collins, et al., op. cit., p. 10.

willing to purchase. It is assumed that the commodity in question is demanded by similar buyers who intend to use it for similar purposes. In fact, processing firms in California use tomatoes in the production of a wide variety of final and semi-finished products; in addition, there is some interaction between tomatoes for processing and those for the fresh market. The demand for raw tomatoes in California is complicated further by the fact that California processing firms are selling their products in a national market. Thus these firms have to compete with those in other major production areas, and that competition is translated back to the farm level in this state."

It was already pointed out, that the southern tomato producing states are the areas where the market for fresh tomatoes competes heavily with the processing outlet. A third though minor "outlet" consists in that part of the crop which is abandoned every year.

Shuffe^{19/} suggests a set of eight simultaneous equations for the estimation of the elasticities in the tomato processing industry. He feels that such a system is apparently needed to represent the economic relationships in this industry which result from the dual outlet for the crop, i.e., the fresh and processing markets.

As mentioned above, the assumption is made that all processing tomatoes are procured through contracts. This is equivalent to saying that there exists only one outlet for processing tomatoes. The limitations of this assumption have already been appraised. It may be argued, however, that in the future this assumption may become more and more justified. With the continued specialization and concentration of production, competition between the fresh and processing outlets will decline. New cultural practices and especially the lack of marketing facilities for the competing use in specialized areas will, to an increasing extent lead to a separation of the

^{19/}H. Shuffet, op. cit., p. 109.

two markets.

With respect to nonharvesting for economic reasons, we make the assumption that it can be neglected. The data presented in Table 2 show that nonharvesting was of minor importance during the past five years.

Table 2. Nonharvesting for Economic Reasons of Processing Tomatoes, 1961-1965

1961	Planting intentions 1.2%	less than harvested acreage
1962	Planting intentions 4.4%	greater than harvested acreage
1963	Planting intentions 6.6%	greater than harvested acreage
1964	Planting intentions 0.9%	greater than harvested acreage
1965	Planting intentions 0.3%	less than harvested acreage

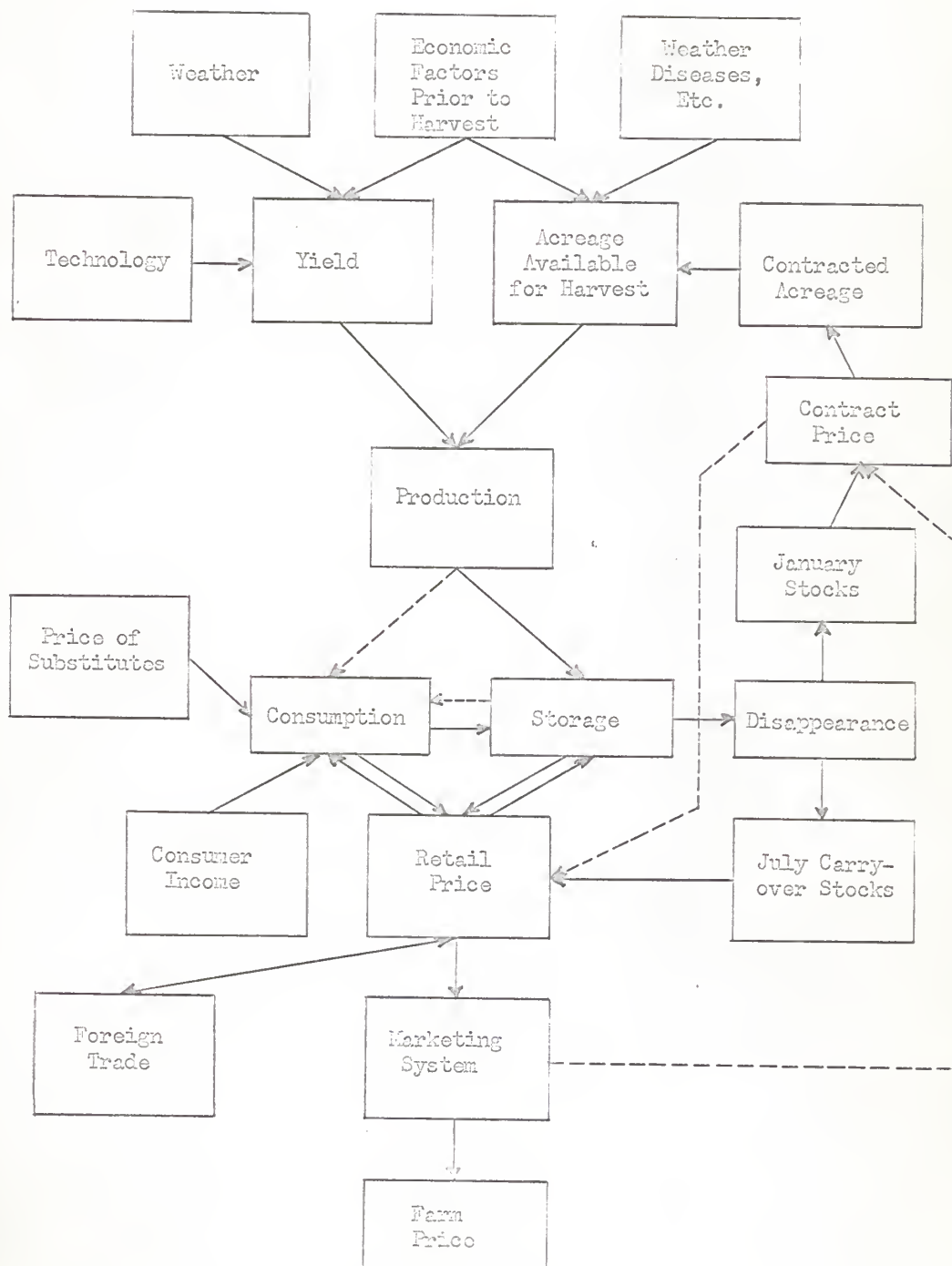
Source: The Almanac of the Canning, Freezing, Preserving Industry; Crop Statistics.

Demand for processing tomatoes is reflected by the offered contract price.^{20/} Theoretically processors are willing to pay a raw product price (p_a) equal to their marginal physical product (MPP_a) times the price of the final product (p_x). Since the retail price of the future output (p_x) is not yet known, it is assumed that processors consider the going retail price ($p_{x,t-1}$) as the best estimate of the future retail price (p_x).

This theoretical concept, however, is nothing but a rough approximation. First, it implies that consumer demand is the major source of demand, an implication which is not entirely warranted. Rather, there are several

^{20/}In recent years grower-processor contracts in California do not include price as part of the contract term. The prices are determined through later negotiation under the aegis of bargaining associations. National Commission on Food Marketing, op. cit., p. 189.

Figure 2. Demand and Price Structure of Processing Tomatoes.



sources of demand for processed tomato products: consumers demand, demand of institutions, military demand, export demand, and demand of other food processing industries. These different sources of demand can at certain times have a great influence on the total demand for processing tomatoes without showing their effects in retail prices.

In addition, several other factors are believed to influence the contract price of processing tomatoes. January stocks are considered the most important of these. Assuming consumption of tomato products to be constant, there exists a positive correlation between last year's production and the January stocks. If last year's production was high relative to the quantity demanded, January stocks will be high, and canners in an attempt to reduce their heavy supplies, will offer lower contract prices.

But January stocks reflect not only last year's output but also the disappearance in the first quarter of the marketing period. Hence, it is believed that January stocks may influence the contract price more than does last year's production of processed tomatoes. January stocks are considered because most of the contracting takes place around January and February according to experiences in California with forward buying. However, when demand conditions appear to warrant a large crop, contracting may begin as early as October and November, with most of the crop being contracted from December through February. On the other hand, when a smaller demand is expected, canners may contract as late as February and even April.

Other things being equal, the demand for processing, reflected through

the contract price, is a function of the lagged retail price^{21/} and of the January stocks of processed tomato products.

Supply of Processing Tomatoes. Other things being equal, supply increases if the price of a commodity increases.

In the case of processing tomatoes, a higher contract price leads to an increased contracted acreage which will, under normal conditions, increase the final supply. This latter relationship, however, is relatively weak as is evidenced by Figure 3. Factors such as cultural practices and weather have a considerable effect on the yield per acre and thus on the final quantity supplied.

In appraising Figures 3 and 4 it becomes obvious that tremendous structural changes have occurred in the production of processing tomatoes. Through the introduction of new cultural techniques and through important shifts in supply areas, the yield per acre increased rapidly in the period under investigation.

Assuming a constant product price, one would expect that this increased yield per acre would result in a larger output from the same bundle of resources.

Since the yield per acre is determined not only by technology and weather, but also by economic factors (e.g. amount of fertilizers employed^{22/}) it is believed that the only variables necessary to explain the quantity of processing tomatoes supplied by growers are contract price and yield.

^{21/}It is the lagged retail price with respect to the retail price obtained for the products processed from the crop which is actually contracted.

^{22/}In 1964, only 29 per cent of investigated contracts stated obligations concerning fertilizer use. Compared to other input variables growers had the greatest flexibility in applying fertilizers. National Commission on Food Marketing, op. cit., p. 187.

Figure 3. Acreage, Yield, of Tomatoes for Processing in the
United States, 1935 - 1965. (Index: 1935 - 1939 = 100)

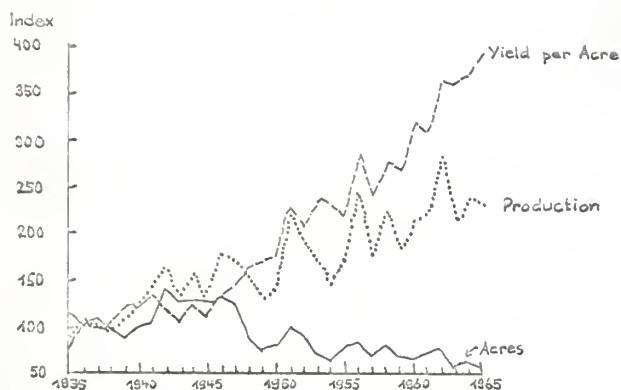
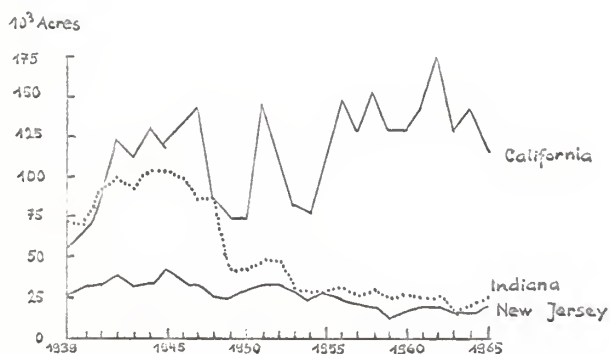


Figure 4. Acreage Trend of Tomatoes for Processing in Certain
Important Producing States.



Source: American Tomato Yearbook, 1966, p. 27.

A study described by Helmberger and Hoos^{23/} estimates the change in acreage with respect to changes in farm prices, and trend as a measure for increasing yields. As an additional variable it includes the index of prices received by U.S. farmers for all crops lagged one year. It allows for the grower's possibility of substituting any other crop for tomatoes in his rotation.^{24/}

In the present model the farm price for fresh tomatoes lagged one year is included in the supply equation instead of the index of prices received by farmers. If the coefficient of this variable is significantly different from zero this would mean that tomato growers have the opportunity of choosing whether to grow fresh tomatoes or processing tomatoes. We do not expect, however, that this coefficient is significantly different from zero since we assumed no competition between the two outlets. An insignificant regression coefficient would support this assumption.

^{23/}Helmberger and Hoos, op. cit., p. 166.

^{24/}The variables of the discussed equations have the following meaning and their coefficients the following magnitude:

$$x_1 = 424.720 + 13.015x_2 - 3,157.44x_3 - 10.482x_4$$

*(3.18) *(2.19) *(4.68) $R^2 = 0.74$

x_1 = planted acreage in the U.S. from 1947-1962

x_2 = average U.S. price received by farmers for processing tomatoes

x_3 = index of prices received by U.S. farmers for all crops lagged one year (1957-1959 = 100)

x_4 = linear trend variable indicating sharply rising yields

* figures in brackets are t-values; $t_{p=.05, n=12} = 2.179$

Furthermore, we do not think that a cost variable must be included in the supply equation. When setting the contract price, processors have to take into account eventual changes in production costs. Empirical evidence for this is given by the fact that in 1961 contract prices had to be increased because the sign up of contracts was slow, due to concern of the growers of whether or not enough labor would be available at harvest.^{25/}

The supply of processing tomatoes will be expressed as a function of the contract price, the average yield per acre and the lagged farm price for fresh tomatoes.

At this point we have to mention that, when interpreting the demand and supply elasticities at the farm level, one has to keep in mind that the contract price does not accurately measure the returns the farmer gets for his crop. There are a lot of nonprice services processors grant their farmers preventing an exact measurement of the elasticities. This is due to the fact that the demand and supply forecasts rarely turn out to be accurate. At harvest time nonprice competition devices determine the "equilibrium price" for the crop. Among others, the following devices are the most commonly used to adjust the contract price:

- variable waiver and picking box rent
- variable hauling allowances
- variable payment tolerances for mold and worm damages
- credits and other nonprice arrangements.

A study of the National Canner's Association estimated that the costs of services provided by canners to growers of processing tomatoes vary from

^{25/}The Vegetable Situation - 140, April 1961.

\$1.32 to \$3.97 per ton among regions. The yearly variation of these costs could not be ascertained.^{26/}

Supply of Processed Tomatoes. The supply of processed tomato products comes from three sources: domestic production, previous stocks, and imports.

If imports are considered to be of minor importance and ceteris paribus conditions assumed, then the retail price for current production is a function of current output and of carryover stocks.

As was mentioned previously, structural changes took place in the canning industry during the time period under investigation. An index indicating the technological improvements of the industry would be preferable to a trend variable. Lack of such an index made the use of a trend variable inevitable in order to account for these structural changes.

In order to justify the assumption that imports are of minor importance, Table 3 was compiled from available data. It shows that imports varied from 1.4 to 5.2 per cent of total production from 1950 to 1965. This percentage is considered small enough to permit us to neglect imports as a source of supply.

The retail price of processed tomatoes is therefore specified as a function of current supply, carryover stocks and trend.

This structural equation holds under ceteris paribus conditions as well as under conditions of perfect competition. This latter assumption, however, does not hold for the early fifties because a general price ceiling policy was pursued by the U.S. Government which was also applied to the products of

^{26/}A summary report on the economic analysis project. The Structure and Economic Significance of the Canning Industry. National Canners Association, Division of Statistics and Economics, September 1963, p. 9.

the tomato canning industry during this period.

Table 3. Imports of Processed Tomato Products 1950-1964.

Year	Total : Production	: Canned Tom.	Paste	: Canned Tom.	Paste	Total Import
:	: 10 ³ tons	: 10 ⁶ pounds	:	per cent	total production	:
:	:	: canned weight	:	:	:	:
1950	2,734	73.2	25.7	1.9	2.3	4.2
1951	4,267	54.8	8.4	0.9	0.5	1.4
1952	3,524	60.4	3.8	1.2	0.3	1.5
1953	3,235	58.7	2.0	1.3	0.1	1.4
1954	2,698	77.7	6.6	2.0	0.6	2.6
1955	3,278	82.9	9.2	1.8	0.7	2.5
1956	4,638	94.8	5.8	1.4	0.3	1.7
1957	3,315	89.7	4.7	1.9	0.3	2.2
1958	4,287	118.9	9.5	1.9	0.5	2.4
1959	3,509	96.1	6.1	1.9	0.4	2.3
1960	4,043	126.3	15.1	2.2	0.9	3.1
1961	4,248	148.1	48.3	2.4	2.8	5.2
1962	5,377	125.4	24.0	1.6	1.1	2.7
1963	4,071	80.3	15.6	1.4	0.9	2.3
1964	4,561	82.9	15.4	1.3	0.8	2.1

Source: Agricultural Statistics 1966, Table 291 p. 201. American Tomato Yearbook 1966, p. 22.

Demand for Processed Tomato Products. The different sources of demand for tomato products were listed in the section dealing with the demand for processing tomatoes at the farm level. They included: domestic civilian demand, military demand, institutional demand, demand of other food processors which use tomato products as inputs, export demand, and inventory demand of the processors themselves.

Domestic civilian consumption constitutes by far the most important source of demand. Table 1 shows the major tomato products available to

consumers and their changing relative importance in the diet of the population from 1950 to 1965. Figure 1, on the other hand, depicts the steadily increasing civilian consumption.

One expects military demand to fluctuate since it is subject to rapid changing political decisions and circumstances. During the period under investigation a peak occurred in 1951 when approximately 20 per cent of the total U.S. pack was purchased by military agencies. 27/

No indications could be found indicating the relative importance of the institutional demand.

According to Collins, et al. over one-half of California's production of processed tomatoes in 1955 was used by the remanufacturing industry as ingredients in other foods. 28/

Ketchup and paste are the most important export products, whereas canned whole tomatoes and juice are exported in negligible amounts as is shown in Table 4. Total exports increased from two per cent of the total pack in 1950 to 4.5 per cent in 1957. Since then exports have again declined to about two per cent (1965). This decline may be due to new import regulations issued by the Canadian Government, since Canada is the main importer of tomato products.

The "demand" of the processing industry itself consists in the decision of the firm to hold back a certain amount of its current output in order to take advantage of a changing market situation. This behaviour is a matter of the firm's inventory policy; policies which vary among firms as well as

27/The Vegetable Situation - 140, April 1952, p. 5.

28/N. Collins, et al., op. cit., p. 10.

Table 4. Exports of Processed Tomato Products, 1950 - 1964.

Year	Total production	Canned : whole : tom.	Catsup & Sauces	Paste	Juice	Canned : whole : tom.	Catsup & Sauces	Paste	Juice	Total Exports
:	:	:	:	:	:	:	:	:	:	:
:	10 ³ tons	:	10 ³ pounds	:	:	:	:	:	per cent of total production	:
1950	2,734	1,211	5,377	17,920	13,561	0.03	0.2	1.6	0.3	2.0
1951	4,267	20,319	18,283	22,127	31,625	0.3	0.5	1.3	0.5	2.9
1952	3,524	3,991	23,118	12,664	37,161	0.1	0.7	0.8	0.7	2.3
1953	3,235	1,442	25,260	24,019	29,509	0.03	0.9	1.8	0.6	3.3
1954	2,698	9,420	33,663	20,822	37,204	0.2	1.4	1.9	0.9	3.4
1955	3,278	8,339	25,759	11,393	41,168	0.2	0.9	0.8	0.9	2.8
1956	4,638	23,633	33,021	27,825	59,116	0.4	0.8	1.5	0.9	3.6
1957	3,315	6,504	34,493	28,177	52,763	0.1	1.1	2.1	1.1	4.4
1958	4,287	8,199	25,002	15,511	36,607	0.1	0.6	1.0	0.6	2.3
1959	3,509	11,055	19,934	21,849	27,615	0.2	0.6	1.5	0.5	2.8
1960	4,043	6,962	16,952	16,140	28,256	0.1	0.5	1.0	0.5	2.1
1961	4,248	4,046	13,964	12,386	26,627	0.1	0.4	0.7	0.4	1.6
1962	5,377	3,274	15,284	12,786	26,479	0.04	0.3	0.6	0.3	1.2
1963	4,071	8,041	16,619	14,068	31,874	0.1	0.4	0.8	0.5	1.8
1964	4,561	18,602	20,144	13,623	30,675	0.3	0.5	0.7	0.5	2.0

Source: Agricultural Statistics: Tomatoes, Commercial Crop, Foreign Trade Table 291, p. 201.
American Tomato Yearbook 1966: Tomatoes for Processing, p. 22.

Compiled using the conversion factors listed in: "Conversion Factors and Weights and Measures."
USDA Stat. Bul. 362 June 1965, Table 52, p. 58.

among production areas. Collins, et al. indicate that in California processors may still dispose over 30 to 50 per cent of their annual pack immediately prior to harvesting.^{29/}

In contrast, R.A. Kelly shows for 1953 that in Illinois about 50 per cent of the processors disposed of their stocks as soon as possible (August through December) and that these canners had only occasional carryover stocks.^{30/}

We conclude from the foregoing discussion that the demand for processed tomatoes is far from being homogeneous even though it was shown that the different sources of demand may be of minor importance. These different demands may, however, influence total demand quite significantly if they are aggregated. Hence, the assumption of one major source of demand, domestic civilian consumption, is probably more than a simplifying assumption. Figure 1 seems to support this argument very strongly.

Per capita consumption of processing tomatoes is under ceteris paribus conditions a function of the going retail price. However, good substitutes exist for tomato products, so the prices of these also influence consumption. The substitutes for canned whole tomatoes are considered to be fresh tomatoes and, according to Shuffet, other tomato products.^{31/} Tomato juice competes with citrus fruit juices (mainly with orange juice) as was shown by K.E. Ogren in a study covering the 1948-1949 marketing period.^{32/} The other

^{29/}Collins, et al., *op. cit.*, p. 25.

^{30/}R.A. Kelly: The Vegetable Canning Industry in Illinois. Ill. Agr. Expt. Stat. Bul. 612. 1957.

^{31/}K. Shuffet, *op. cit.*, p. 111.

^{32/}K.E. Ogren cited by Shuffet, *ibid.*, p. 102.

tomato products probably compete among themselves. In order to allow for the substitution effect, prices of substitutes have to be included in the structural equation. Also, consumers' tastes and preferences have changed over the time period under investigation. A number of studies mention that increasing disposable income affects per capita consumption of processed vegetables, including tomatoes. The following quotation lists other important factors:

"Characteristics of the population believed to significantly influence the consumption of fruits and vegetables and to reflect these social changes include income, regional distribution of population, homemaker employment, and the growth of the nonhousehold market." 33/

Another point worth mentioning is that still a further structural change occurred during the time period under analysis. In the past consumers purchased tomato products in No. 2 cans, whereas today they buy the same product in No. 303 cans. 34/

Per capita disposable income will be included as explanatory variable in the structural demand equation for processed tomatoes.

Shuffet's 35/ estimation of demand for processing tomatoes yielded the

33/ National Commission on Food Marketing, op. cit., p. 25.

34/ The Vegetable Situation - 146, 1962, Table 6, p. 24. The can sizes are defined as follows:

	diameter	height	capacity
can no. 2:	3 7/16 in.	4 9/16 in.	20.55 ozs. of water of 68°F.
can no. 303:	3 3/16 in.	4 6/16 in.	16.88 ozs. of water of 68°F.

See: USDA - ERS "Conversion Factors and Weights" Stat. Bul. 362, 1965, p. 44.

35/ M. Shuffet, op. cit., pp. 109-111.

following results for the years 1921 to 1952:

$$X_1 = 0.770 - 0.404X_2 + 0.219X_3 - 0.198X_4$$

*(2.46) *(1.52) *(2.66) $R^2 = 0.479$

where X_1 = per capita consumption of canned whole tomatoes.

X_2 = retail price per no. 2 can.

X_3 = disposable per capita income. (Note that the coefficient of this variable is not significantly different from zero.)

X_4 = per capita consumption of processed tomato products (excluding tomato juice). Since the coefficient of this variable has a negative sign, this indicates that the different tomato products compete with canned whole tomatoes.

* figures in brackets are t-values; $t_p=0.05$, $n=28=2.084$.

This statistical estimation indicates that the elasticity of demand of canned whole tomatoes is -0.4. (It will be interesting to see, whether this elasticity remained constant over time or not.) Furthermore it estimates that an income change of 10 per cent brings about a 2 per cent change in the same direction in the demand for canned tomatoes.

G.E. Brandow ^{36/} showed in his study that an income change of 10 per cent was associated with a 1.5 per cent change in the use rates for all vegetable products. "Somewhat higher consumption responses to income changes probably would be characteristic of processed fruits and vegetables..." ^{37/} Shuffet's and Brandow's estimates of the income elasticity are surprisingly

^{36/}G.E. Brandow: "Interrelationships Among Demand for Farm Products and Implications For Control of Market Supply", Penna. Agr. Expt. Stat. Bull. 680, August 1961, p. 20.

^{37/}National Commission on Food Marketing, op. cit., p. 27.

similar if one considers the totally different approaches taken by the two authors to derive this elasticity. However, it is interesting to note that Shuffet's coefficient is not significantly different from zero at the 5 per cent level.

Shuffet had to satisfy himself with the estimation of the elasticities for canned whole tomatoes since no retail prices for other tomato products were recorded. He points out in his study that the wholesale prices of other tomato products are not correlated with the wholesale price of canned tomatoes. Consequently no estimation of the elasticity of demand for aggregated tomato products could be undertaken, not even at the wholesale level.

This same observation will be valid for the statistical estimation of the model developed in this report.

We summarize this section by saying that per capita consumption of processed tomatoes is a function of the retail price, the price of substitutes and of per capita disposable income, other things being equal.

Relationship Between the Contract and Farm Price. We are less interested in explaining the factors affecting the contract price than we are in explaining the factors influencing the farm price for processing tomatoes. As mentioned previously, the farm price - defined in this chapter as the total value the farmer gets for his crop - is not only a function of the contract price but may also be affected by the difference between the effective quantity produced and the quantity demanded by the producers at the time the contract price is announced. No indication could be obtained about the magnitude of this influence; it may, however, be minor since downward adjustments would certainly be resisted by growers. We make, therefore, the simplifying assumption that the farm price is a function of the contract

price only.

The Structural Model Summarized. The model developed in this chapter can be rewritten in the following simplified form:

$$\begin{aligned}
 (1) \quad P_{\text{con.}} &= f(P_r, t-1, S) \\
 (2) \quad Q_p &= f(P_{\text{con.}}, A, P_{\text{FR}}, t-1) \\
 (3) \quad P_r &= f(Q_p, C, T) \\
 (4) \quad Q_c &= f(P_r, P_s, Y_d) \\
 (5) \quad P_f &= f(P_{\text{con.}})
 \end{aligned}$$

In this model the following variables are endogenous (determined by the system).

- P_{con} contract price offered farmers for processing tomatoes prior to planting time.
- Q_p quantity of processing tomatoes produced in the major producing states; New York, New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Michigan, Delaware, Maryland, Virginia, Florida, Texas, Colorado, Utah, California.
- P_r weighted average retail price of canned tomato products averaged over the marketing year for tomato products which begins July 1st.
- Q_c per capita consumption of canned tomato products on a fresh equivalent basis.
- P_f weighted average price received by farmers for processing tomatoes, the weights being the respective production of the states included in the analysis.

The exogenous variables are defined as follows:

- S canner's stocks of processed tomato products, January 1 of each year

- $P_{r,t-1}$ retail price of canned tomatoes lagged one production period (see definition of P_r).
- A weighted average yield per acre of processing tomatoes, the weights being the respective production of the states included in the analysis
- C canner's carryover stocks, July 1 of each year.
- P_s aggregated retail price of substitutes.
- Y_d per capita disposable income.
- $P_{FP,t-1}$ weighted average price for fresh tomatoes paid to farmers, the weights being the respective production of fresh tomatoes in the states included in the analysis.
- T trend variable.

Unfortunately it was not possible to obtain data for all the variables included in this model, so it was not possible to evaluate it statistically. The next section will indicate how the model will be estimated approximately.

The Alternative Economic Model. Prior to turning our attention to the description of the statistical model we have to make a few comments about the alternative model.

The structural equations used in the alternative model are exactly the same as in the initial model. The only difference consists in our decision to consider the market of the raw products as separated from the market of the finished products. The endogenous variables in the structural equations representing the relationships at the farm level (equations (1), (2), and (5)) are considered to be simultaneously determined as are the endogenous variables in the equations representing the relationships at the retail level (equations (3) and (4)).

The differences in the two models will become more apparent when the endogenous variables are estimated through the reduced form equations.

Statistical Model

For the quantification of the economic models discussed in the previous chapter we need not only answer certain questions with respect to the choice and transformation of the data, but we also have to rearrange our initial models so that they can - at least - be approximated with the available data.

Choice and Transformation of Data.

Years to be Included: Data about stocks of canned tomato products were first reported in 1949. This limits the analysis to the years 1949 to 1965. For other variables the data series are not available prior to 1955 (retail prices for fresh tomatoes and orange juice) so they had to be estimated by a simple regression analysis. But even with complete data series available back to 1940 or earlier, it seems reasonable to start the present analysis with data for 1950 or 1952, when some kind of a postwar equilibrium was approximately attained in the industry. To support this statement somewhat, Table 1 also shows the consumption figures for the immediate postwar years 1945 to 1950. In order to maintain a reasonable number of degrees of freedom, the years 1950 to 1952 were not dropped from the analysis even though they were characterized by an abnormally high military demand.

Time Period: The present analysis uses yearly data. The most serious data problem consists in the fact that the retail prices are aggregated over the calendar year, whereas an aggregation of the marketing year, starting July 1st, is required.

Price Level: To allow for an increasing price level during the time period under investigation, farm prices, retail prices, and disposable income were deflated by the prices-received-by-farmers-index for all commodities, consumer price index for food items, and by the consumer price index for all commodities respectively, using the basis years 1957-59 for all indices. This procedure, however, may be questioned since some doubt can be raised as to whether producers and consumers respond to real changes or money changes. Furthermore, because of the short time period the deflation might have little effect. Lack of time did not allow for a test of this point.

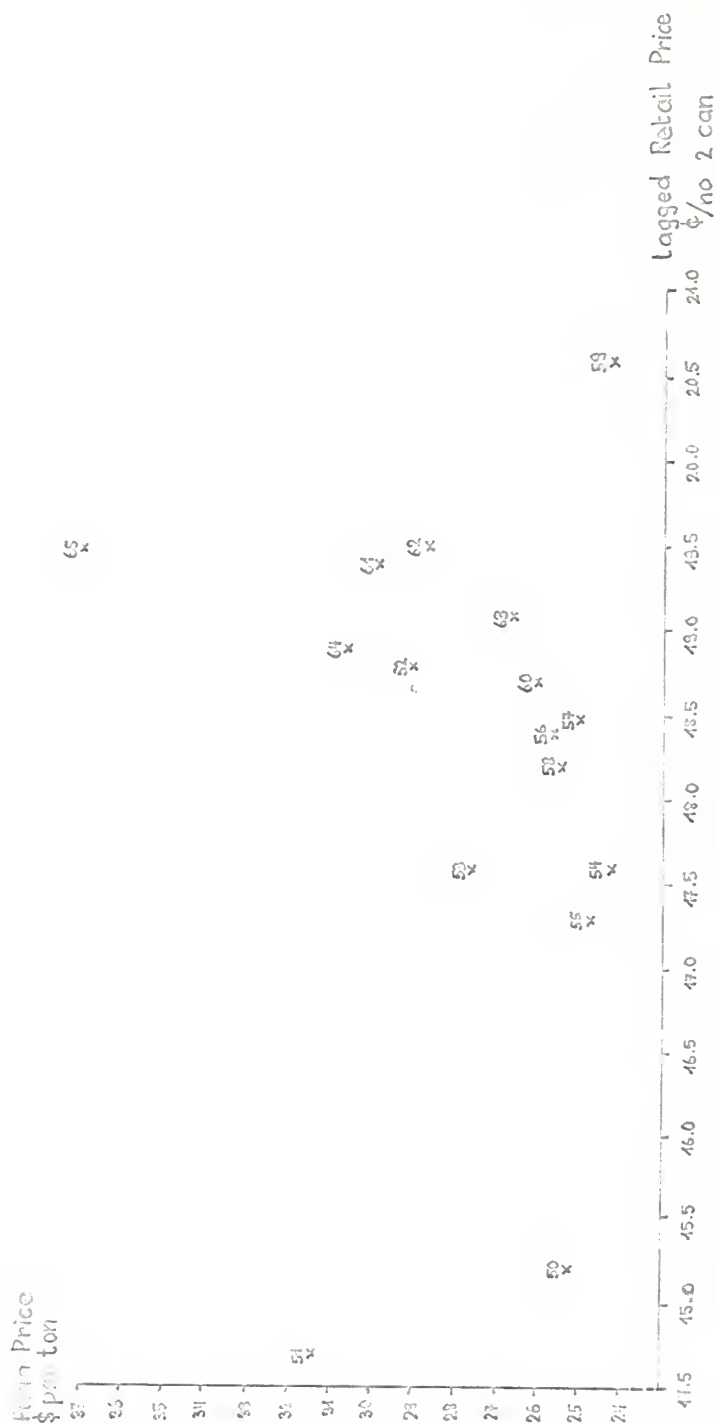
Transformation: Both models were estimated using logarithmic data. For the demand equation for processing tomatoes this procedure seems adequate since the farm price - retail price relationship in Figure 5 is obviously curvilinear. Whether better fits result from logarithmic transformations for the other equations can be questioned. Again, lack of time prevented a check of this point.

Single Equation or Simultaneous Equation Approach: In developing the economic model this point was already discussed in some length. The decision was clearly in favor of the simultaneous equation approach.

Variables for Which no Data Were Available: As mentioned above not all of the required data were available to estimate the economic model. First of all there exists no time series for the contract prices offered to farmers. ^{28/} Retail prices were available only for canned whole tomatoes and the statistics indicating the prices received by farmers for processing

^{28/} Information obtained from the National Canner's Association.

Figure 5. Retail Price (Lagged) - Farm Price Observations Plotted for the Period 1950 - 1965.
 "Demand for Processing Tomatoes" (Uninflated Data).



Source: Table 10

tomatoes do not include the value of the services offered to growers by the processors as requested by the model.

The Revised Model. Subject to the data limitations the economic model will be revised in the following fashion.

As a proxy variable for contract prices, farm prices will be used in equations (1) and (2) and consequently equation (5) has to be dropped. In addition the definition of the variable P_s has to be changed; in the revised model it will include only the average retail price for fresh tomatoes.

Accordingly, the revised model has the following form:

$$(1a) \quad P_f = f(P_r, t-1, S)$$

$$(2a) \quad Q_p = f(P_f, A, P_{FR}, t-1)$$

$$(3a) \quad P_r = f(Q_p, C, T)$$

$$(4a) \quad Q_o = f(P_r, P_s, Y_d)$$

The alternative model is composed by the two systems formed by equations (1a) and (2a) representing demand and supply at the farm level and by equations (3a) and (4a) representing supply and demand at the retail level.

Prior to leaving this section, a final comment on data problems is offered. As can be seen from the data tables in the appendix, the sampling criterions of the original data changed in many cases so that conversion factors had to be used in order to get comparable data. However, it cannot be assumed that, in an industry experiencing structural changes, the conversion factors remain constant over time. But worse, in some instances no correction could be made at all and in a few instances data had to be estimated.

Unfortunately the data used in this analysis have to be considered as relatively poor.

The Identification Problem.

The Four Equation Model: To make sure that there exists a mathematical solution for a certain model one has to check whether it is identifiable or not. The necessary condition for identification says that

$$(6) \quad H - H^* \geq G - 1$$

for each equation, where

H indicates the number of variables in the system

H* indicates the number of variables in each equation

G indicates the number of endogenous variables in the system

The right hand side of equation (6) takes the numerical value 4-1 for each structural equation, whereas the left hand side takes the values of 12-3; 12-4; 12-4; and 12-4 for the equations (1a), (2a), (3a), and (4a), respectively. A greater numerical value for the left hand side of equation (6) indicates that the system might be overidentified, so that it must be estimated by the two stage least square method, using reduced form equations in the first stage.

However, only if the necessary and sufficient conditions described below are fulfilled, can one be sure that all equations in a system are identifiable. This condition reads as follows: At least one determinant derived from a matrix formed according to the following instructions must be non-zero for each equation in the model. Square matrices of the order $G-1$ ^{39/} are formed by the regression coefficients of the variables not included in the equation for which the identification test is made. Of course, this test can be performed only after the coefficients are estimated. Again,

^{39/}G = number of endogenous variables in the system.

lack of time did not allow to work out this test.

The Alternative Model: If one checks the necessary condition for the alternative model one gets the following inequalities for equation (6):

$$H-H^* \geq G-1$$

$$\text{equation (1a)} \quad 6-3 > 2-1$$

$$\text{equation (2a)} \quad 6-4 > 2-1$$

$$\text{equation (3a)} \quad 7-3 > 2-1$$

$$\text{equation (4a)} \quad 7-4 > 2-1$$

This check indicates that the equations of the alternative model might be overidentified and that the two stage least square model must be applied.

The Reduced Form Equations. We are now ready to formulate the reduced form equations for the two models. For the initial model they have the form indicated below:

$$(7) \quad P_f = f(P_r, t-1, P_s, A, Y_d, T, S, C, P_{FR}, t-1)$$

$$(8) \quad Q_p = f(P_r, t-1, P_s, A, Y_d, T, S, C, P_{FR}, t-1)$$

$$(9) \quad P_r = f(P_r, t-1, P_s, A, Y_d, T, S, C, P_{FR}, t-1)$$

$$(10) \quad Q_c = f(P_r, t-1, P_s, A, Y_d, T, S, C, P_{FR}, t-1)$$

Since Q_c does not appear as an independent endogenous variable in either model it would not be necessary to estimate it by the reduced form equation (10). However, the estimation was performed for the following reasons: In general one expects to get significant coefficients in the reduced form equations for those variables included in the corresponding structural equation. An estimation of Q_c yields, therefore, a check as to whether the expectation to get significant coefficients for the retail price, the price for substitutes, and the per capita disposable income in equation (10) is

correct. In addition the reduced form equations can be used for predictive purposes. Exactly the same argument holds for equation (14).

The reduced form equations for the alternative model read as follows:

$$(11) \quad P_f = f(P_r, t-1, A, S, P_{FR}, t-1)$$

$$(12) \quad Q_p = f(P_r, t-1, A, S, P_{FR}, t-1)$$

and

$$(13) \quad P_r = f(Q_p, P_s, Y_d, T, C)$$

$$(14) \quad Q_c = f(Q_p, P_s, Y_d, T, C)$$

The Exact Formulation of the Statistical Models. Once the coefficients of the reduced form equations are obtained, it is possible to compute the predicted values of the endogenous variables and to insert these values in the structural equations in which they appear as independent variables. We are therefore ready to formulate the exact statistical models. The equations have the following form:

$$(1b) \quad P_f = a_1 + b_{11}P_r, t-1 - b_{12}S + u_1$$

We expect to get a positive relationship between the farm price as an approximation for the contract price and the lagged retail price and a negative one between the farm price and the January stocks.

$$(2b) \quad Q_p = a_2 + b_{21}\hat{P}_f + b_{22}A - b_{23}P_{FR}, t-1 + u_2 \quad \underline{40/}$$

The higher the farm price the more farmers are expected to produce. As mentioned earlier, higher yields per acre are expected to bring forth a larger crop under ceteris paribus conditions and we also expect higher farm prices to have a negative effect on quantity produced if there exists

^{40/}The symbol ^ means that the predicted values of the respective endogenous variables are used.

competition between the two products at the farm level.

$$(3b) \quad P_r = a_3 - b_{31}\hat{Q}_p - b_{32}C - b_{33}T + u_3$$

All independent variables in this equation are believed to be negatively related to the retail price. Higher production as well as high carryover stocks will lower retail prices. If the trend variable reflects better processing technology resulting in lower costs this should affect retail prices inversely.

$$(4b) \quad Q_c = a_4 - b_{41}\hat{P}_r + b_{42}P_s + b_{43}Y_d + u_4$$

The price elasticity of demand should be negative and, according to Shuffet's estimate, approximately -0.4. Figure 8, however, suggests that it might be much smaller.

The higher the price of fresh tomatoes the greater should be the consumption of canned whole tomatoes. Finally, the higher disposable income, the more should the consumer be inclined to consume. Shuffet's estimation of the income elasticity was 0.2.

For the alternative model the exact formulation of the statistical model looks quite similar. There will be differences in the values of the constant terms, of the regression coefficients, and of the residuals. The important difference, however, occurs in equation (3b) where the actual value of Q_p is used rather than the estimated value \hat{Q}_p .

CHAPTER III

STATISTICAL RESULTS

In the preceding chapters we were concerned with the development of an economic model which was hypothesized to represent approximately the forces at work in the tomato processing industry. We were also concerned with the statistical problems involved and the ways by which they could be solved. However, in looking at the statistical results presented below, it seems that almost too many restrictions and simplifying assumptions were made. When looking at the different coefficients one should keep in mind that these are the results of the very first computation.

Initial Model.

Estimated Coefficients of the Structural Equations (figures in brackets are t-values).

$$(1a) \log P_F = 2.210 - 0.798 \log P_{FR,t-1} + 0.205 \log S$$

$$\qquad\qquad (-1.152) \qquad\qquad (1.886)$$

$$t_{0.05, 13} = 2.160 \qquad\qquad R^2 = 0.227$$

$$(2a) \log Q_P = -0.586 + 0.694 \log A - 0.175 \log P_{FR,t-1} + 0.362 \log \hat{P}_F$$

$$\qquad\qquad (1.787) \qquad\qquad (-0.468) \qquad\qquad (0.565)$$

$$t_{0.05, 12} = 2.179 \qquad\qquad R^2 = 0.569$$

$$(3a) \log P_r = 1.328 + 0.07 \log A - 0.051 \log C - 0.153 \log \hat{Q}_p$$

$$(2.144) \quad (-2.597) \quad (-1.180)$$

$$t_{0.05, 12} = 2.179 \quad R^2 = 0.444$$

$$(4a) \log Q_c = 1.376 - 0.536 \log P_g + 0.006 \log Y_d + 0.043 \log \hat{P}_r$$

$$(-1.878) \quad (0.40) \quad (0.142)$$

$$t_{0.05, 12} = 2.179 \quad R^2 = 0.237$$

Alternative Model.

Estimated Coefficients of the Structural Equations (figures in brackets are t-values).

$$(1a') \log P_r = 2.210 - 0.798 \log P_{r,t-1} + 0.205 \log S$$

$$(-1.152) \quad (1.886)$$

$$t_{0.05, 13} = 2.160 \quad R^2 = 0.227$$

$$(2a') \log Q_p = 0.147 + 1.027 \log A - 0.08 \log P_{PR-1} - 0.477 \log \hat{P}_r$$

$$(1.408) \quad (-0.192) \quad (-0.234)$$

$$t_{0.05, 12} = 2.179 \quad R^2 = 0.560$$

$$(3a') \log P_r = 1.260 + 0.033 \log T - 0.031 \log C - 0.002 \log Q_p$$

$$(0.931) \quad (-1.525) \quad (-0.016)$$

$$t_{0.05, 12} = 2.179 \quad R^2 = 0.368$$

$$(4a') \log Q_c = 1.591 - 0.492 \log P_g - 0.011 \log Y_d - 0.131 \log \hat{P}_r$$

$$(-1.718) \quad (-0.073) \quad (-0.386)$$

$$t_{0.05, 12} = 2.179 \quad R^2 = 0.294$$

The results obtained from the estimation of the reduced form equations are presented in tabular form to facilitate their appraisal (see Table 5).

Table 5. Statistical Results of the Initial and Alternative Model for the Reduced Form Equations.

Eq. #	Dep. Vari- ables :	Independent Variables					:		
		P_s	A	Y_d	T	S	C	$P_{FR,t-1}$	$t_{p,n}$
(7) Initial Model	P_f b	0.484	0.685	1.343	-0.221	-0.119	0.030	0.300	0.873
(11) Alternative Model	t	0.745	1.758	2.497	-2.156	-0.662	0.642	1.390	2.365
	P_f b	-0.540	0.390			0.012	0.126	0.126	0.656
(8) Initial Model	t	-1.065	2.363			0.124	0.611	0.611	2.201
	Q_p b	1.933	1.328	0.458	-0.143	-0.220	0.066	0.212	0.826
(12) Alternative Model	t	1.490	1.704	0.426	-0.700	-0.612	0.720	0.492	2.365
	Q_p b	0.860	1.016			-0.441	0.090	0.090	0.784
(9) Initial Model	t	1.255	4.559			-3.406	0.324	0.324	2.201
	P_r b	-0.319	0.386	-0.281	0.131	-0.140	-0.005	0.046	0.871
(13) Alternative Model	t	-1.299	2.150	-1.901	3.369	-2.052	-0.285	0.560	2.365
	P_r b	0.233	-0.623		0.088		-0.032		0.706
(10) Initial Model	t	1.409	-3.478		4.263		-3.669		2.201
	Q_c b	-0.112	-0.347	0.358	-0.011	0.044	-0.023	0.159	0.592
(14) Alternative Model	t	-0.229	-0.969	0.884	-0.139	0.323	-0.651	0.980	2.365
	Q_c b	-0.499	0.301		-0.033		-0.008		0.387
(14) Alternative Model	t	-1.873	1.042		-0.982		-0.553		2.201

Interpretations and Suggestions

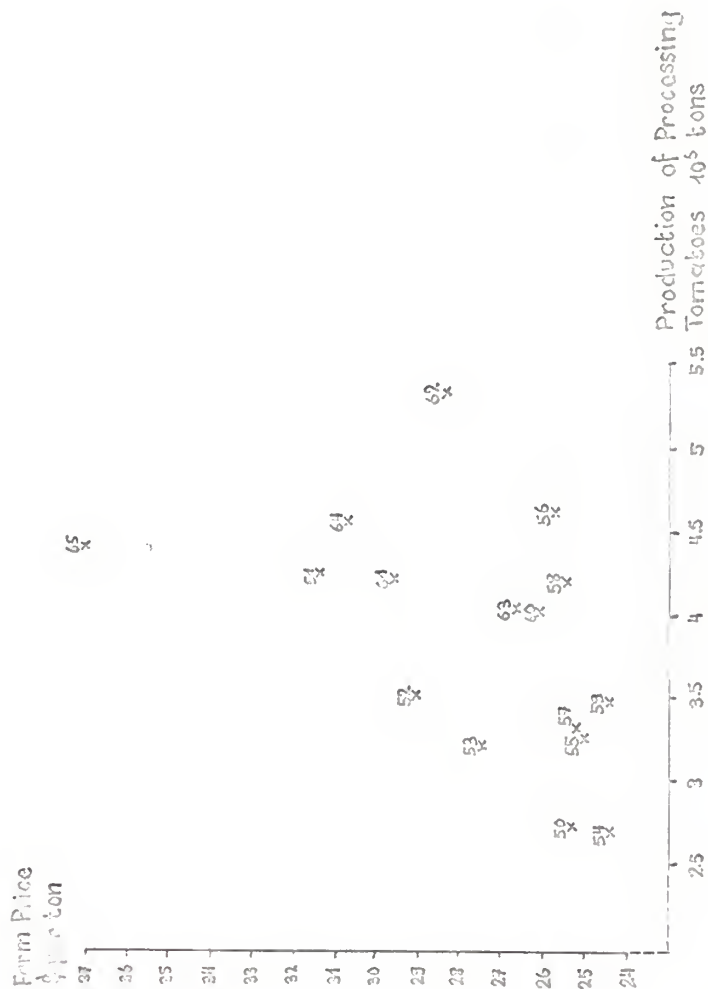
At first glance the results do not seem worth any further discussion. Only one coefficient is significantly different from zero, and most of the coefficients have the wrong sign, sometimes even associated with t-values near the significance level. In addition the explanatory power of the structural equations is weak. A discussion and economic interpretation of the various coefficients is considered of little use under these conditions. Rather, we will focus our attention on the possible improvements of the statistical results and suggest some modifications of the economic model.

Demand for Processing Tomatoes. The coefficients of the two explanatory variables for the farm price -- lagged retail price and January stocks -- both show the wrong signs; the coefficient of January stocks being almost significantly different from zero.

Looking at Figure 9 it seems likely that the extreme values for 1951 and 1965 were responsible for the negative slope of the regression plane. The coefficient of -0.8 would, under these circumstances, be consistent with a freehand fitted line with a slope of -1 . Figure 13 shows that there exists no apparent relationship between the January stocks and the farm prices. The reason for this is that data for actual stocks rather than relative stocks were used in the analysis. In attempting to improve the situation the following procedure may be followed: Based on the available data, an average per capita stock would be determined as an estimate for what processors consider to be an "equilibrium" stock. The hypothesis then is that the contract price (approximated by the farm price) is a function of the differences between the actual per capita stock and the "equilibrium" per capita stock.

Figure 6. Farm Price --- Quantity Observations Plotted for the Period 1950 -- 1965.

"Supply of Processing Tomatoes" (Uninflated Data).



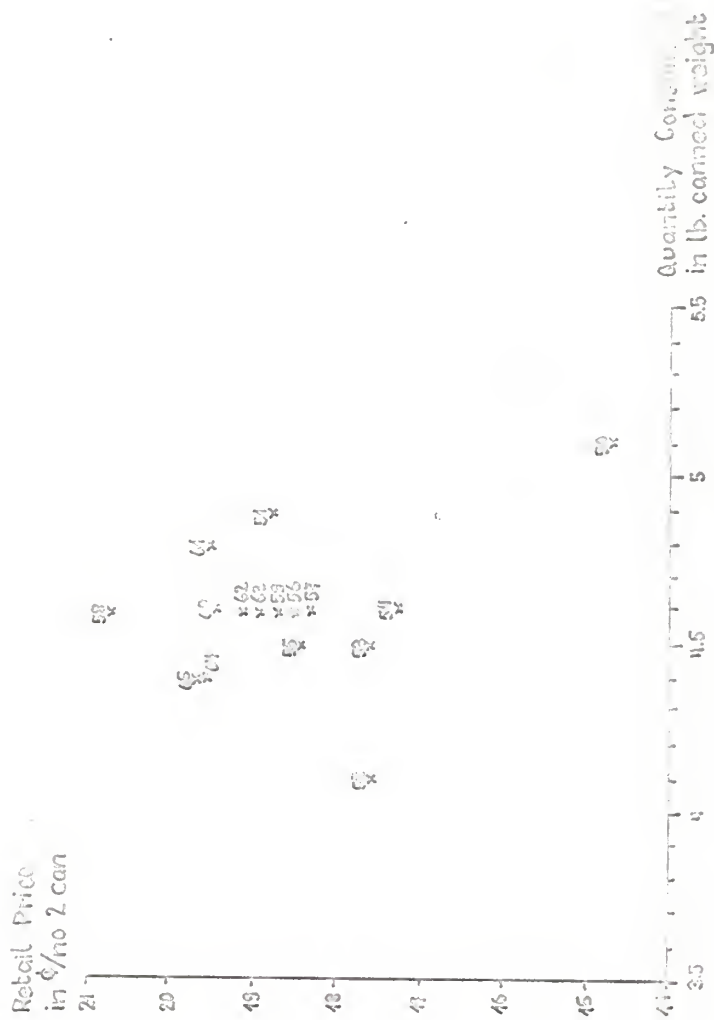
Source: Tables 8 and 10.

Figure 7. Retail Price --- Quantity Observations Plotted for the Period 1950 -- 1965.
 "Supply of Canned Whole Tomatoes" (Uninflated Data).



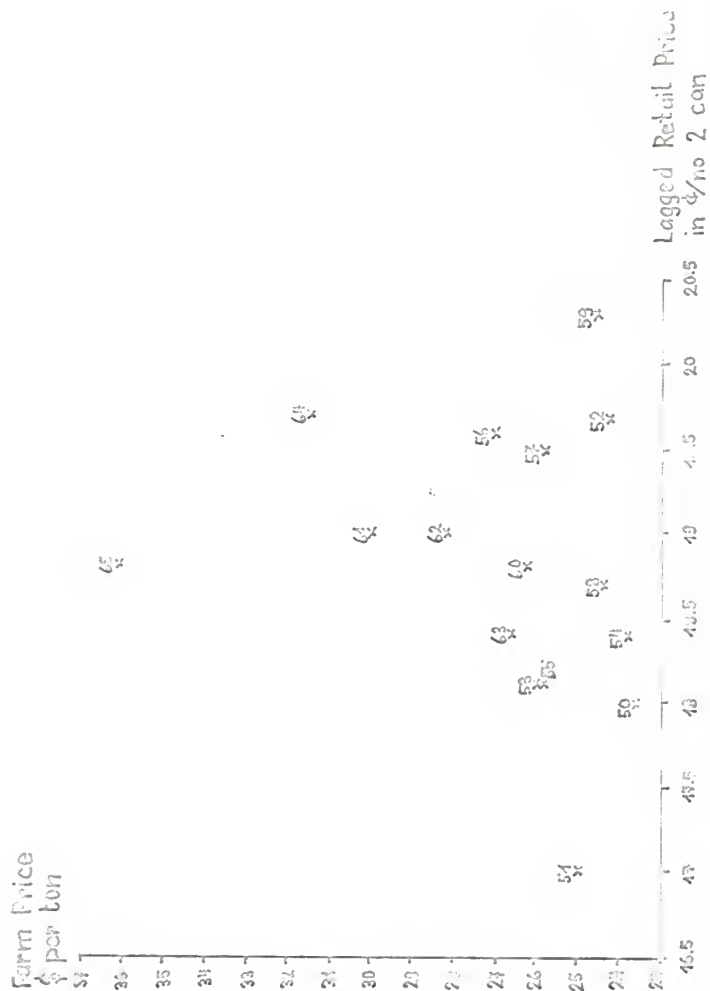
Source: Tables 8 and 10.

Figure 8. Retail Price --- Quantity Observations Plotted for the Period 1950 - 1965.
 "Demand for Canned Whole Tomatoes" (Unadjusted Data).



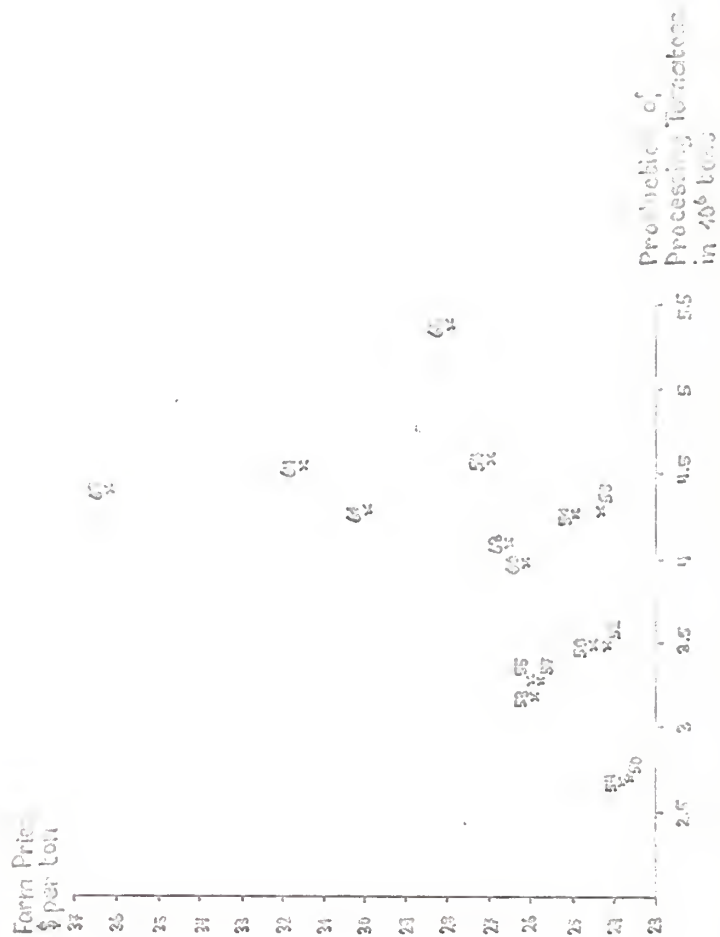
Source: Tables 8 and 10.

Figure 9. Retail Price (Lagged) --- Farm Price Observations Plotted for the Period 1950 - 1965.
 "Demand for Processing Tomatoes" (Deflated Data)



Source: Tables 7 and 8.

Figure 10. Farm Price --- Quantity Observations Plotted for the Period 1950 ~ 1965.
 "Supply of Processing Tomatoes" (Deflated Data).



Source: Table 8.

Figure 11. Retail Price -- Quantity Observations Plotted for the Period 1950-1965. "Supply of Canned Whole Tomatoes" (Deflated Data).

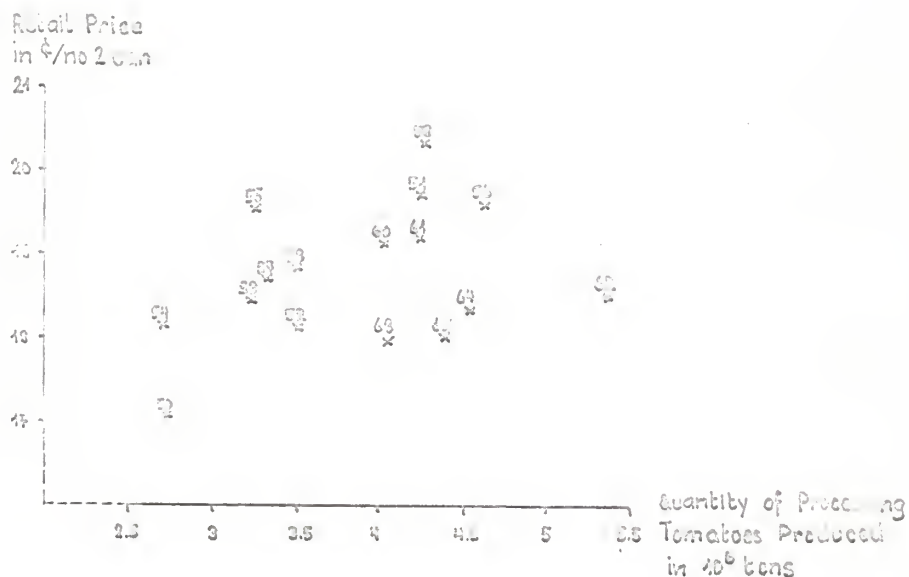
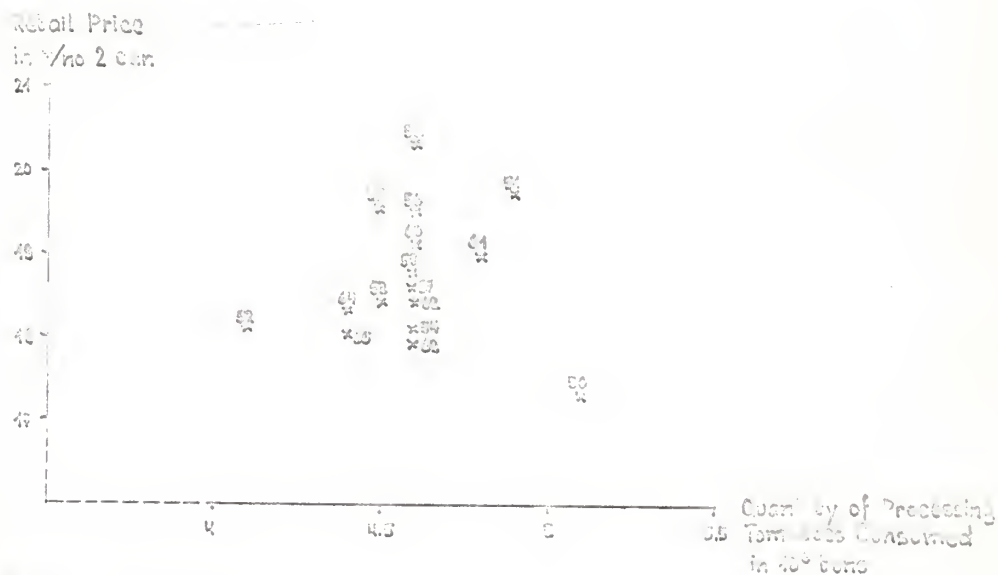


Figure 12. Retail Price -- Quantity Observations Plotted for the Period 1950-1965. "Demand for Canned Whole Tomatoes" (Deflated Data).



Source: Table 8.

Figure 13. Far Price --- Canner's January Stocks Observations Plotted for the Period 1950 - 1965.
(Deflated Data)



Source: Tables 7 and 8.

Since no endogenous variable appears as an independent variable in this equation, the statistical results are exactly the same in both the initial and the alternative model.

Supply of Processing Tomatoes. The signs of all variables included in this equation are consistent with economic theory. Changes in the three independent variables -- yield per acre, farm price of fresh tomatoes lagged one year and contract price (approximated by the farm price) -- explain 57 per cent of the variations in the quantity produced. The t-value of A (= yield per acre) is 1.79 as compared to $t_{0.05, 12} = 2.18$. The other t-values, however, are substantially below 1. In the case of the farm price the variation may be reduced by excluding the year 1965 (see Figures 6 and 10) from the analysis.

The fit of the same supply equation in the alternative model is considerably poorer. Its main disadvantage consists in the negative sign of the price elasticity of supply and the lower t-values.

Supply of Canned Whole Tomatoes. The t-values of the coefficients of the trend variable and of the carryover stocks are 2.14 and -2.6 respectively ($t_{0.05, 12} = 2.18$). The latter value indicates that the retail price of canned tomatoes varies significantly and inversely with changes in the carryover stocks. But even though this result is in line with what we expected, the same procedure is suggested here as before for dealing with January stocks; namely, to consider the retail price as a function of deviations from the "equilibrium" carryover stocks.

The coefficient of the trend variable shows an almost significant and positive relationship with the retail price, indicating that the trend variable does not represent cost saving improvements in the tomato processing

industry. According to Table 6, trend is highly correlated with the yield per acre and with disposable income. The positive regression coefficient may therefore stay for disposable income, indicating that with raising disposable income prices will increase.

The quantity produced has a negative effect on the retail price, an influence which is consistent with economic theory. The t-value is 1.28 for this coefficient ($t_{0.05, 12} = 2.18$). Changes in the three independent variables explain 44 per cent of the variation in the retail price.

Also for this equation, the results are much poorer for the alternative than for the initial model. The explanatory power of the same variables is less and the t-values are considerably smaller.

Demand for Canned Whole Tomatoes. The estimated demand elasticity of +0.04 is completely different from Shuffet's estimate of -0.4. Two reasons can be given for this: Either the economic model is inaccurate or the differences are due to structural changes. The first reason may apply, but the steeply sloped demand curves depicted in Figures 8 and 12 seem to support the second argument. Since 1952 ^{41/} a saturation point must have been reached. The positive coefficient which was estimated from deflated data is not significantly different from zero. However, it is consistent with what one would expect from looking at Figure 12 (a freehand plotted regression line would be positively sloped). This suggests that for the particular time period under investigation canned whole tomatoes may be considered a Giffen good for reasons, however, not apparent to the author. The demand curve is negatively sloped when actual data are used. The conclusions one can draw from the foregoing discussion are: (1) for the analyzed period the demand

^{41/}Shuffet's analysis includes the years 1921 - 1952.

Table 6. Matrix of Simple Correlation Coefficients.

	$P_r, t-1$	P_s	A	Y_d	T	S	C	$P_{FR, t-1}$	P_f	Q_p	P_r	Q_c
$P_r, t-1$	1.000	0.308	0.078	0.132	0.332	0.361	0.589	0.116	0.123	0.052	0.061	0.347
P_s		1.000	0.551	0.495	0.465	0.299	0.284	0.415	0.326	0.408	0.183	0.534
A			1.000	0.911	0.914	0.520	0.387	0.753	0.780	0.743	0.121	0.425
Y_d				1.000	0.889	0.656	0.500	0.787	0.839	0.618	0.066	0.262
T					1.000	0.667	0.577	0.826	0.636	0.602	0.191	0.360
S						1.000	0.914	0.532	0.334	0.005	0.414	0.251
C							1.000	0.703	0.239	0.105	0.360	0.340
								1.000	0.652	0.514	0.264	0.084

For the exact definition of the variables see pp. 30-31.

for canned whole tomatoes is very inelastic; (2) per capita consumption has leveled off at about 4.6 pounds; (3) the fact that with higher real prices consumers may demand more suggests that consumers are not very price conscious with respect to canned tomatoes; and (4) better fits could certainly be obtained by using actual data.

In this paper fresh tomatoes are considered to be substitutes for canned whole tomatoes. The cross elasticity is estimated to be -0.5, indicating that the two products might be complements. It is, however, difficult to find a reasonable explanation for this. Thus, one is inclined to reject the hypothesis of fresh tomatoes being substitutes for canned tomatoes.

The Alternative Model (Structural and Reduced Form Equations). The estimation of the same coefficients for the alternative model is no more satisfactory than for the initial model. There is the difference, however, that the price elasticity of demand shows the negative sign consistent with economic theory. The t-value is somewhat larger than in the initial model but still less than 1.

From the statistical results discussed so far we can now draw the conclusion that the results for the alternative model are, relatively speaking, considerably poorer than those obtained for the initial model. This seems to support our hypothesis that the endogenous variables in the economic model are simultaneously determined in a market which involves the farm level as well as the retail level. However, the statistical results were not good enough to prove this hypothesis statistically.

Based on this conclusion the following discussion will not involve an appraisal of the statistical results obtained through the estimation of the reduced form equations of the alternative model. It should be mentioned,

however, that the estimates for the alternative model are poorer with respect to the explanatory power of the variables, but slightly better with respect to the t-values than in the case of the initial model.

When using reduced form equations, the eight exogenous variables included in this analysis do explain changes in the endogenous variables quite accurately, with R^2 's ranging from 0.83 to 0.87 for the quantity of processing tomatoes produced, the farm price, and the retail price for canned tomatoes. The same variables do not, however, explain the practically constant per capita demand for canned tomatoes very accurately ($R^2 = 0.39$).

In the case of the reduced form equations one expects to get significant regression coefficients for those variables included in the corresponding structural equations. With one exception, this is not the case for the reduced form equations estimated in this study.

Estimation of the Farm Price. The only statistically significant coefficient in this equation relates per capita disposable income to the farm price, the proxy variable for the contract price. The hypothesis that disposable income may have a positive effect on the consumption of canned vegetables is widely held. Neither Shuffet's analysis nor the present study seem to support this argument. On the basis of these two observations it is hypothesized that, in setting up the contract price, producers take into account rising incomes as an indicator for rising consumption, even though no real economic relationship may exist between these two variables.

It might be mentioned that the structural variables -- lagged retail price and January stocks -- show the correct signs. Their t-values, however, are smaller than 1. This was not the case in the structural equation.

Estimation of the Quantity of Processing Tomatoes Produced. The largest t-value is associated with the regression coefficient of the yield per acre, whereas the farm price of fresh tomatoes adds little to the explanation of the quantity produced. Furthermore, its coefficient shows the wrong sign. Whether this can be considered as a supporting fact for the hypothesis that there is actually little interaction between the fresh and the processing market cannot be determined.

Estimation of the Retail Price of Canned Tomatoes. With two exceptions the t-value of the explanatory variables are near or above the significance level. The fact that the coefficient of the trend variable is positive and significant indicates, once more, that it does not account for cost reducing improvements in the vegetable processing industry. Furthermore, the influence of disposable income is negative. This conflicts with our earlier comment that rising disposable income may raise prices, if other things remain equal.

Carryover stocks have little effect on the retail price, but January stocks do seem to have an impact on the level of the retail price. This result may be due to multicollinearity.

Estimation of the Quantity Consumed. In the previous chapter it was mentioned that the quantity consumed does not appear as an independent endogenous variable in any equation, so it does not need to be estimated by the reduced form equation. If the results obtained are poor it may be due to the fact that per capita consumption of canned tomatoes is almost constant during the investigated time period.

Statistical Assumptions. A series of statistical assumptions has to be made in order to get best and unbiased estimates of the coefficients. These assumptions include the following: ^{42/}

^{42/} Lecture notes taken in the Price Analysis course offered by Dr. E. Tyrczniewicz.

- a. The variables must be random variables.
- b. The variables should be normally distributed.
- c. Independent variables have to be independent of each other.
- d. The expected value of the error term should be zero.
- e. The variance of the error term should be constant.
- f. There should be no serial correlation among the error terms.
- g. The error term should not be correlated with the independent variables.

Rough checks will be made for the assumption of independence between independent variables and for the serial correlation of the residuals.

Table 6 indicates that the condition of independence among independent variables is fairly well met. Low simple correlation coefficients occur between the variables included in the four structural equations. However, very high simple correlations are observed between yield per acre and disposable income, between yield per acre and trend, between disposable income and trend, and between January and carryover stocks. The latter observation suggests that there is not much point in using both of these variables separately, since the relationship between January and carryover stocks is certainly causal in nature. Trend and income cannot be used in the same structural equation because a strong relationship exists between these two variables also. The high interrelationship between yield per acre and disposable income is accidental, and to include both variables in the same equation could be justified.

In order to check for serial correlation in the residuals, these were plotted against time for the reduced form equations as well as for the structural equations (Figures 14 to 24). Since the dots are randomly

Figure 14. Plotted Residuals. Reduced Form Equation for Farm Price.
(Equation 7)

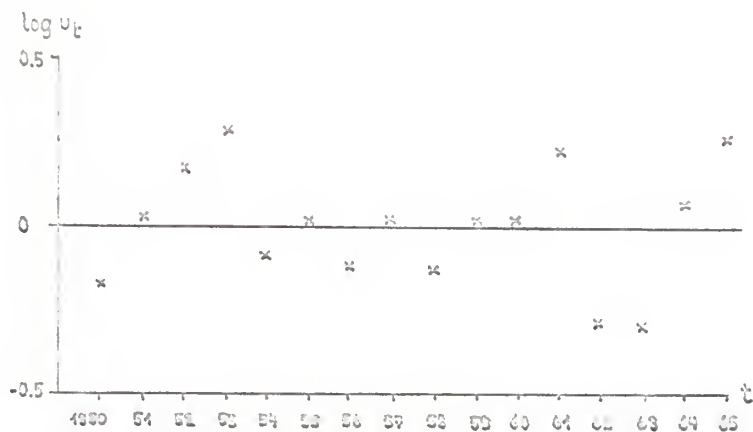


Figure 15. Plotted Residuals. Reduced Form Equation for Quantity Produced.
(Equation 8)

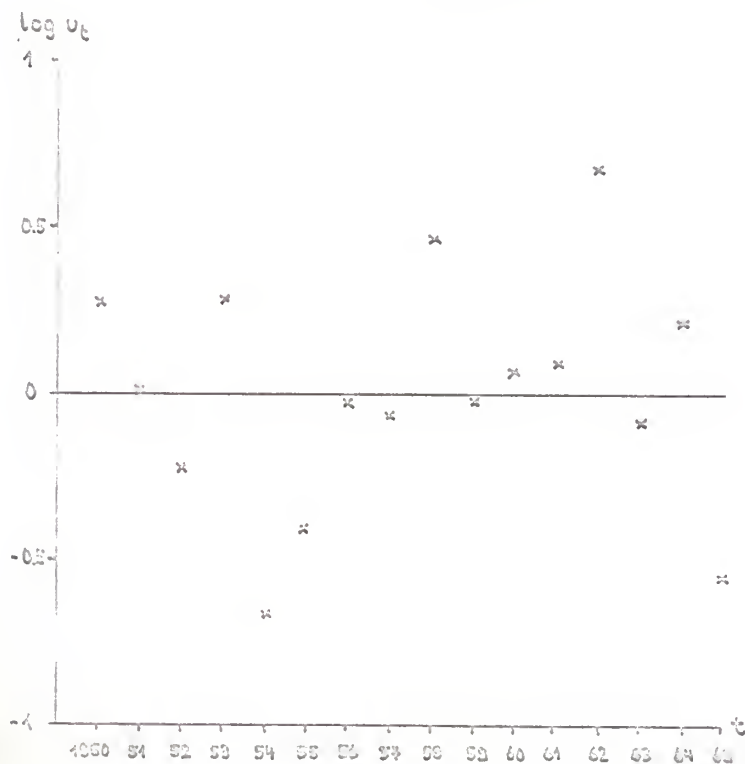


Figure 16. Plotted Residuals. Reduced Form Equation for Retail Price.
(Equation 9)

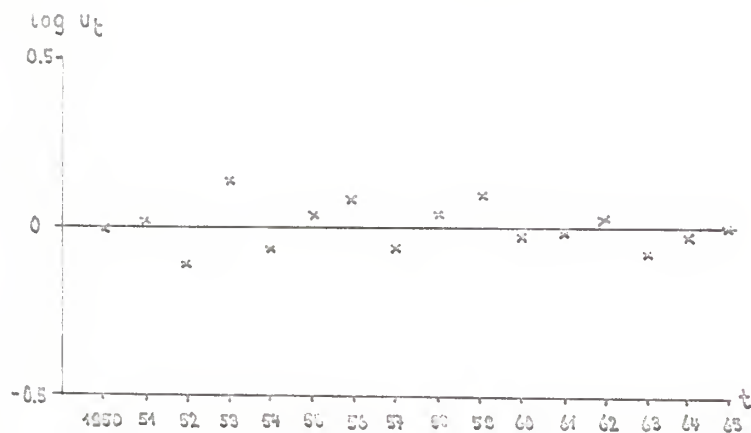


Figure 17. Plotted Residuals. Reduced Form Equation for Quantity Consumed.
(Equation 10)

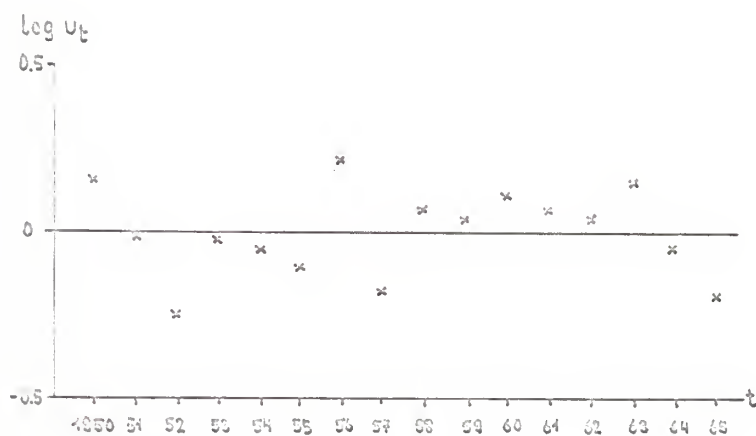


Figure 18. Plotted Residuals. Structural Equation for Farm Price.
(Equations 1b and 1b')

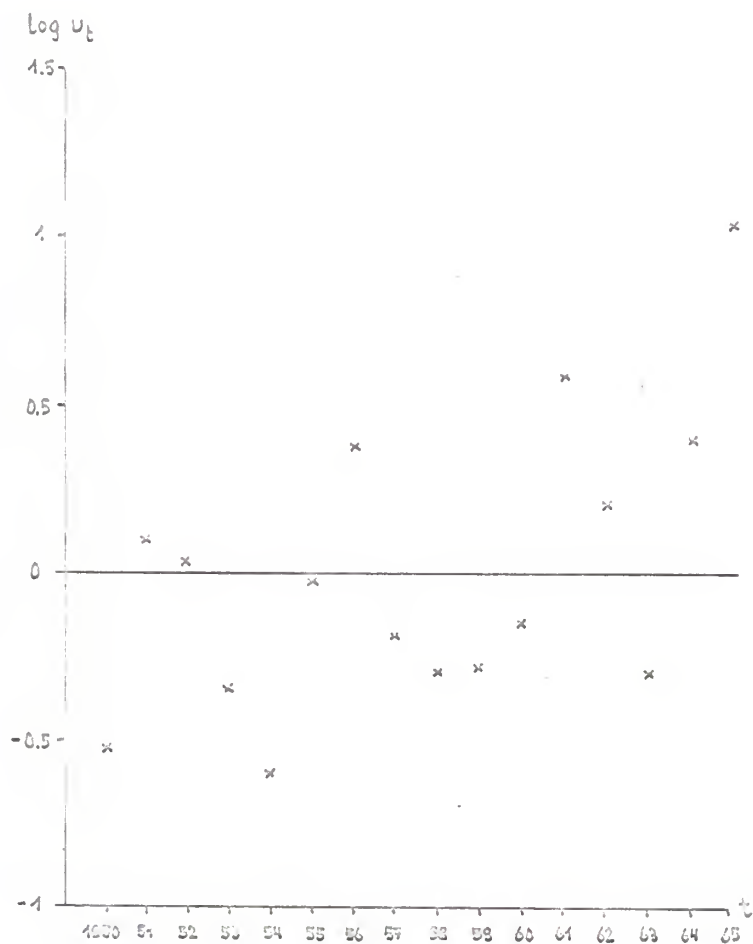


Figure 19. Plotted Residuals. Structural Equation for Quantity Produced.
(Equation 2b)

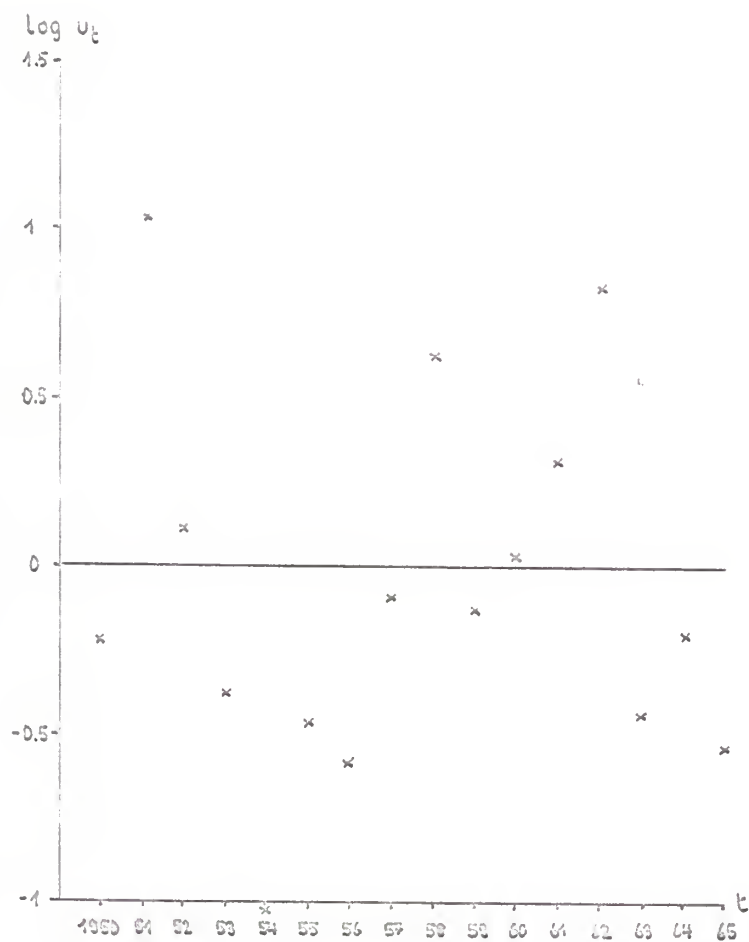


Figure 20. Plotted Residuals. Structural Equation for Retail Price.

(Equation 3b)

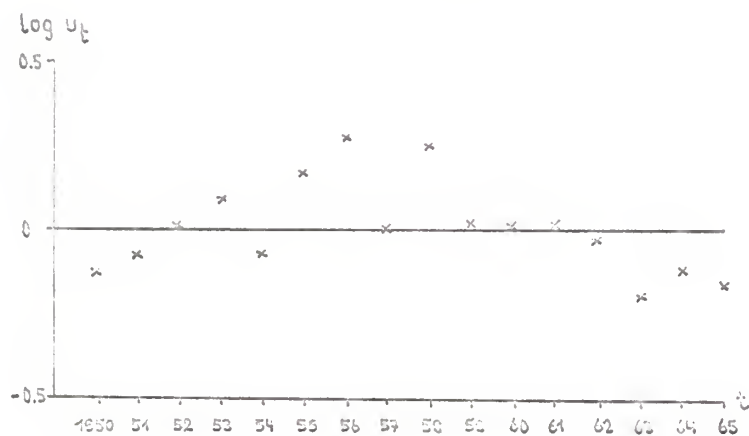


Figure 21. Plotted Residuals. Structural Equation for Quantity Consumed.

(Equation 4b)

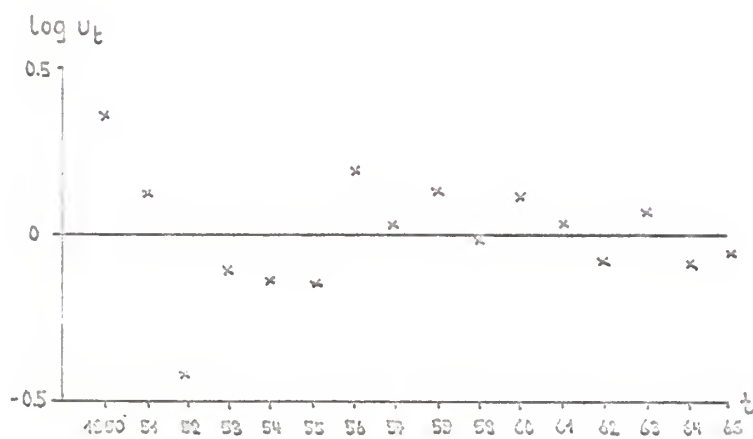


Figure 22. Plotted Residuals. Structural Equation for Quantity Produced.
Farm Level (Equation 2b')

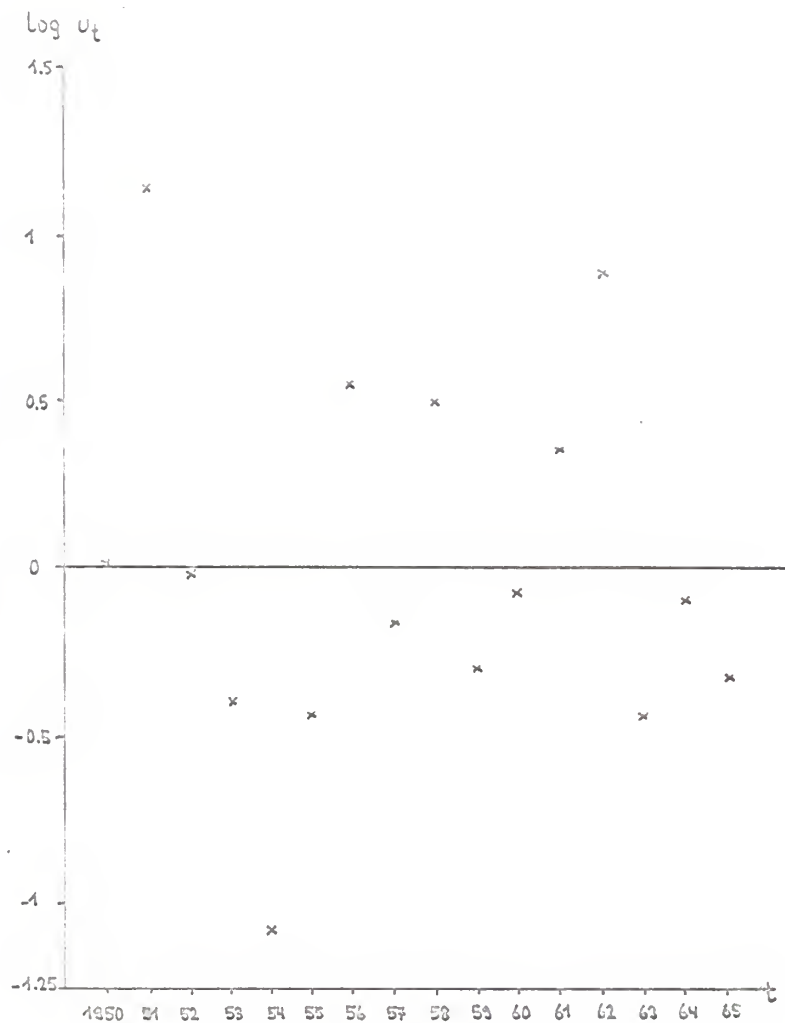


Figure 23. Plotted Residuals. Structural Equation for Retail Price
Retail Level (Equation 3b')

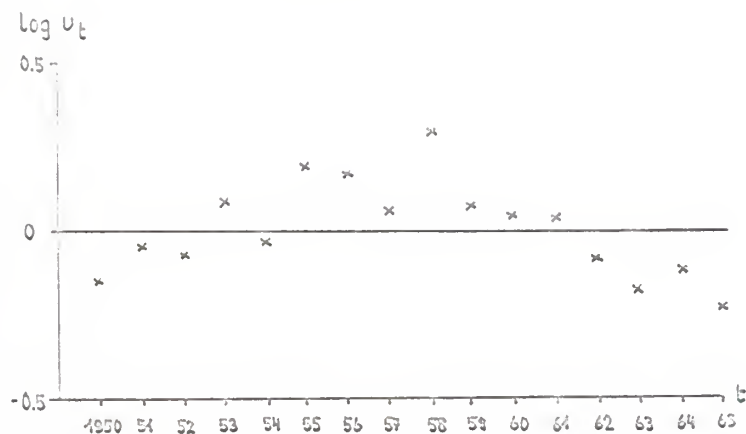
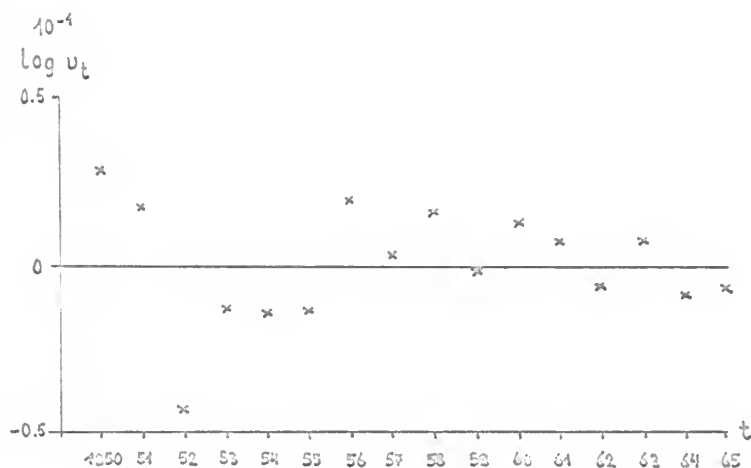


Figure 24. Plotted Residuals. Structural Equation for Quantity Consumed.
Retail Level (Equation 4b')



distributed around zero in most of the cases, this indicates that serial correlation of the residuals is unlikely. Serial correlation may be responsible, however, for the nonrandom distribution of the calculated residuals in the structural equation explaining the retail price in both the initial and the alternative model (see Figures 20 and 23). Since serial correlation biases the standard error downwards it may be possible that the higher t -values of these equations compared to the others are due only to serial correlation.

Improvements of the Initial Model

On the basis of our knowledge about the market structure of the tomato processing industry and the indications obtained through the first evaluation of the model, some changes can be suggested to improve the explanatory power of the initial model as discussed in chapter II. These suggestions follow.

A comparison of the figures 5 through 8 with the figures 9 through 12 supports the hypothesis that undeflated data may yield better fits than deflated data. This is true for all equations in the system.

Demand for Processing Tomatoes. It has been hypothesized that per capita disposable income may have some influence in determining the contract price because processors may have the impression that this variable has an influence on per capita consumption. Consumption, lagged one production period, could also be an estimator for future consumption and therefore may have a positive effect on the determination of the contract price. Furthermore, the experience of 1961 indicates that expected (labor) costs can influence the contract price positively. In addition, dummy variables may allow for the unusually high military demand during the early fifties; and

finally, as already mentioned, relative stock figures should be used rather than absolute stock figures.

This leaves us with a new structural equation which has the following form:

(15) P_{con} , respectively $P_f = f(P_r, t-1, Q_c, t-1, Y_d, t-1, S, K_L, t-1, D_1, D_2)$ with the following meaning attributed to the new variables (the variables already used in the previous models are defined the same way as in chapter II.)

S relative January stocks on a per capita basis.

$K_L, t-1$ expected labor costs based on last year's labor costs.

D_1, D_2 dummy variables allowing for the heavy military demand during the early fifties.

Supply of Processing Tomatoes. With adjusted data and eventually excluding the exceptional values of 1965 from the analysis, this structural equation is formulated the same as before except that the farm price for fresh tomatoes has been dropped. In this case:

$$(16) \quad Q_p = f(P_f, A)$$

Supply of Processed Tomato Products. In order to explain the aggregated supply of processed tomato products the following changes are suggested:

The aggregated retail price is, first of all, not a function of the quantity produced and carryover stocks, but rather a function of $Q_p + C$. Both variables would reflect per capita values and carryover stocks would be expressed as differences from an estimated "equilibrium" carryover stock. If the trend variable reflects rising income as was suggested previously, it might as well be replaced by disposable income. Increasing costs of production are usually added to the retail price. Since the raw product costs plus the costs for cans account for roughly 50 per cent of the total costs

of production, ^{43/} they will both be included in this equation.

The new supply equation reads then:

$$(17) \quad P_r = f(Q_p + C, Y_d, P_r, K_{ST})$$

where K_{ST} represents a steel price index as an approximation for can prices.

Demand for Canned Tomato Products. Among other factors affecting consumption of fruits and vegetables the National Commission on Food Marketing lists the amount of homemaker employment. It says: "Homemaker employment appears to have a depressing effect on household consumption of both fresh and processed fruits and vegetables." ^{44/} However, for certain specific processed products homemaker employment may also have a positive effect on consumption. Since we feel that disposable income has less influence on consumption than is usually believed, this variable is dropped from the equation which finally reads as follows:

$$(19) \quad Q_c = f(P_r, P_s, N_H)$$

where N_H stands for homemaker employment.

This revised model is, of course, subject to similar assumptions and limitations as the economic model developed in chapter II. It does not solve the data problems we mentioned when discussing the original model. The revised model lists some additional variables, deletes other variables and rearranges the whole in a manner which is believed to better approximate the situation in the tomato processing industry than the initial model.

With up to seven exogenous variables in one equation the degrees of freedom are below ten, if one uses only sixteen observations. Unless the

^{43/}National Commission on Food Marketing, op. cit., Table 7-31, p. 203.

^{44/}National Commission on Food Marketing, op. cit., p. 31.

number of observations is increased one cannot expect to get good statistical results, even if this revised model would include all of the relevant variables.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The tomato processing industry has been experiencing tremendous structural changes during the postwar period. On the one hand these structural changes are due to a change in the living and eating pattern of the population and, on the other hand, to technological improvements which occurred at the farm as well as at the processing level.

The tomato processing industry is characterized, with the exception of the South East, by widespread grower-processor integration consisting in forward buying of the crop. It is hypothesized that this integration leads to a strong interdependence between the raw product market and the retail market. The purpose of this study is to analyze in which fashion the consumer demand is translated back to the farm level and to evaluate the magnitudes of the different factors so as to derive policy implications useful to both farmers and processors.

An economic model was developed which attempted to reflect the economic relationships at work in the markets under investigation. Three structural equations specified these forces in the raw product market and a demand and supply equation were specified for the retail market of processed tomato products. In order to test the hypothesis of whether these two markets are interrelated or not, the initial model assumed simultaneous determination of the dependent variables of all structural equations whereas under the alternative hypothesis the dependent variables were assumed to be simultaneously

determined only by the structural equations describing the raw product market and the retail market respectively.

Since no data were available for the contract prices offered to farmers and since retail prices are only reported for canned whole tomatoes, the model had to be reformulated using farm prices as a proxy variable for contract prices, and some variables had to be redefined somewhat in order to make the model operational.

The revised model describes the demand for processing tomatoes as a function of the retail price for canned tomatoes lagged one year and of the January stocks of this commodity. The demand for processing tomatoes is reflected by the contract price offered to farmers. It had to be approximated by the price received by farmers.

The supply of processing tomatoes is expressed as a function of the contract price and of the average yield per acre, a variable reflecting structural changes in the production methods of tomatoes. The farm price for fresh tomatoes lagged one year was also included in order to test whether fresh tomatoes are a substitute crop for processing tomatoes at the farm level.

At the retail level the supply of canned whole tomatoes was expressed in terms of its retail price, which is believed to be a function of the quantity of processing tomatoes produced, of the carryover stocks and of a trend variable accounting for cost reducing improvements in processing. Finally per capita demand of canned tomatoes is specified as a function of the retail price of canned whole tomatoes, the price of fresh tomatoes and per capita disposable income.

This model rests on the assumption of perfect competition in the markets

we are concerned with and assumes furthermore that domestic civilian consumption is the major source of demand. The first assumption can be considered as being consistent with the real world situation whereas the second one is probably not justified.

Since all structural equations are overidentified the two stage least square method was used to estimate the coefficients of the explanatory variables.

The statistical results of the analysis were poor since lack of time prevented additional computation. However, the results seem to support the hypothesis that the raw and the finished product market are interrelated; better fits were obtained by using the initial model.

The variables explaining the demand for processing tomatoes showed the wrong signs. Using underlated prices and relative stock figures this result could probably be improved. All the coefficients of the supply equation of processing tomatoes had the right sign; the coefficient of the average yield per acre being almost significantly different from zero; the other variables in this equation were not.

A 10 per cent increase in the carryover stocks of canned tomatoes brings about a 0.5 per cent decrease in the retail price of this product, whereas a 10 per cent increase in trend brings about an almost significant increase in the retail price of 0.7 per cent or of approximately 0.5 per cent a year, other things being equal. It is possible that this reflects the consumer's willingness to pay higher prices for the same product as their income increase, since trend is highly correlated with per capita disposable income. The coefficient relating the supply of processing tomatoes to the retail price is not significantly different from zero.

Finally, in the demand equation for canned whole tomatoes the price elasticity is positive. Even though it is not significantly different from zero its value being close to zero indicates a very inelastic demand. The cross elasticity of demand shows a negative sign indicating that canned whole tomatoes may be a complement to fresh tomatoes. Per capita disposable income has virtually no effect on consumption.

These results and the ones obtained from the estimation of the reduced form equations suggest:

- (1) That per capita disposable income may be a factor influencing the contract price due to the fact that processors may believe per capita disposable income to be a determining factor of the consumption of canned tomatoes.
- (2) With increasing incomes consumers may be willing to pay higher real retail prices for the same tomato product.
- (3) There exists a very low price elasticity of demand for canned whole tomatoes.

These conclusions are valid, of course, only for the time period under investigation.

ACKNOWLEDGMENTS

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LIST OF REFERENCES

Cited References

Articles and Periodicals

- Brandon, G. E.: "Interrelationships Among Demand for Farm Products and Implications for Control of Market Supply." Pennsylvania Agr. Expt. Stat. Bull. 680, August, 1961.
- Cain, J. L. and F. P. Hopkins: "The Termination of Fruit and Vegetable Processing Firms in Maryland, 1950-1961." Agr. Expt. Sta. Univ. of Maryland, Misc. Pub. 550, May, 1965.
- Cain, J. L. and M. E. Hutchinson: "An Analysis of Structural Changes in the Maryland - Delaware Fruit and Vegetable Industry, 1950-1962." Maryland Agr. Expt. Stat. Misc. Pub. 550, October, 1965.
- Collins, N. R., Mueller, W. F., and E. M. Birch: "Grower-Processor Integration. A Study of Vertical Integration Between Growers and Processors of Tomatoes in California." California Agr. Expt. Stat. Bul. 768, October, 1959.
- Helmberger, P. G. and S. Hoos: "The Vegetable Processing Industry" in J. R. Moore and R. G. Walsh: Market Structure of the Agricultural Industries, 1966.
- Kelly, R. A.: "The Vegetable Canning Industry in Illinois." Illinois Agr. Expt. Stat. Bul. 612, 1957.
- Shuffet, M.: "The Demand and Price Structure for Selected Vegetables." USDA, Technical Bulletin, 1105, December, 1954.

Public Documents

- Almanac of the Canning, Freezing, and Preserving Industry. Edited by E. E. Judge, 9 Court St., Westminster, Md. 21157.
- American Tomato Yearbook. Edited by Rutgers University, College of Agriculture, New Brunswick, N. J.
- Economic Statistics Bureau of Washington, D.C. Handbook of Basic Economic Statistics, 1966.
- National Canner's Association: "The Structure and Economic Significance of the Canning Industry." 1963.
- National Commission on Food Marketing: "Organization and Competition in the Fruit and Vegetable Industry." Technical Study 4, June, 1966.

Supplement to Economic Indicators, Historical and Descriptive Background.
88th Congress, Second Session, 1964.

United States Department of Agriculture. Agricultural Marketing Service.
The Vegetable Situation, Volumes 100 - 162.

_____. Agricultural Statistics.

_____. Department of Commerce, Bureau of the Census. Statistical
Abstract of the United States.

_____. Economic Research Service. "Conversion Factors and Weights and
Measures for Agricultural Commodities and Their Products." Statistical
Bulletin 362, June, 1965.

Related Literature

Burns, D. J.: "Procurement Practices of N.J. Processors for Asparagus and
Tomatoes." New Jersey Agr. Expt. Stat. AE 234 New Brunswick, 1959.

Burns, D. J.: "Marketing of Tri-State Canned Vegetables 1949-1951 Pack."
Misc. Pub. No. 215. Maryland Agr. Expt. Stat. Univ. of Maryland,
June, 1954.

Hoos, S.: "Tomatoes and Tomato Products: Economic Trends and F.O.B. Price
Relationships." March, 1956. Berkeley Univ. Calif. Agr. Expt. Stat.
Giannini Foundation Rept. 185.

Kearl, C. D.: "Costs and Returns in Producing Canning Factory Tomatoes on
24 Western New York Farms, 1951." Cornell Agr. Expt. Stat. A.E. No.
793, Feb., 1952.

Manchester, A.C. and J. C. Podany: "Shifts in Supply Areas and Consumption
Rates for Vegetables 1939-1955." USDA. Agric. Marketing Service,
Marketing Res. Rep. No. 221, 1958.

McDaniel, W. E.: "Delaware's Competitive Position in the Production of
Tomatoes for Processing." Delaware Agr. Expt. Stat. Tech. Bul. 313,
1955.

Mueller, W. F. and N. R. Collins: "Grower Processor Integration in Fruit and
Vegetable Marketing." Journal of Farm Economics, Vol. 39: 1471-1483,
December, 1957.

National Canner's Association: "Developing the Institutional Market for
Canned Foods." (A symposium) Proceedings of the Marketing Sessions
at the 48th Annual Convention, February, 1955.

Osgood, C. T. and T. R. Hedges: "Practices Used in the Production, Canning, and Marketing of Northwestern Arkansas Tomatoes, in 1940-41." Univ. of Arkansas, Agr. Expt. Stat. Bull. No. 460, October, 1945.

Paul, A. L.: "The Economic Structure of the Food Processing Industries." Illinois Agr. Expt. St. Circular, No. FT 5, 1949.

Ritchey, J. F.: "The Marketing of Indiana Tomatoes and Tomato Products." Unpublished Master's Thesis, Dept. of Agr. Econ., Purdue Univ., January, 1958.

Ruttan, V. W.: "The Marketing of Indiana Canned Tomatoes and Tomato Products." Purdue Univ. Agr. Expt. Stat. Res. Mimeo JD-24, 1958.

Stutts, H. P.: "Some Marketing Aspects of the Food Processing Industry in Maryland, Delaware, and New Jersey." Maryland Agr. Expt. Stat. Misc. Publ. 329, Contrib. 2945.

A P P E N D I X

Table 7. Data for the Variables used in Estimating the Statistical Model.
Exogenous Variables

Year	$P_{R,t-1}$	P_s	A	Y_d	T	S	C	$P_{PR,t-1}$
	$\phi/2^1s$	$\phi/lb.$	t/a	\$		10^6 cases	$2A/2^1s$	$\$/cwt.$
1950	17.95	28.3	09.19	1,634	01	11.4	2.2	5.42
1951	17.13	27.9	11.79	1,630	02	06.2	0.1	5.99
1952	19.70	30.6	12.11	1,644	03	10.0	2.1	5.26
1953	18.12	29.4	12.94	1,697	04	15.7	5.7	6.36
1954	18.41	27.9	12.59	1,690	05	14.2	4.8	6.72
1955	18.13	29.1	13.42	1,780	06	10.5	2.7	6.80
1956	19.55	32.3	15.27	1,838	07	10.9	2.5	7.32
1957	19.53	30.2	12.81	1,839	08	16.3	5.7	8.53
1958	18.67	31.5	14.52	1,813	09	12.0	2.7	7.97
1959	20.28	29.5	13.38	1,876	10	16.9	6.5	6.36
1960	18.80	31.2	15.70	1,878	11	15.0	3.7	7.70
1961	19.08	28.0	14.90	1,905	12	13.3	4.3	7.98
1962	18.97	28.7	16.90	1,954	13	14.7	4.7	7.59
1963	18.44	30.6	17.56	1,992	14	17.6	5.6	7.37
1964	17.94	31.2	18.47	2,093	15	16.0	5.5	7.58
1965	18.29	31.5	19.31	2,185	16	17.1	4.2	8.94

Source: Compiled from Tables 9-11. For the definition of variables see pp. 30-31.

Table 8. Data for the Variables Used in Estimating the Statistical Model.
Endogenous Variables.

Year	P _f \$/t	P _r ¢/2's	Q _p 10 ⁶ t	Q _c lb/pers.
1950	23.64	17.13	2.73	5.1
1951	25.08	19.70	4.27	4.9
1952	24.30	18.12	3.52	4.1
1953	26.11	18.41	3.24	4.5
1954	23.84	18.13	2.70	4.6
1955	25.88	19.55	3.28	4.5
1956	26.98	19.53	4.64	4.6
1957	25.70	18.67	3.32	4.6
1958	24.41	20.28	4.29	4.6
1959	24.63	18.80	3.51	4.6
1960	26.33	19.08	4.04	4.6
1961	29.97	18.97	4.25	4.6
1962	28.13	18.44	5.38	4.8
1963	26.67	17.94	4.07	4.6
1964	31.36	18.29	4.56	4.6
1965	36.31	18.00	4.40	4.4

Sources: P_f and P_r compiled from Table 10.
 Q_p from "American Tomato Yearbook 1966" p. 22.
 Q_c from Table 1.
 For the definition of the variables see pp. 30-31.

Table 9. Original Data for Prices of Fresh Tomatoes (P_s) Farm Price for Fresh Tomatoes (P_{FR}), Per Capita Disposable Income (Y_d) and U. S. Population.

Year	P_s 1) ¢/lb.	P_{FR} 2) \$/cwt.	Y_d 3) \$	CPI ⁷⁾ all commodities (1957-59 = 100)	U. S. 9) Population 10 ³
1949	—	5.58	—	—	—
1950	24.3 3)	6.41	1369	83.8	151,132
1951	26.7 3)	6.58	1475	90.5	153,691
1952	29.8 3)	7.57	1521	92.5	156,421
1953	28.2 3)	7.06	1582	93.2	159,012
1954	26.7 3)	6.57	1582	93.6	161,716
1955	27.4 3)	6.75	1661	93.3	164,607
1956	30.6 3)	7.83	1741	94.7	167,509
1957	29.5	7.48 8)	1803	98.0	170,496
1958	32.1	6.35	1826	100.7	173,367
1959	29.6	7.30 4)	1904	101.5	176,551
1960	31.6	7.90	1936	103.1	180,007
1961	28.7	7.51	1985	104.2	183,043
1962	29.7	7.44	2060	105.4	187,979
1963	32.2	7.58	2125 6)	106.7	188,741
1964	33.2	8.76	2263 6)	108.1	191,463
1965	34.3	9.30	2401	109.9	—

- 1) Statistical Abstract of US: Average Retail Prices for Selected Foods.
 2) Agricultural Statistics 1966: Tomatoes; Commercial Crop: Table 291, p. 201.
 3) estimated, using simple regression analysis with the independent variable being the farm price for fresh tomatoes
 4) value on f.a.b. basis starting with 1960.
 5) 1964 Supplement to Economic Indicators 88th Congress, 2nd Session, Table 5.
 6) 1967 Supplement to Economic Indicators 88th Congress, 2nd Session. (figures given there were multiplied by 0.996).
 7) Agricultural Statistics 1966: Economic Trends, Table 629, pp. 433-434.
 8) Was excluded for the computation of the regression between P_{FR} and P_s .
 9) Agricultural Statistics 1966: Total and Farm Population p. 443.

Figure 25. Regression Between Farm Price and Retail Price of Fresh Tomatoes (Current Prices).

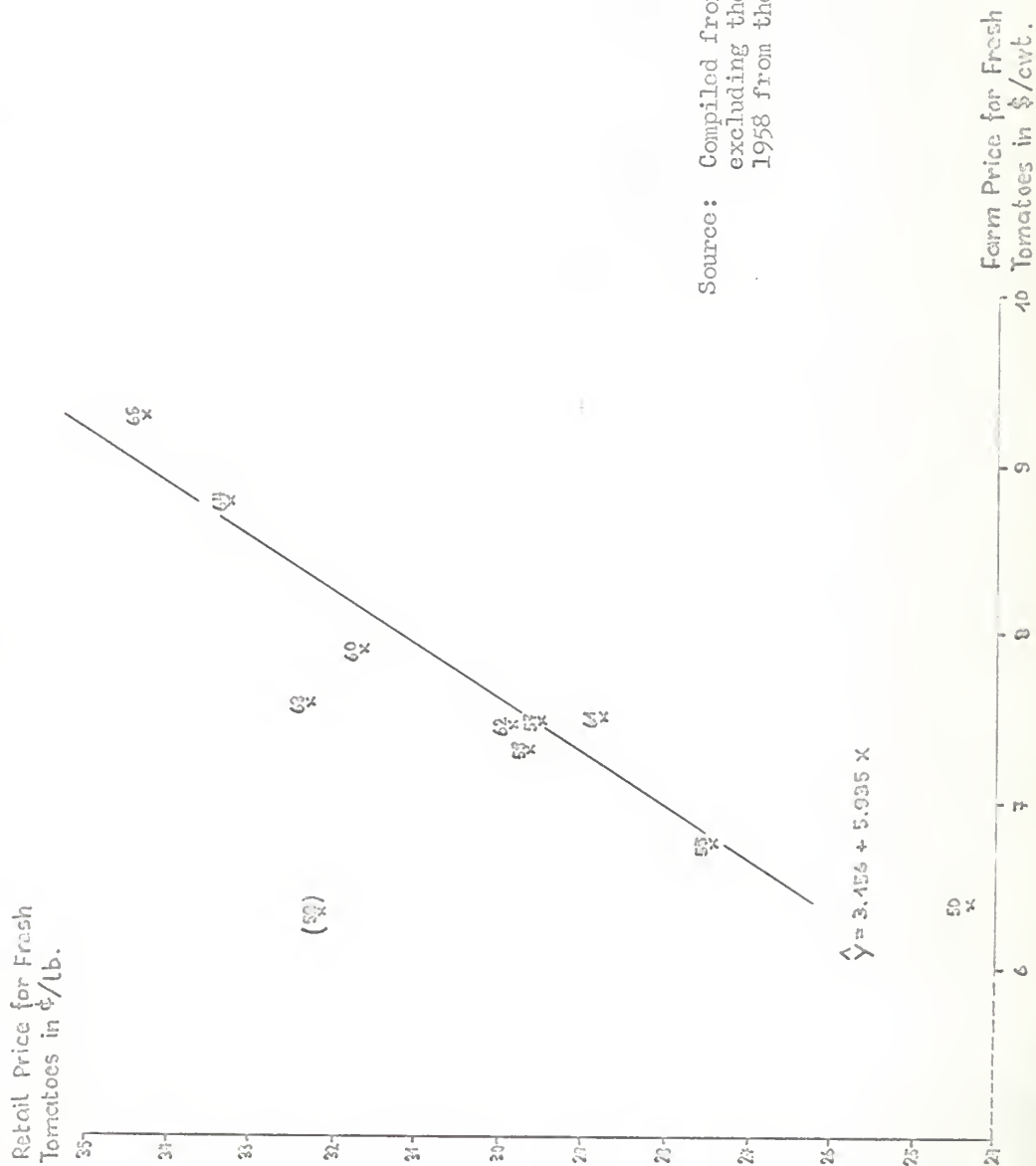


Table 10. Original Data for Prices Received by Farmers for Processing Tomatoes (P_f) and Retail Price of Canned Tomatoes (P_r).

Year	1) P_f \$/ton	2) P_{PF} index all farm prod. (1957-59 = 100)	3) P_r original data, ¢	5) P_r ¢ per no. 2 can	6) CPI food items 1957-59 = 100
1949	---	---	15.2	15.2	84.7
1950	25.30	107	14.7	14.7	85.8
1951	31.35	125	18.8	18.8	95.4
1952	28.92	119	17.6	17.6	97.1
1953	27.42	105	17.6	17.6 4)	95.6
1954	24.32	102	17.3	17.3	95.4
1955	24.84	96	15.1	18.38	94.0
1956	25.63	95	15.2	18.50	94.7
1957	24.93	97	15.0	18.26	97.8
1958	25.39	104	17.0	20.67	101.9
1959	24.38	99	15.5	18.86	100.3
1960	26.07	99	15.9	19.35	101.4
1961	29.67	99	16.0	19.47	102.6
1962	28.41	101	15.7	19.11	103.6
1963	26.67	100	15.5	18.86	105.1
1964	30.73	98	16.0	19.47	106.4
1965	37.04	102	16.1	19.59	108.8

1) Agric. Statistics. Tomatoes commercial crops: Acreage Production, Season Average Price
 P_f is a weighted average price including: N.Y., N.J., Pa., Ohio, Ind.,
 Ill., Mich., Del., Md., Va., Pa., Texas, Colo., Utah, Calif.

2) Agric. Statistics 1966: Economic Trends, Table 629, pp. 433-34.

3) 1950-1954 ¢/2's and 1955-1965 ¢/303's see: Statistical Abstract of US; Average Retail
 Price of Selected Foods.

4) estimated

5) prices from 1955-65 of col. 1 were multiplied by 1.217, see: USDA Stat. Bul. 326, p. 44.

6) Handbook of Basic Economic Statistics 1966 p. 97 ff.

Table 11. Camner's and Distributor's Stocks (January 1st) and Carryovers (July 1st).

Year	Camner's: Stocks	Distributor's: Stocks	Camner's: Stocks	Distributor's: Stocks	Camner's: Carryover	Distributor's: Carryover	Camner's: Carryover	Distributor's: Carryover
:	10 ³ cases	10 ³ cases	24/no. 2 cans	24/no. 2 cans	10 ³ cases	10 ³ cases	24/no. 2 cans	24/no. 2 cans
1950	9479	5473 1)	11375	6568	1868 1)	4027 1)	2242	4832
1951	5151	6632	6181	7958	55	2233	66	2680
1952	8359 2)	6973 2)	10031	8368	1727 2)	4558 2)	2072	5470
1953	15735	5548	15735	5548	5749 2)	3597	5749	3597
1954	14183	3717	14183	3717	4794	3012	4794	3012
1955	10476	3755	10476	3755	2666	3039	2666	3039
1956	10879	4233	10879	4233	2456	3007	2456	3007
1957	16312	3128	16312	3128	5142	2619	5742	2619
1958	11964	3063	11964	3063	2715	2652	2715	2652
1959	16942	3308	16942 4)	3308 4)	6513	2901	6513	2901
1960	n.a. 3)	n.a. 3)	15094 4)	3224 4)	3268 3)	2690	3268	2690
1961	16155	3830 3)	13247	3141	5290 3)	3434 3)	4338	2816
1962	17934	3912	14706	3208	5702	3204	4676	2627
1963	21417	3746	17562	3072	6778	3546	5558	2908
1964	19491	3576	15983	2932	6753	3142	5537	2576
1965	20815	3661	17068	3002	5144	3509	4218	2877

1) 1951-52: Actual cases: conversion factor to no. 2 cases: 1.2

2) 1952-60: 24/2's 10³ cases

3) 1961-65: 24/30's 10³ cases: conversion factor to no. 2 cases: 0.82.

4) Arith. tic average between 1959 and 1961 stocks.

Source: The Vegetable Situation: Commercial Packs.

AN ANALYSIS OF THE DEMAND AND PRICE STRUCTURE
OF THE TOMATO PROCESSING INDUSTRY

1950 - 1965

by

JEAN-PIERRE JACCARD

B. S. Federal Institute of Technology, Switzerland, 1965

AN ABSTRACT OF A MASTER'S REPORT

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The tomato processing industry has been experiencing tremendous structural changes during the postwar period. On the one hand these structural changes are due to a change in the living and eating pattern of the population and, on the other hand, to technological improvements which occurred at the farm as well as at the processing level.

The tomato processing industry is characterized, with the exception of the South East, by widespread grower-processor integration consisting in forward buying of the crop. It is hypothesized that this integration leads to a strong interdependence between the raw product market and the retail market. The purpose of this study is to analyze in which fashion the consumer demand is translated back to the farm level and to evaluate the magnitudes of the different factors so as to derive policy implications useful to both farmers and processors.

An economic model was developed which attempted to reflect the economic relationships at work in the markets under investigation. Three structural equations specified these forces in the raw product market and a demand and supply equation were specified for the retail market of processed tomato products. In order to test the hypothesis of whether these two markets are interrelated or not, the initial model assumed simultaneous determination of the dependent variables of all structural equations whereas under the alternative hypothesis the dependent variables were assumed to be simultaneously determined only by the structural equations describing the raw product and the retail market separately.

Among others, the two models rest on the assumption of perfect competition in the markets we are concerned with and assumes furthermore that domestic civilian consumption is the major source of demand. The first

assumption can be considered as being consistent with the real world situation whereas the second one is probably not justified.

Since no data were available for the contract prices offered to farmers and since retail prices are only reported for canned whole tomatoes, the models had to be reformulated using farm prices as a proxy variable for contract prices, and some variables had to be redefined in order to make the models operational.

In both models all structural equations are overidentified so that the two stage least square method had to be used to estimate the coefficients of the explanatory variables.

The statistical results of the analysis were poor since lack of time prevented additional computations. However, the results seem to support the hypothesis that the raw and the finished product market are interrelated; better fits were obtained by using the initial model. Moreover the results obtained suggest that for the time period covered by the present analysis:

- (1) The per capita disposable income may be a factor influencing the contract price due to the fact that processors may believe per capita disposable income to be a determining factor of the consumption of canned tomatoes.
- (2) With increasing incomes consumers may be willing to pay higher real retail prices for the same tomato product.
- (3) There exists a very low elasticity of demand for canned whole tomatoes.