LATE SUMMER ONION SUPPLY RESPONSE IN THE UNITED STATES

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Lee F. Schrader

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by

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AN ABSTRACT

Submitted to the College of Agriculture of
Michigan State University of Agriculture and Applied Science
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ABSTRACT

The objectives of this study were first to determine a useful model for prediction of late onion supplies under specified conditions and second, to test the applicability to the late onion crop of some proposed hypotheses regarding supply response.

Four prediction models were constructed for harvested acreage of late onions using information available prior to planting. The primary differences between the models involve the assumptions regarding expected prices. The methods are termed 1) conventional, 2) Hicksian, 3) distributed lags, and 4) a special model constructed for the late onion crop. Yield, unharvested production and production are analyzed using methods in the latter category.

Estimates of expected prices, expected costs, technology and, in some cases, fixed asset position are considered in the supply models. The percent of variance explained is fairly high, that is, from 45 percent for unharvested production to 90 percent for production. Performance of several models depends on the inclusion of a time variable which is not a cause in itself.

Usefulness for prediction is limited to estimates prior to planting. Once planting has been completed subjective modifications are necessary to allow for the effects of weather.

Estimates of price elasticity of supply are low (+.028 to +.271). The high degree of uncertainty involved in onion prices and production brings about the low elasticity and contributes to the difficulty in ascertaining a measure of expectations.

Each of the methods applied proved to be useful in establishing the particular relationships it measures with the exception of the Hicksian model which proved inappropriate in this study.

All models were fitted using least squares regression on data within the years 1921 to 1957, excluding the World War II years. The parameter estimates are subjected to statistical tests of significance. The criteria for judgments concerning the models presented are statistical significance, prediction performance, and reasonableness of the estimates.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

Introduction

Supply response in agriculture has long been a subject of controversy both in and outside agricultural economics. Not only are there differences of opinion as to the magnitude of supply response to price but also disagreement as to the direction of the response. The greatest controversy exists regarding the total agricultural supply; however, there is less than full agreement even at the single commodity level. Ample evidence of disagreement at both levels may be found in papers submitted to the Joint Economic Committee of Congress in November 1957.[1] Congressional Hearings on the bill to ban future trading in onions[2] reveal rather extreme impressions regarding onion supply response. Studies involving empirical verification of supply response hypotheses, several of which are discussed in Chapter II, are subject to less divergence than the writings referred to above.

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[1] Policy for Commercial Agriculture: Its Relation to Growth and Stability, Joint Economic Committee, Government Printing Office, Washington, D. C., November 22, 1952, Sec. VI.

[2] Hearings Before the Subcommittee on Domestic Marketing of the Committee on Agriculture, House of Representatives, on H. R. 376, 1933-1935, 3418, May 12 and 13, U. S. Government Printing Office, Washington, D. C., 1957.

The Setting[3]

Table 1.1 below is an indication of the size and value of the total onion crop and the late summer onion crop (hereafter referred to as late onions). Late onion yields have increased from a level of 350 sacks in 1920-30 to approximately 600 sacks per acre in the past five years. Acreage

Table 1.1

Onions for Fresh Market and Processing (1949-55 average)*

		Unit	Michigan	United States
Acreage:	Total	acres	9,500	119,850
	Late crop		9,500	61,600
Production:	Total	thousands of	2,266	43,284
	Late crop	50# sacks	2,266	33,004
Value:	Total	thousands of	6,314	55,021
	Late crop	dollars	6,314	39,312

*Vegetables - Fresh Market, 1957 Annual Summary, Dec. 17, 1957, USDA, AMS, p. 41.

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[3] Information about the crop was obtained in informal interviews with Dr. Lucas, Soils Department, Michigan State University and Dr. Carew, Horticulture Department, Michigan State University.

Further information is available in:

D. Milton Shuffett, The Demand on Price Structure for Selected Vegetables, Tech. Bul. 1105, USDA, December, 1954.

J. W. Park, Marketing Onions, Tech. Bul. 555, USDA, April, 1957.

Commodity Yearbook, 1956, Commodity Research Bureau Inc., New York, 1956.

increased from about 45,000 in the early twenties to the 70,000 area in 1950 and has since declined to the 60,000 acre level.

Late onions are produced commercially in 19 states with the bulk of production in New York, Michigan, Colorado, Oregon, and California. The crop is harvested during August, September, and October. A substantial portion of the late crop is stored each year to provide for trade needs until the spring crop is moving in volume (usually March). Approximately half to two-thirds of the crop is placed into storage, mostly on farms. There is no carryover from one year to the next. Prior to 1950 it could be said that the late crop marketing season extended through the month of March. The early spring crop harvest has shifted to the point that Texas onions are competing with late onions in March. The 1930-34 average carlot and boat shipments of early onions was 27 cars during March. The corresponding 1954-56 average was 1730 cars. Much of the price uncertainty associated with late onions arises from the variability in size and harvest date of the early crop.

Production within the late summer states is concentrated into areas where soil type and climate are favorable. The tendency has been toward large (100 or more acres) specialized farms. Fixed costs involved in production and storage are high, but labor costs are the largest item in onion production amounting to 40-55% of the total costs. Harmer and Lucas[4] estimated that 450 labor hours/acre are required to produce onions on 100 acres yielding 800 bags per acre using primarily hand methods. In addition, about 20 equipment hours and 35 tractor and truck hours per acre are required for production and movement into storage. Costs of bags, seed, fertilizer, fuel, etc. would amount to approximately $200 per acre. Costs would be somewhat less per acre at lower yields. Labor costs would be lower in the western states where mechanical harvesting is more common, however, the irrigation costs are likely to offset this factor.

Alternative use of the land is limited. The land involved is too expensive for grain production and a switch to another vegetable crop is likely to require additional specialized equipment, knowledge, and market potential. Growers in the western area would seem to be less limited as to alternative use and suitable land available. Coefficients of variability (standard deviation divided by the mean) computed for harvested acreage by area are Eastern .125, Central .175, and Western .152. Weather effect on harvested acreage may be less in the western area, however, the difference is not large enough to justify a supposition that acreage in the western area is adjusted more readily.

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[4]Paul M. Harmer and Robert E. Lucas, Muck Soil Management for Onion Production, Extension Bulletin 123, Michigan State College Cooperative Extension Service, East Lansing, Second Revision, February, 1955, p. 46.

Late onions are traded on organized cash and futures exchanges. Dealers, brokers, and association publications keep the trade, including growers, well informed. The crop is relatively free from government regulation, being involved in neither acreage controls nor price support programs. Imports of late onions are of minor importance, in most years amounting to only about 1% of the total U. S. onion crop. The U. S. import duty applicable to countries exporting onions to the U. S. of 87½ cents per 50 pound bag[5] precludes imports except at prices considerably higher than this figure.

The onion grower's situation is commonly characterized as highly uncertain. Table 1.2 below provides an indication

Table 1.2

Variability of Corn and Late Onion Acreage, Yield, Price, and Income Expressed as Coefficients of Variability*

	Harvested Acreage	Yield/A.	Price	Gross Income/A.
Late onions	.094	.092	.518	.478
Corn (all)	.044	.160	.461	.363

*Standard deviation divided by the mean, computed using data for 1921-41 and 1946-56, see Appendix for onion data, corn data from agricultural statistics, trend removed from acreage, yield, and income.

[5] United States Import Duties, 1952, United States Tariff Commission, U. S. Government Printing Office, Washington, D. C., 1952.

of the relative variability of late onions and corn. Much of the uncertainty attributed to the late onion crop is because of the price variation within the crop year. The yearly high-low range of mid-month farm prices as a percentage of the average monthly farm prices is a measure of this variation. Averages of the yearly percentages for five commodities in the 26 year period, 1929 through 1955 are shown in Table 1.3.

Table 1.3

Within Season Price Variability for Specified Commodities*

Commodity	Price range as a percentage of average price
Onions	111.3
Potatoes	58.8
Eggs	49.9
Corn	30.3
Wheat	20.4

*Futures Trading in Onions, Commodity Exchange Authority, USDA, Washington, 25, D. C., Dec. 1956, p. 12.

This within year variation relates to the early spring crop size and timing and to the difficulty of obtaining accurate production estimates early in the marketing season. Since such a large portion of the crop is stored on farms the within year variation is very important.

The Objective

The objective of this study is twofold. The first is to determine a useful model for prediction of late onion supplies under specified conditions. The second is to test the applicability to the late onion crop of some proposed hypotheses regarding supply response.

CHAPTER II

Review of Literature

Important work has been done at both the total agricultural supply level and at the single commodity level. While this study falls into the latter category some of the literature at both levels will be discussed.

At the aggregate level recent contributions have been made by D. Gale Johnson,[1] Glenn L. Johnson,[2] Heady,[3] Cochrane,[4] and Hathaway.[5] D. Gale Johnson develops a theory of aggregate production response which he believes is applicable to both depression and full employment conditions. His

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[1]D. Gale Johnson, "The Nature of the Supply Function for Agricultural Products," American Economic Review, Vol. 40, No. 4, Sept., 1950, p. 539.

[2]Glenn L. Johnson, "Supply Function - Some Facts and Notions," Agricultural Adjustment Problems in a Growing Economy, Earl O. Heady, Howard G. Diesslin, Harold R. Jensen, and Glenn L. Johnson, ed., North Central Farm Management Committee, Iowa State College Press, Ames, Iowa, 1958.

[3]Earl O. Heady, "The Supply of Farm Products Under Conditions of Full Employment," American Economic Review, Vol. 45, No. 2, May, 1955, p. 228.

[4]Willard W. Cochrane, "Conceptualizing the Supply Relation in Agriculture," Journal of Farm Economics, Vol. 37, No. 5, Dec., 1955, p. 1161.

[5]Dale E. Hathaway, "Agriculture and the Business Cycle," Policy for Commercial Agriculture: Its Relation to Economic Growth and Stability, U. S. Government Printing Office, 1957, p. 51.

theory rests on the assumptions 1) farmers are profit maximizing entrepreneurs, and 2) the following characteristics of factor supply to agriculture: a) labor supply shifts with business activity, b) land supply is inelastic, and c) capital supply has a low elasticity for downward movement and higher for expansion. He defends the idea that agriculture is price responsive. He introduced the notion that fixed assets and resource availability are more important in the explanation of output than fixed costs which had been advanced as the explanation of agriculture's failure to reduce output in depressions.[6] Johnson notes that a response may take place as failure to maintain present assets which has no immediate effect on output.

Glenn Johnson emphasizes that supply is affected by many factors and that attempts to explain agricultural supply with any one factor are not likely to succeed. In addition to price-cost relationships and levels of business activity, he suggests consideration of 1) technology, 2) resource movements between regions, firms, and enterprises, 3) changes in risk, 4) changes in asset holdings. He formalizes the fixed asset approach to the analysis of supply

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[6]Fixed assets refer to factors of production fixed to the farm and fixed costs refer to costs which the farm incurs regardless of production such as taxes, interest, and support of family labor (which may be a fixed asset).

response to price. Johnson defines an asset as fixed if its marginal value productivity in its present use neither justifies acquisition of more of it nor its disposition. Use of this fixed asset theory indicates that the aggregate supply function is only partly reversible.

Heady sees agriculture as a price responsive industry. He attributes the low elasticity of supply in the short run to 1) low reservation price for labor, 2) capital limitations, 3) risk discount, and 4) fixed short run production function. He also calls attention to the "identification problem." That is to say, conventional regression analysis may indicate an erroneous relationship if the data represents different supply curves rather than successive observations along the same supply curve.

Cochrane believes productivity advances are due primarily to technological advances and concludes that the supply relation is not reversible. While the aggregate supply is inelastic to price decreases, the substitution of resources between enterprises does allow for considerable response to relative price.

Hathaway shows that inputs are varied in response to price levels and presents empirical evidence that aggregate production is responsive to price.

Cromarty[7] presents a combination approach to supply analysis. His aggregate estimates are built from separate commodity analysis. He attempts to include 1) price expectation (lagged product prices), 2) prices of alternative crops, 3) costs of production, 4) weather and 5) technology as measured by physical units of equipment or changing cultural practices in the case of crops.

Some elasticity estimates made by Cromarty using data for 1929-1953 are:

Wheat	.129
Feed grains	.364
Dairy	.212
Fresh vegetables	.316

The various single commodity supply estimates include a wide variety of expectation models and measures of response.

Halvorson[8] attempted to measure supply elasticity for milk using feeding rates related to milk-feed ratio, pasture condition, and cow numbers. His correlation and regression coefficients did not appear significant. He concludes that the short run elasticity of milk production is less than .25 in winter and less than .10 in summer. He also found some

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[7] William A. Cromarty, Economic Structure in American Agriculture, Ph.D. thesis, Michigan State University, 1957.

[8] Harlow W. Halvorson, "The Supply Elasticity for Milk in the Short Run," Journal of Farm Economics, Vol. 37, No. 5, Dec., 1955, p. 1186.

slight evidence that feeding rates are more responsive to price increases than to price decreases.

Walsh[9] found a significant relationship between acreage and the price of cotton with no improvement in fit when cottonseed prices were included. He found an increase in both the level and slope of the acreage response function after 1924 as cotton growers gained confidence in their ability to control the boll weevil. For prediction he used absolute first differences in acreage and price adjusted for an index of prices paid. A relatively good fit (correlation coefficient of .90) was obtained for 1911-33 data. He concluded that, yields being price inelastic but more variable than acreage, production is quite inelastic to changes in price.

Bowlen[10] using lagged first differences of price and acreage, found a discontinuous and perfectly inelastic supply function for wheat in the specialized areas of Kansas in the short run. The favorable relative price of wheat in the specialized areas accounts for this situation. An elasticity of .315 was determined for the less specialized eastern Kansas area. Correlation coefficients were relatively low, e.g., .03 to .62. He points out the problem of

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[9]Robert M. Walsh, "Response to Price in Production of Cotton and Cottonseed," Journal of Farm Economics, Vol. 26, No. 2, May, 1944, p. 359.

[10]B. J. Bowlen, "The Wheat Supply Function," Journal of Farm Economics, Vol. 37, No. 5, Dec., 1955, p. 1177.

estimating the lag in the employment of additional resources when prices increase or the withdrawal of resources when prices decline.

Kohls and Paarlberg[11] found evidence that farmers as a group do respond to changing deflated crop prices from year to year by changing acreage planted. They attempted to explain changes in acreage using lagged deflated price. They found 33 percent of the acreage variability in onions was associated with deflated price one and two years preceding.

Nerlove[12] emphasizes the fact that the farmers react not to last year's price, but rather to the price they expect, and this expected price depends only to a limited extent on last year's price. He hypothesizes that the expected price is a weighted average of past prices with the most recent weighted heaviest and that this expectation is revised in proportion to the error made in predicting current price. He sees agricultural production as more

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[11] R. L. Kohls and Don Paarlberg, The Short Time Response of Agricultural Production to Price and Other Factors, Station Bulletin 555, Purdue University, Agricultural Experiment Station, Lafayette, Indiana, Oct., 1950.

[12] Marc Nerlove, "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," Journal of Farm Economics, Vol. 38, No. 2, May, 1956, p. 496.

responsive to price than is revealed in less general hypotheses applied in the past. His "more general" method provided elasticity estimates as follows:

Commodity	Estimated elasticity of supply
Cotton	0.67
Wheat	0.93
Corn	0.18

Nerlove's hypothesis will be explored further in Chapter III.

Brennan[13] estimated cotton acreage on an area basis using "expected prices" of cotton and four competing crops plus a trend variable. His "expected prices" are computed from Hicks' "elasticity of price expectation." Coefficients of determination are .73, .79, and .84 for the areas studied. The expectation model will be considered later.

Suits and Koizumi[14] constructed a three equation model of the United States onion market. Their supply schedule was fitted using first differences of logs. Lagged price, cost index and trend were used to predict production. Their method will be discussed at greater length below.

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[13] Michael J. Brennan, Progress Report on Cotton Production Response, FERD, ARS, USDA, Apr., 1958.

[14] D. B. Suits and S. Koizumi, "The Dynamics of the Onion Market," Journal of Farm Economics, Vol. 38, No. 2, May, 1956, p. 475.

Johnson,[15] Gray, Sorenson, and Cochrane,[16] and Hathaway[17] in their separate analyses of the effects of government programs on burley tobacco, potato and dry bean industries provide information on farmer's response to reduced price uncertainty. All three studies reveal a willingness on the part of farmers to supply more product at the same average price after the reduction in uncertainty.

Johnson used lagged price deflated by costs of production, acreage allotment minus previous 6-year average acreage, and overplanting penalty to estimate underplantings of burley tobacco. His yield model included lagged price (in logs), prices paid, trend, acreage allotment minus 3-year average acreage harvested and a weather index (computed from test plot yields).

In the dry bean study, Hathaway calculated planted acreage as a function of percentage of previous year's acreage

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[15] Glenn L. Johnson, Burley Tobacco Control Programs, Bul. 580, Kentucky Agricultural Experiment Station, University of Kentucky, Lexington, Feb., 1952.

[16] Roger W. Gray, Vernon L. Sorenson, and Willard W. Cochrane, An Economic Analysis of the Impact of Government Programs on the Potato Industry of the United States, Tech. Bul. 211, University of Minnesota Agricultural Experiment Station, June, 1954.

[17] Dale E. Hathaway, The Effects of the Price Support Program on the Dry Bean Industry in Michigan, Michigan State College, Agricultural Experiment Station, April, 1955.

abandoned before harvest, index of expected income from corn and wheat, cost of production and log of price received the previous year. In his yield model he considered weather (test plot yields), log of price received the previous year and current acreage. Coefficients of determination obtained were .803 and .872 for the acreage and yield models.

Gray, et al. estimated changes in acreage using price received for potatoes divided by an index of prices received for all farm products lagged one and two years. This method yielded a coefficient of determination of .74 for the years 1923-41. In addition to the change in response, there was a shift in production area. Acreage in the specialist states increased and maintained one-third higher acreage than that which existed prior to price support action. Growers in the lake states, after a one-year increase, continued a downward trend in acreage.

The above studies represent the more usual approach to supply analysis. Knudtson and Cochrane[18] advance a linear programming approach to the determination of a supply function for flax. They observe that a supply function may be constructed in this way when historical data are not

[18] A. C. Knudtson and W. W. Cochrane, "A Supply Function for Flax at the Firm Level," Journal of Farm Economics, Vol. 40, No. 1, Feb., 1958, p. 117.

available. Separate estimates would be required for each homogeneous production area to establish an "average" response for prediction purposes.

An extreme view is represented in a paper prepared for the 1952 International Wheat Council by the Food and Agriculture Organization of the United Nations[19] the hypothesis was advanced that the world supply schedule for wheat is backward sloping above a certain price level. This situation is attributed to the "income effect" of a price change. No empirical evidence is presented in support of the hypothesis. It involves much of the same reasoning which appears in the "high fixed cost" explanations of output maintenance during the great depression.

The above review is by no means exhaustive but presents a variety of opinions and methods. The empirical studies cited generally support the notion that agriculture does respond to price. In different ways they reveal the difficulty of obtaining an accurate estimate of expected price and measures of relevant variables other than price.

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[19] A Reconsideration of the Economics of the International Wheat Agreement, Food and Agriculture Organization of the United Nations Commodity Policy Studies, No. 1, Sept., 1952, pp. 17-22.

CHAPTER III

The Analysis

This is a study in economic dynamics. Economic dynamics is defined by Hicks as that part of economic study in which every quantity must be dated.[1] A comparative static analysis similar to that proposed by Hicks in conjunction with the above definition is applied.

Time must be considered for two reasons. Most important is the fact that the current supply of a commodity depends not so much on current price as upon what farmers expected the price to be when production plans were made. Secondly, adjustments toward an optimum require time and, in many cases, are not made in the span of a single production period.

A modified partial equilibrium analysis involving an aggregation of firms is utilized in this study. The farmer is a price taker in both the factor and product markets. Assume profit maximization as the motive for production. Then factors of production (x . . . z) will be applied to enterprises (f . . . h) to the extent and in combinations such that:

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[1] J. R. Hicks, Value and Capital, Clarendon Press, Oxford, Second edition, 1946, p. 115.

$$\frac{MVP^f_x}{P_x} = \frac{MVP^f_y}{P_y} = \ldots\ldots\ldots\ldots = \frac{MVP^f_z}{P_z}$$

$$\frac{MVP^g_x}{P_x} = \frac{MVP^g_y}{P_y} = \ldots\ldots\ldots\ldots = \frac{MVP^g_z}{P_z}$$

$$\begin{array}{ccc} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{array}$$

$$\frac{MVP^h_x}{P_x} = \frac{MVP^h_y}{P_y} = \ldots\ldots\ldots\ldots = \frac{MVP^h_z}{P_z}$$

where MVP^f_x = <u>expected</u> marginal value product of factor x used in enterprise f. P_x = expected price of factor x.

Thus, given farmers expectations as to price, technology, weather, institutional factors, etc., plus an estimate of asset fixity[2] the adjustment to be made may be estimated. It cannot be assumed, however, that adjustment is from a state of equilibrium. Rather the firm is in a position which would have approached an optimum organization in the unlikely event that expectations held in the previous period had been fully realized.

The empirical studies discussed in Chapter II attest to the acceptability and usefulness of the assumption of profit

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[2]Fixed asset defined as one for which salvage value is less than expected MVP which is less than cost of acquiring an additional unit.

motivated production and indicate that resource allocation in agriculture is price responsive.

A major portion of the problem at hand is that of obtaining values for the farmers expectations. The relative certainty with which an expectation is held is very important at the single firm level; however, since this study involves "average" expectations the problem is of lesser importance. The method of analysis employed in this study dictates that the expectations considered be single valued. The only allowance for uncertainty is a risk discount (positive or negative) implicit in the supply response equation which does not appear as such.[3] By this method the risk discount becomes a constant which may well be unrealistic.

Economic theory has little to offer as to hypotheses on the nature and formation of expectations which may be

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[3]On the existence of risk discount, Hicks, op. cit., p. 135, observes "we shall find as we go on that there are reasons for suspecting that the economic system loses more by mistrust than by overconfidence." Conversely, Keynes states "it is probable that the actual average results of investments, even during periods of progress and prosperity, have disappointed the hopes which prompted them. Businessmen play a mixed game of skill and chance, the average results of which to the players are not known by those who take a hand. If human nature felt no temptation to take a chance, . . . there might not be much investment merely as a result of cold calculation." J. M. Keynes, The General Theory of Employment Interest and Money, Harcourt, Brace, and Company, New York, 1935, p. 150.

applied to a study such as this. Specific hypotheses will be presented as the various supply models are considered.

The Data

The harvested acreage, yield, production, unharvested production and price data utilized in this study consist of series published by the United States Department of Agriculture. Data for the periods 1918 to 1941 were obtained from USDA general publications for commercial vegetables (provided by the Statistical and Historical Research Branch of the Agricultural Marketing Service) for 1939-1949 from _Commercial Vegetables for Fresh Market, Revised Estimates_, Statistical Bulletin 126, USDA, 1953; for 1949-1955, _Vegetables for Fresh Market, Revised Estimates_, Statistical Bulletin 212, USDA, 1957, and data for the 1956 and 1957 crops from _Vegetables for Fresh Market, Annual Summary_, 1957. The series are presented in the Appendix. The data for 1939 forward includes a change in the definition of "commercial." Production for sale on local markets is included after 1939. Previous estimates related to production in well recognized commercial areas mainly producing for shipment to distant markets. Comparable estimates are not available for the years prior to 1939. There is an overlap of three years, however, the differences vary to the extent that a correction factor cannot be applied with any degree of confidence. No correction procedure is proposed in the basic publication. The discrepency amounts to approximately +2000 acres and -5 sacks per acre in yield. While the 1957 publications listed above do not include the word commercial in the title, the estimates are comparable to the 1939 to 1949 data.

The observations for the years 1942-45 are excluded to avoid the distortion caused by wartime controls.

Data for planted acreage are not available prior to 1946, therefore, the harvested acreage series is used in the analysis. No estimates of unharvested production are available prior to 1928.

Further comments as to data limitations are made as the various models are considered.

The Method

Models for harvested acreage, yield, unharvested production and quantity available for harvest are constructed for the late onion crop.

Single equation methods are applied in all models presented. The line of causation between the variables considered is clear. Late onion production, as is the case in nearly all crops, is influenced not by current prices but by price expectations which have existed in the past. Lagged values of variables determined within the system are considered as "independent." There is but one "dependent" variable in each model. On the surface it would appear that unharvested production does not satisfy these conditions, however, under the conditions to be outlined in the discussion of that model as single equation estimate is justified.

The equations are fitted using the method of least squares. Preliminary graphic inspection of the relationships provided insufficient evidence to reject the assumption of approximate linearity.

Thirty-three observations are used in fitting the equations in all cases except for production which includes thirty-two and unharvested production for which only 25 observations are available. Thus, it was possible to consider a relatively complete model without suffering a lack of reliability due to insufficient degrees of freedom.

To facilitate evaluation and comparison certain statistical tests of significance are applied. The t test is applied to test the hypothesis that the regression coefficient (b) tested does not differ significantly from zero against the alternative hypothesis that it is significantly different from zero. If the ratio of the parameter to its standard error is greater than $t_{\frac{\alpha}{2}}$, the hypothesis that the b is equal to zero is rejected. The t value is obtained from the "Students'" distribution with n-k-1 degrees of freedom where k is the number of independent variables in the model and α is the probability of rejecting the hypothesis that b is zero when in fact it is true. Standard errors of the b's are included in all cases. One of the assumptions made in the estimation process is that of serial independence of the residuals. The Durbin-Watson test[4] is applied to determine the degree of independence. Results of the test are reported only as indeterminate, acceptance or rejection at the .05 level of significance of the hypothesis of serial independence. Results of the test applied to a model containing a lagged variable determined within the system are only approximate. This must be considered since most of the models presented do include lagged price as an explanatory variable.

The tests of significance are designed for use with data having these characteristics:[5] (1) the population must be homogeneous, (2) the variables must be normally distributed, (3) observations must be independent, and (4) the sample must be selected at random. Since the data used in the study do not have these characteristics except only approximately it follows that while the results are expressed

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[4]For computational method and tables used see J. Friedman and R. J. Foote, Computational Methods for Handling Systems of Simultaneous Equations, Agriculture Handbook No. 94, USDA, AMS, Nov., 1955.

[5]G. S. Shepherd, Agricultural Price Analysis, Fourth edition, The Iowa State College Press, Ames, 1957, p. 188.

to the fourth decimal they must be evaluated as to reasonableness and correspondence with experience. Unless otherwise stated, all equations are fitted using data for the 33 years, 1921-41 and 1946-57.

Harvested acreage is considered first and used to test four expectation hypotheses. The four include a conventional, Hicksian, distributed lags (Nerlove) and a model constructed specifically for the late onion crop. One model is presented for unharvested production and two for quantity available for harvest. Consideration of the latter two models includes an evaluation of the methods advanced by Suits and Koizumi mentioned in Chapter II.

Harvested Acreage

The conventional analysis of supply response to price involves an attempt to associate changes in acreage to lagged adjusted price. The work of Kohls and Paarlberg discussed in Chapter II is an example. The assumptions involved are 1) price expectations are equal to prices received in the immediate past, 2) expectations as to state of the arts are constant or follow a uniform trend, 3) the level of all prices has no effect on resource allocation, and 4) the farmer is a profit maximizing entrepreneur. Four variations of the conventional method are considered.

$$(3.1) \quad Y_1 = a_1 + b_1X_1 + u_1$$

$$(3.2) \quad Y_1 = a_2 + b_{1.1}X_1 + b_2X_2 + u_2$$

$$(3.3) \quad Y_1 = a_3 + b_3X_3 + u_3$$

$$(3.4) \quad Y_1 = a_4 + b_{3.1}X_3 + b_4X_4 + u_4$$

where

Y_1 = late onion acreage in year t expressed as percent of year t-1.

X_1 = season average price received by farmers for late onions year t-1 in cents per bag divided by an index of prices paid for items used in onion production[6] in year t-1 multiplied by 100.

X_2 = season average price received by farmers for late onions in year t-2 in cents per bag divided by an index of prices paid for items used in onion production in year t-2 times 100.

X_3 = prices received by farmers for late onions in year t-1 in cents per bag divided by USDA index of prices received by farmers for all crops in year t-1 times 100.

X_4 = prices received by farmers for late onions in year t-2 in cents per bag divided by USDA index of prices received by farmers for all crops in year t-2 times 100.

and the u's are different randomly distributed residuals.

The X's above measure only expected price. Deflation by the cost index provides a very rough net price measure in constant dollars. The use of prices received index removes price level effects and a very rough measure of onion price

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[6]Computed using USDA index of prices paid by farmers for items used in production weighted according to estimated use for onion production.

relative to price of all crops. The deflated prices lagged two years are included to allow for the possibility of measurable adjustment lags and that expectations may be based on more than the previous year's experience.

The fitted equations are as follows (standard errors of the b's in parentheses):

$$(3.5) \quad \hat{Y}_1 = 88.23 + \underset{(.0599)}{.2763^*X_1} \qquad r_y^2 = .41 \qquad s_{\hat{y}} = 6.66$$

$$(3.6) \quad \hat{Y}_1 = 84.53 + \underset{(.0617)}{.2923^*X_1} + \underset{(.0610)}{.0640X_2} \qquad R_y^2 = .39 \qquad s_{\hat{y}} = 6.66$$

$$(3.7) \quad \hat{Y}_1 = 89.71 + \underset{(.0486)}{.1839^*X_3} \qquad r_y^2 = .32 \qquad s_{\hat{y}} = 7.16$$

$$(3.8) \quad \hat{Y}_1 = 87.28 + \underset{(.0538)}{.1956^*X_3} + \underset{(.0540)}{.0289X_4} \qquad R_y^2 = .28 \qquad s_{\hat{y}} = 7.25$$

* Significant at the .01 level.

The Durbin-Watson statistic computed for equation 3.5 is 2.22 and provides insufficient evidence to reject the hypothesis of serial independence of residuals at the .05 level.

Price adjusted for production costs appears to be a better indicator of changes in acreage than price adjusted for the price of other crops. The regression coefficients are not significant at the .10 level for either deflated price lagged two years. Model 3.5 is considered as representative of the conventional method. To compare the performance of this model with those to follow $\hat{Y}_1$ from 3.5 is converted to an acreage estimate. The correlation coefficient between the estimated and actual acreage is 0.89 and the coefficient of determination is 0.79. The price elasticity of supply indicated by equation 3.5 is .125. A comparison of actual and estimated acreage is presented in Figure 1.

Because of the limited amount of information considered and the sweeping nature of the assumptions involved, this method alone does not provide a satisfactory estimate of the basic relationships involved.

A desire to allow the relation between past and expected prices to be determined by a means other than entirely by assumption leads to a consideration of Hicks' elasticity of expectation. Hicks defines elasticity of expectation of commodity X as the ratio of the proportional rise in expected future prices of X to the proportional rise in its current price.[7]

The method used to derive expected price (P*) in accord with the above definition is as follows.[8] Assume the price in period t-1 is an exponential function of price in period t-2. Then:

$$(3.9) \qquad P_{(t-1)} = k\, P_{(t-2)}^{\alpha}$$

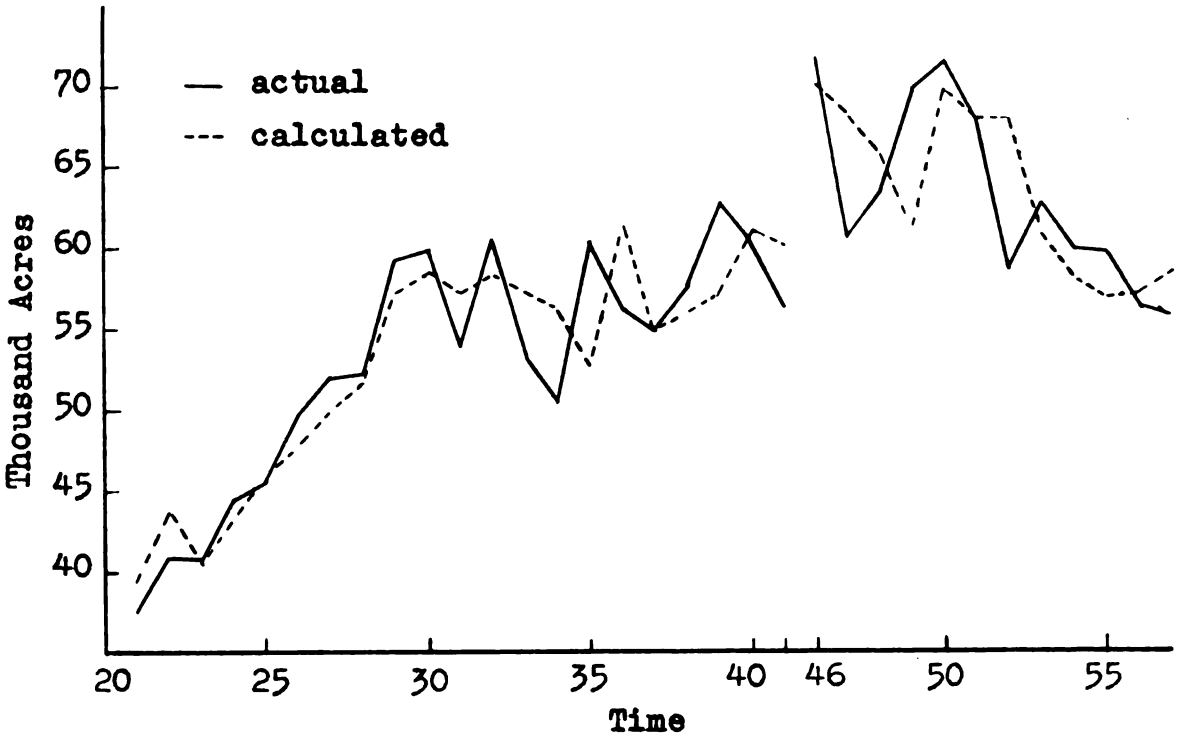
where k and α are constants. Expressed in logarithmetic form 3.9 becomes

[7]Hicks, op. cit., p. 205.

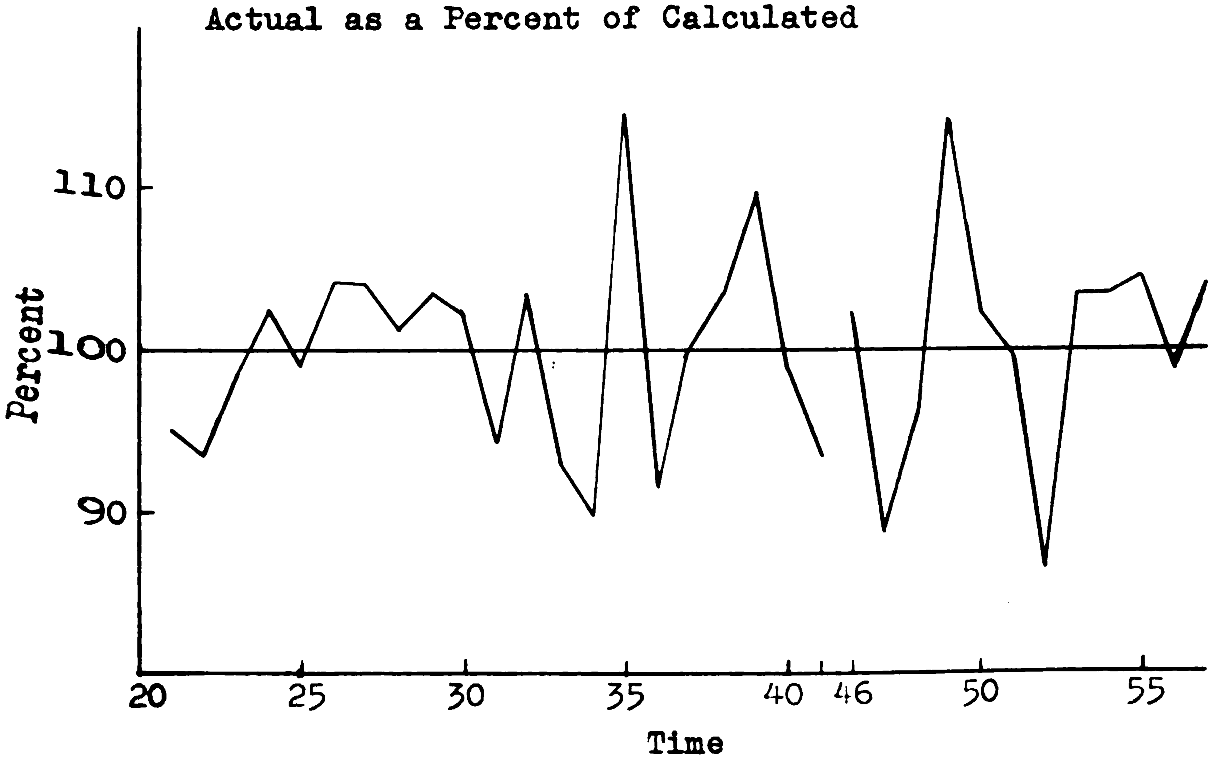
[8]Brennan, op. cit., p. 29.

Figure 1

Actual and Calculated Late Onion Acreage
from the Conventional Model (3.5)



Actual as a Percent of Calculated



$$(3.10) \qquad \log P_{(t-1)} = \alpha \log P_{(t-2)} + \log k$$

differentiating 3.10 with respect to $P_{(t-2)}$

$$(3.11) \qquad \frac{1}{P_{(t-1)}} \cdot \frac{d\,P_{(t-1)}}{d\,P_{(t-2)}} = \alpha \frac{1}{P_{(t-2)}} \cdot \frac{d\,P_{(t-2)}}{d\,P_{(t-2)}}$$

which simplifies to

$$(3.12) \qquad \frac{d\,P_{(t-1)}}{P_{(t-1)}} = \alpha \frac{d\,P_{(t-2)}}{P_{(t-2)}}$$

or

$$(3.13) \qquad \frac{\dfrac{d\,P_{(t-1)}}{P_{(t-1)}}}{\dfrac{d\,P_{(t-2)}}{P_{(t-2)}}} = \alpha$$

is the elasticity of expectation as defined by Hicks.

may be estimated by least squares in 3.10. $d\,P_{(t-1)}$ and $d\,P_{(t-2)}$ may be approximated by taking first differences. Then 3.12 becomes

$$(3.14) \qquad \frac{P_t^* - P_{(t-1)}}{P_{(t-1)}} = \alpha \frac{P_{(t-1)} - P_{(t-2)}}{P_{(t-2)}}$$

solving for P^* we have

$$(3.15) \qquad P_t^* = \alpha \frac{P^2_{(t-1)}}{P_{(t-2)}} + 1 - \alpha\, P_{(t-1)}$$

3.10 fitted to late onion data 1921-41 and 1946-56 provides an estimate of α as .73. Assuming that cost of production in the previous period represents the expected costs in the present period, P_t^* was adjusted using the index of prices paid by farmers for onion production in the previous season.

At this point there is nothing to be gained by the construction of a complicated supply model when the first task is to judge the expectation model. To facilitate evaluation a model similar to 3.5 is used. The model:

$$(3.16) \quad Y_1 = a_{16} + b_5X_5 + u_{16}$$

where

Y_1 = harvested acreage as percent of previous year.

X_5 = P* in cents per bag divided by index of prices paid in onion production in year t-1 times 100.

and u is a random residual.

The fitted equation

$$(3.17) \quad \hat{Y}_1 = 96.64 + \underset{(.0236)}{.0674^*}X_5 \qquad r^2_y = .21 \qquad s_{\hat{y}} = 7.71$$

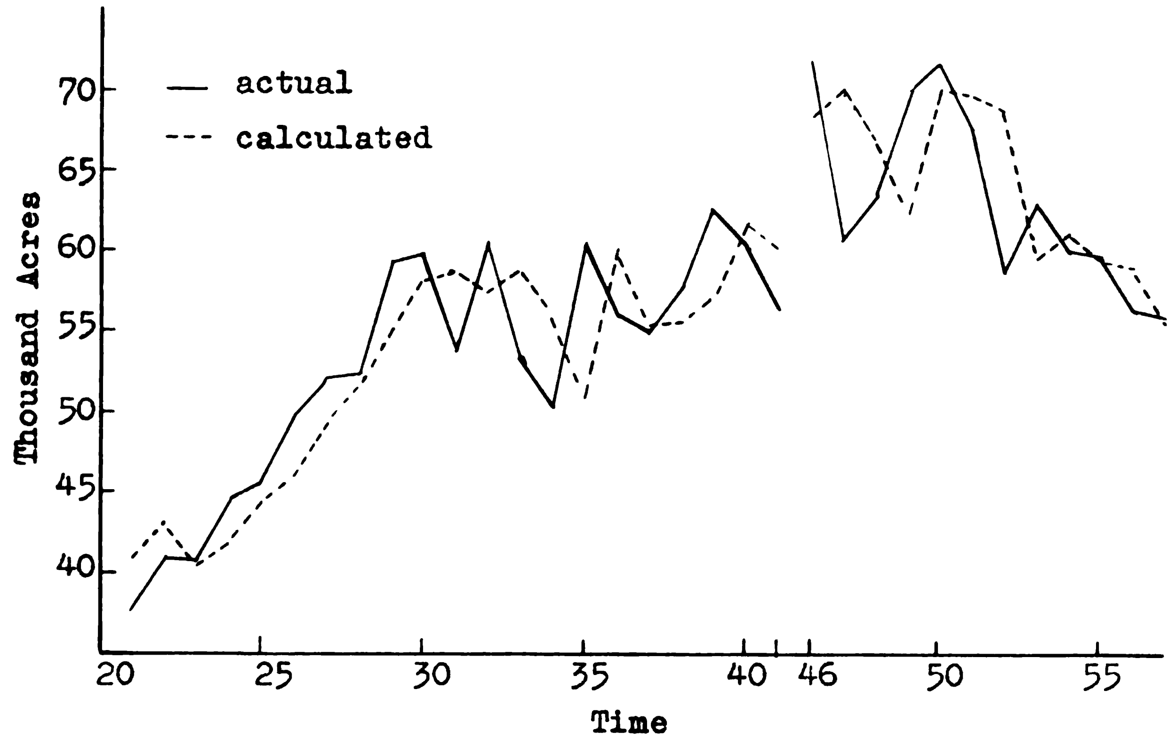
* significant at the .01 level.

The Durbin-Watson statistic of 2.09 provides insufficient evidence to reject serial independence at the .05 level. The coefficient of determination computed for actual and estimated acreage is .75. Although the t test indicates b_5 as highly significant the equation's performance is poorer than equation 3.5 as shown by a larger standard error of the estimate. Elasticity of supply estimated from 3.17 is .042. Figure 2 illustrates the model's prediction performance.

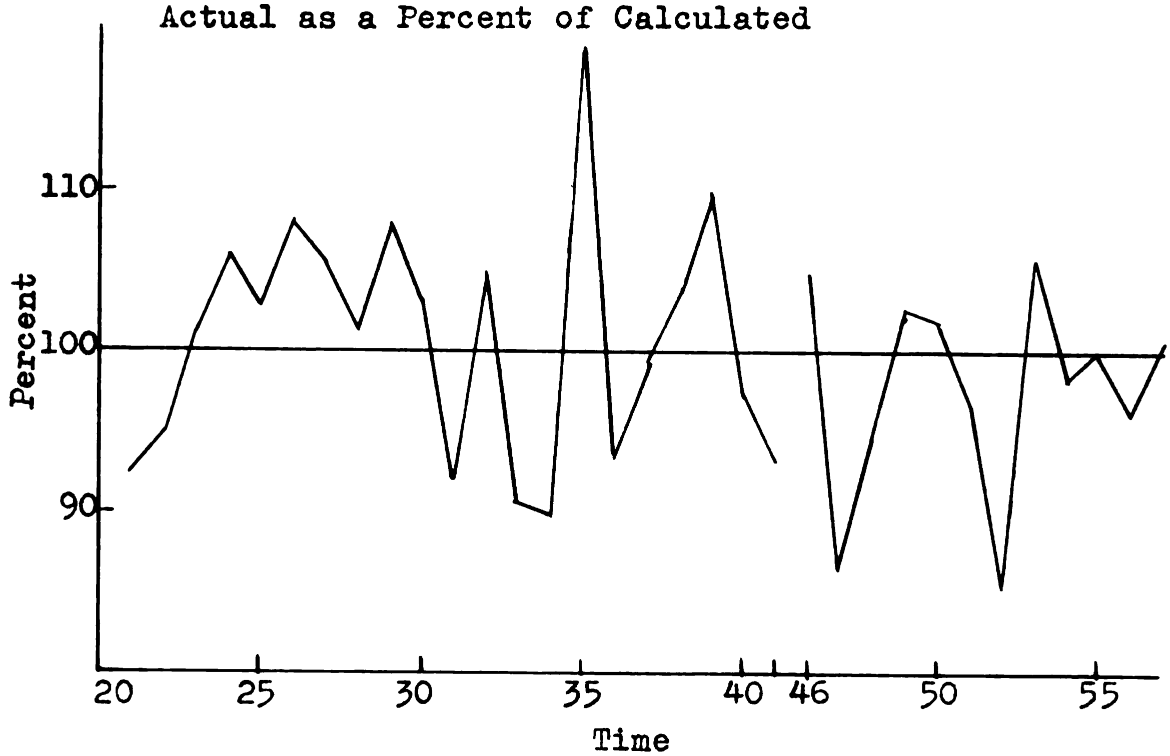
Thus far, relatively simple expectation models have been used to predict changes in acreage. As already observed in Chapter II, Nerlove proposes that expected price depends only to a limited extent on price in the previous period. He

Figure 2

Actual and Calculated Late Onion Acreage
Using the Hicksian Model (3.17)



Actual as a Percent of Calculated



indicates that it is logical and simple to represent expected price as a weighted moving average of past prices in which the weights decline as one goes back in time. Nerlove proposes that the actual values of the weights can be determined from the data. It is also hypothesized that each year farmers revise the price they expect to prevail in the coming period in proportion to the error they made in predicting price this period. To state the above in a way it may be applied to the problem under study, let

P^*_t = price expected in period t

P^*_{t-1} = price expected in period t-1

P_{t-1} = actual price in period t-1

β = proportion by which farmers revise their expectations (the coefficient of expectation)

(3.18) $P^*_t - P^*_{t-1} = \beta (P_{t-1} - P^*_{t-1}) \quad 0 < \beta \leq 1$

3.18 is equivalent to

(3.19) $P^*_t = \beta P_{t-1} + (1-\beta)\beta P_{t-2} + (1-\beta)^2 \beta P_{t-3} + \ldots$

the closer β is to zero the greater will be the number of past prices which must be included. Assume the acreage devoted to a crop is a linear function of the expected price of that crop. Let Y_t be acreage in period t and u_t a random residual. Then

(3.20) $Y_t = a_0 + a_1 P^*_t + u_t$

P_t^* cannot be observed, however, equation 3.20 means P_t^* may be written as a linear function of Y_{t-1} particularly P^*_{t-1} can be represented by Y_{t-1}.

$$(3.21)\quad P_{t-1}^* = -\frac{a_0}{a_1} + \frac{1}{a_1} Y_{t-1} - u_t$$

then replacing P_{t-1}^* in equation 3.18

$$(3.22)\quad P_t^* = -\frac{a_0}{a_1} + \frac{1}{a_1} Y_{t-1} - u_t + \beta\left[P_{t-1} - \left(-\frac{a_0}{a_1} + \frac{1}{a_1} Y_{t-1} - u_t\right)\right]$$

Now substituting this expression for expected price in 3.20

$$(3.23)\quad Y_t = a_0\beta + (1-\beta)\; Y_{t-1} + a_1\beta P_{t-1} + v_t$$

where v_t is a random residual different from u_t. Equation 3.23 is fitted to data for the late onion crop.

The model

$$(3.24)\quad Y_2 = a_{24} + b_6X_6 + b_7X_7 + u_{24}$$

where

Y_2 = harvested acreage of late onions in year t

X_6 = harvested acreage of late onions in year t-1

X_7 = season average price received by farmers for late onions in year t-1 expressed as cents per 50 pound bag.

u_{24} = random residual corresponding to v_t in equation 3.23 above.

Fitted

$$(3.25)\quad \hat{Y}_2 = 9460 + \underset{(.0839)}{.7730^*}X_6 + \underset{(15.33)}{37.63^{**}}X_7 \qquad R^2 = .74 \quad s_{\hat{y}} = 4186$$

* significant at the .01 level.
** significant at the .05 level.

The Durbin-Watson statistic (1.80) provides insufficient evidence to reject the hypothesis of serial independence of residuals.

β estimated from b_6 $(1-\beta)$ is .227. Using the formula

(3.26) $(1-\beta)^n \leq e$

derived from equation 3.19 the number (n) of past prices which should be included in order that the approximate proportion of error be less than or equal to a specified amount (e) may be determined. Then for e of .05 twelve past prices should be included in the determination of expected price for late onions. The estimates of β and elasticity of supply obtained for onions are compared with estimates obtained by Nerlove[9] using the above method in Table 3.1.

Table 3.1

A Comparison of Supply Estimates and β Values for Selected Crops

Crop	Coefficient of expectation (β)	Elasticity
Late onions	.23	.271
Cotton	.51	.67
Wheat	.52	.93
Corn	.54	.18

[9]Nerlove, _op_. _cit_., p. 505.

Because of the degree of uncertainty involved, the indication that twelve past prices are included in expected price is realistic from the uncertainty standpoint, however, changes in price level and technology occurring over that period may well make the estimate unrealistic.

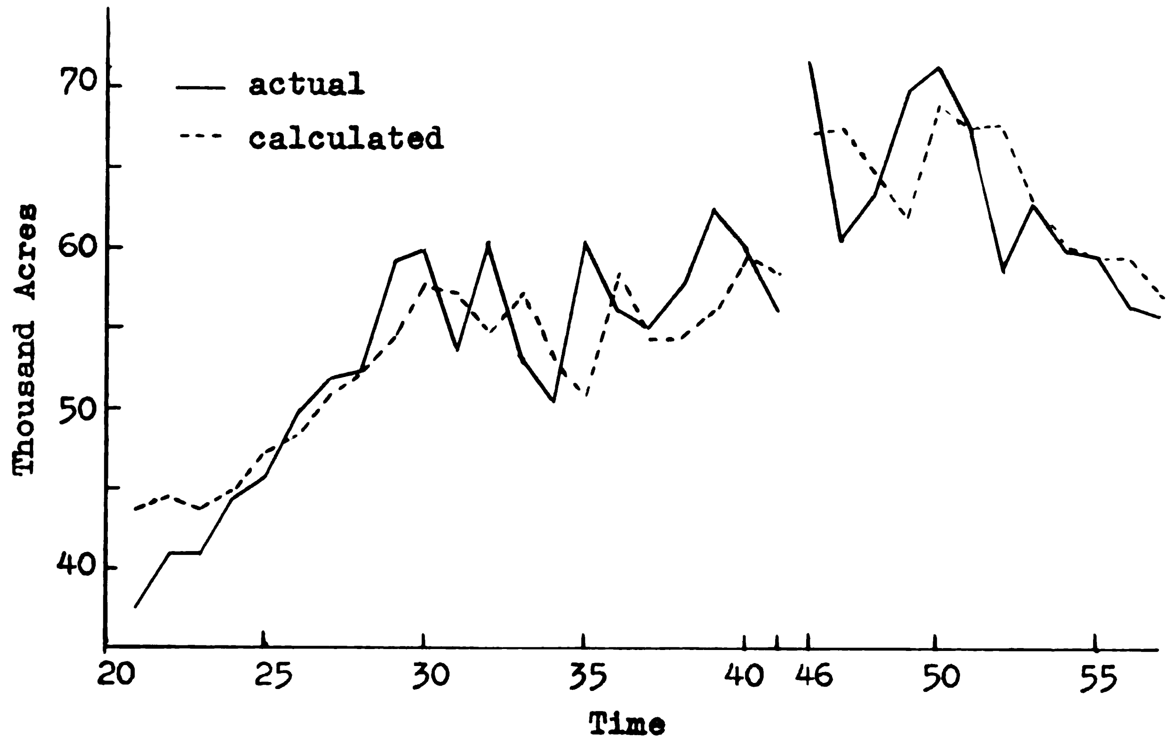
The most serious problem involved in the application of this method is the fact that the harvested acreage probably is not the same as planned acreage in most years. The same limitation applies to the methods presented above, however, it is not as critical to the interpretation as in this case. Even allowing for the discrepencies mentioned, the estimate of elasticity derived using distributed lags may well be more realistic.

A comparison of actual and calculated acreage is presented in Figure 3.

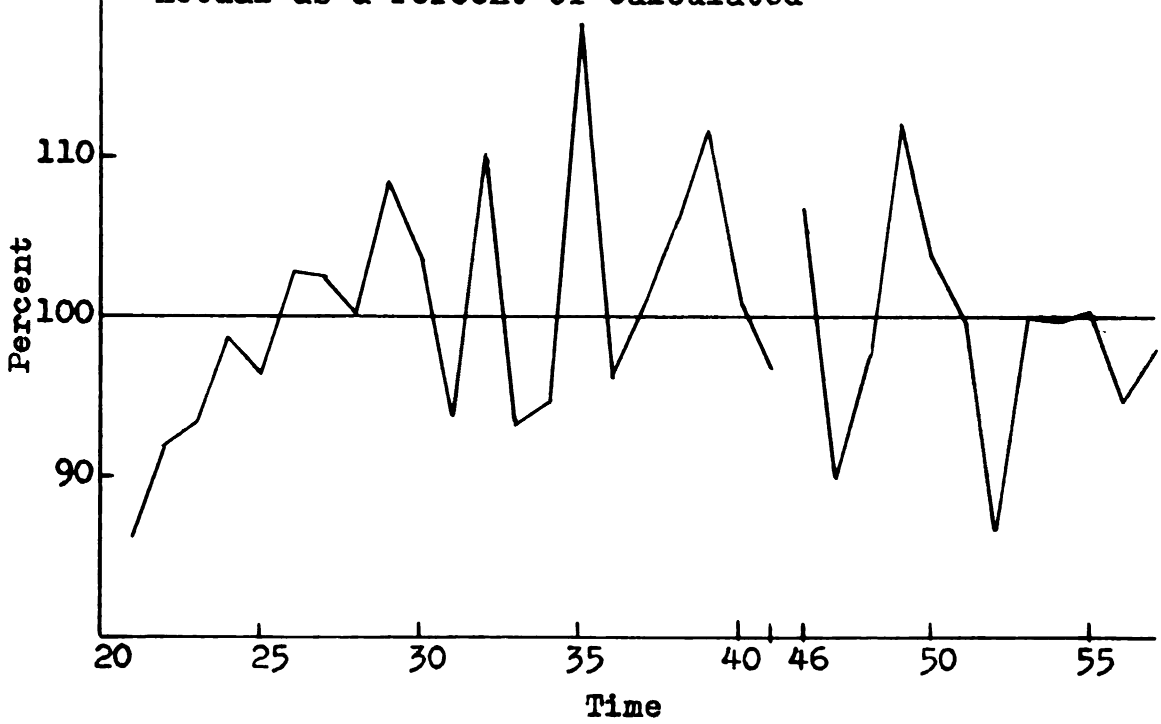
The models presented above consider only response to expected price and price-cost relationship. The limited number of variables considered force some of the variation caused by expectations regarding technology, weather and institutional change to be attributed to the price variable. It cannot be assumed that the variables not included in the analysis are entirely uncorrelated with the included variables. Therefore, estimates based on a very few variables may be biased.

Figure 3

Actual and Calculated Late Onion Acreage
Using the Distributed Lags Model (3.25)



Actual as a Percent of Calculated



It follows that in order to obtain unbiased estimates of the relationships, measures of all relevant expectations must be included. Expectations regarding institutions cannot be measured in a study such as this. The absence of government controls to date and the aggregate nature of this study seem to provide sufficient reason to assume the sum of the institutional expectation effect to be zero. The existence of futures trading in onions is assumed to have no relevant effect. A model including estimates of expectations regarding costs and prices including an estimate of asset fixity is presented. This more complete model, while the prediction performance is less impressive, may provide regression parameters subject to less bias than those estimated based on less information.

The model considered is

$$(3.26) \quad Y_2 = a_{26} + b_{7.1}X_7 + b_8X_8 + b_9X_9 + u_{26}$$

where

Y_2 = acreage harvested in year t

X_7 = price received for late onions in year t-1

X_8 = index of prices paid for onion production in year t-1

X_9 = previous four-year average harvested acreage of late onions.

and the u a random residual.

Price received by farmers in the previous season is used here as an estimate of expected price. A weighted average

(.6, .3 and .1) of three past prices and log of price the previous year proved slightly less effective. Cost of production the previous year is a measure of expected costs of production. Due to the sticky nature of costs it seems reasonable to expect farmers to look to costs in the previous year as an estimate of costs in a given year. Acreage in the previous four years provides an estimate of the fixed asset position of the onion growers, that is, the limits of storage space, land and equipment available. Acreage much larger than the previous four year average is likely to bring lower quality resources into use. The resulting higher per unit cost would indicate that large expansions would be accomplished only when expected prices were very high. On the other hand, a large reduction in acreage would idle specialized equipment and storage space and the land in the eastern and central production areas would be devoted to crops normally considered less profitable than onion production.

Attempts to measure weather and technology, that is, yield expectations were unsuccessful. Use of yield the previous season and yield previous year as a percent of yield two years previous produced nonsignificant regression coefficients with signs contrary to those considered reasonable. Technologic advance being closely related to time its effect becomes a part of b_9 and does not appear explicitly as such.

Weather expectations are likely to be "normal" and, therefore, have no measurable effect on acreage but contributes only to the disturbance term. It will be demonstrated that yield is correlated with price the previous year. If in fact, it is a causal relationship, one would not expect the specific yield the previous year to be closely related to current acreage. Only the general level of yield would be expected to be causally related to acreage.

Equation 3.26 fitted

$$(3.27) \quad \hat{Y}_2 = 12336 + \underset{(18.51)}{17.25}\,X_7 - \underset{(10.32)}{14.09}\,X_8 + \underset{(.1025)}{.8189^*}X_9$$

* significant at the .01 level.

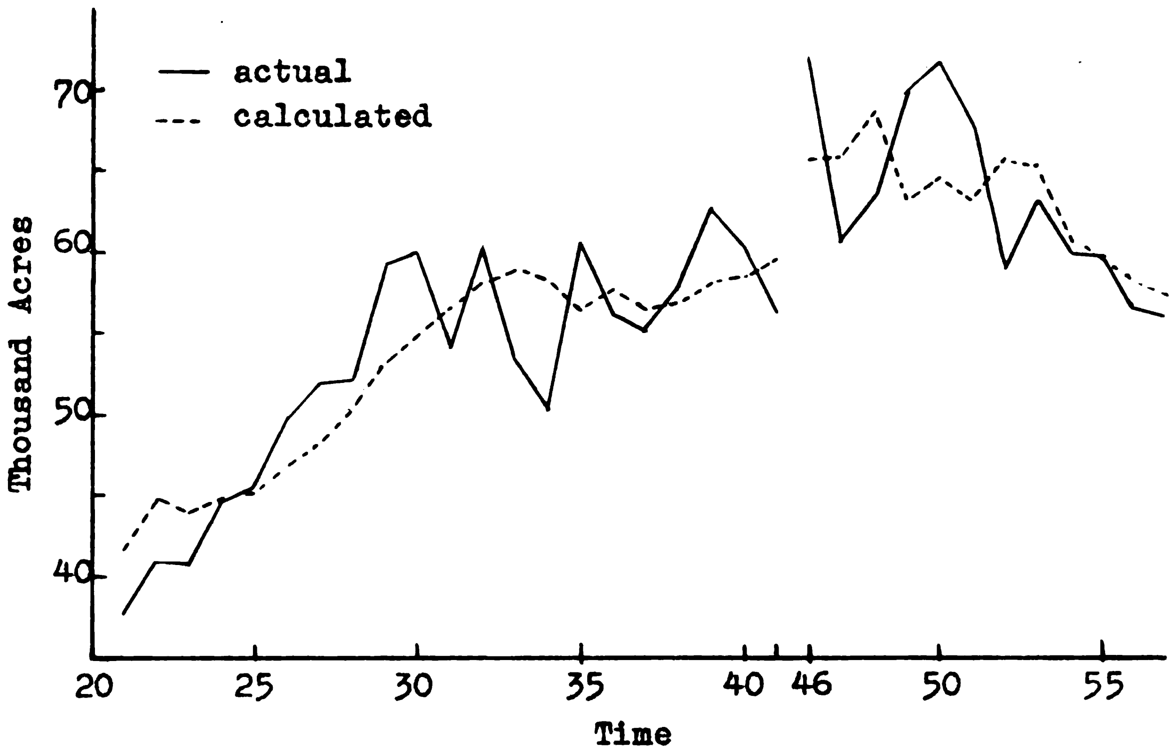
$R^2 = .72 \qquad s_{\hat{y}} = 4414$

The regression coefficients of price and costs are not significantly different from zero at the .10 level. The Durbin-Watson statistic of 1.52 provides insufficient evidence to reject the hypothesis of serial independence of residuals at the .05 level.

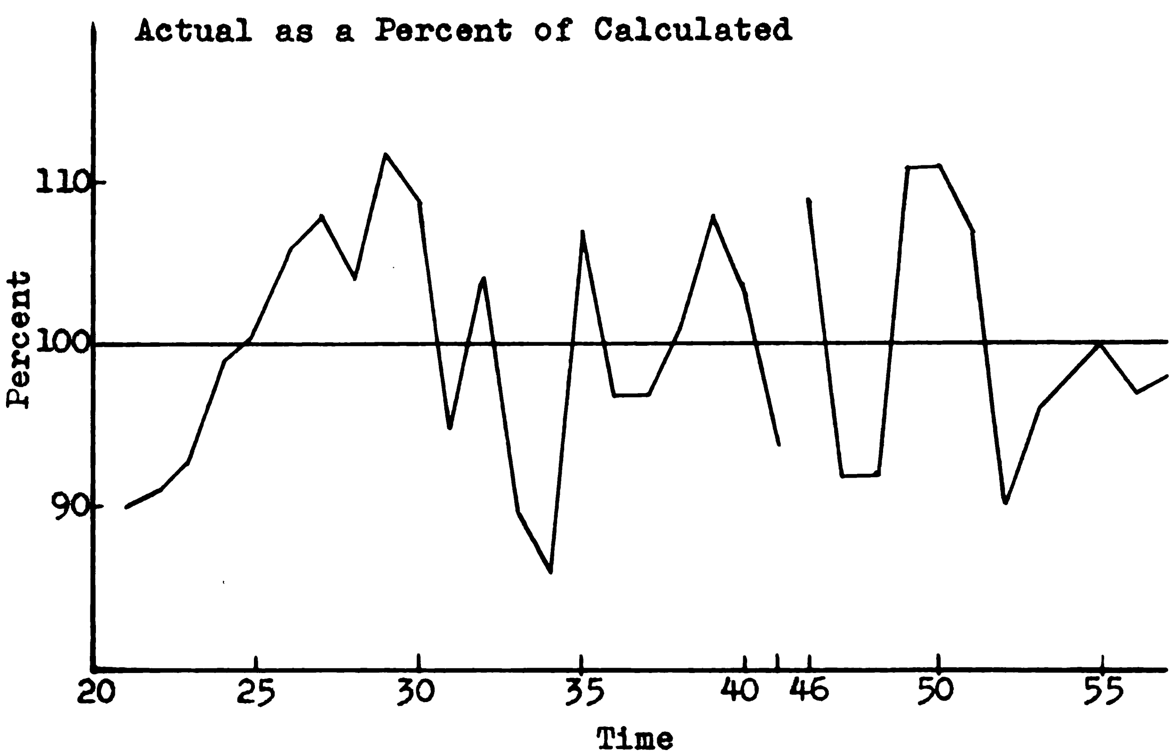
Figure 4 illustrates the performance of the model. Since the tests of significance are only approximate the non-significance of the two parameters does not provide sufficient grounds to reject the relationships indicated. The signs are reasonable and the relationship between the coefficients appear logical.

Figure 4

Actual and Calculated Late Onion Acreage
Using the Special Model (3.27)



Actual as a Percent of Calculated



Yield

It was hypothesized that yield in a given year is determined by technology, weather, quality of land in use and expectations as to costs and prices received. Models presented are:

(3.28) $Y_3 = a_{28} + b_{7.2}X_7 + B_{10}X_{10} + u_{28}$

and

(3.29) $Y_3 = a_{29} + b_{7.3}X_7 + b_{11}X_{11} + u_{29}$

where

Y_3 = United States average yield of late summer onions in year t

X_7 = average price received for late onions in year t-1

X_{10} = USDA yield index for 18 field crops in year t[10]

X_{11} = time, 1920 = 0

and the u's different random residuals.

The price received for onions in the previous season is used as a measure of expected price. The USDA yield index includes measures of overall technology, weather, and perhaps some price response. The yield index is an ex-post measure and cannot be used in a forecasting equation. The yield effect of a weather pattern on onions may be quite different from its effect on the crops included in the index.

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[10] Major Statistical Series of the USDA, Agriculture Handbook No. 118, Vol. 2, USDA, Sept., 1957, p. 50. See Appendix for data.

The yield index is useful only to establish an approximation of the price effect and the correlation between lagged onion price and the yield index ($rY_{3.7}$ = .45) renders its use in this respect questionable.

The trend variable reflects technologic improvement and other factors not included but which exhibit a trend over time. While it explains little, its prediction performance justifies its inclusion.

The variable costs for spraying and dusting, fertilizer and weeding are high and use is likely to be dependent to a certain extent upon the expected price.

The quality of land utilized was expected to be related to the acreage harvested assuming that the poorer land would be taken out of production first when expected price is low. It is also believed that higher onion yields may be obtained after an intertilled crop such as corn because of the reduced weed and disease problem. The two hypothetical relationships, being opposed and reflected in the same variable (acreage harvested), are impossible to separate. Attempts to include acreage as an explanatory variable resulted in regression coefficients close to zero and inconsistent signs. The net effect is assumed to be zero.

Consideration of the cost index yielded signs contrary to those considered reasonable and are not presented. The strong positive trend in both onion yield and the cost index accounts for the unreliable estimate.

The fitted equations

$$(3.30) \quad \hat{Y}_3 = 41.43 + \underset{(.1742)}{.2002}\, X_7 + \underset{(.485)}{4.346^*} X_{10} \qquad R^2 = .78 \quad s\hat{Y} = 43.07$$

$$(3.31) \quad \hat{Y}_3 = 279.14 + \underset{(.1386)}{.3988^*} X_7 + \underset{(.601)}{6.709^*} X_{11} \qquad R^2 = .84 \quad s\hat{Y} = 36.34$$

* significant at the .01 level.

The Durbin-Watson statistic for equation 3.31 of 1.49 indicates insufficient evidence to reject the hypothesis of serial independence at the .05 level.

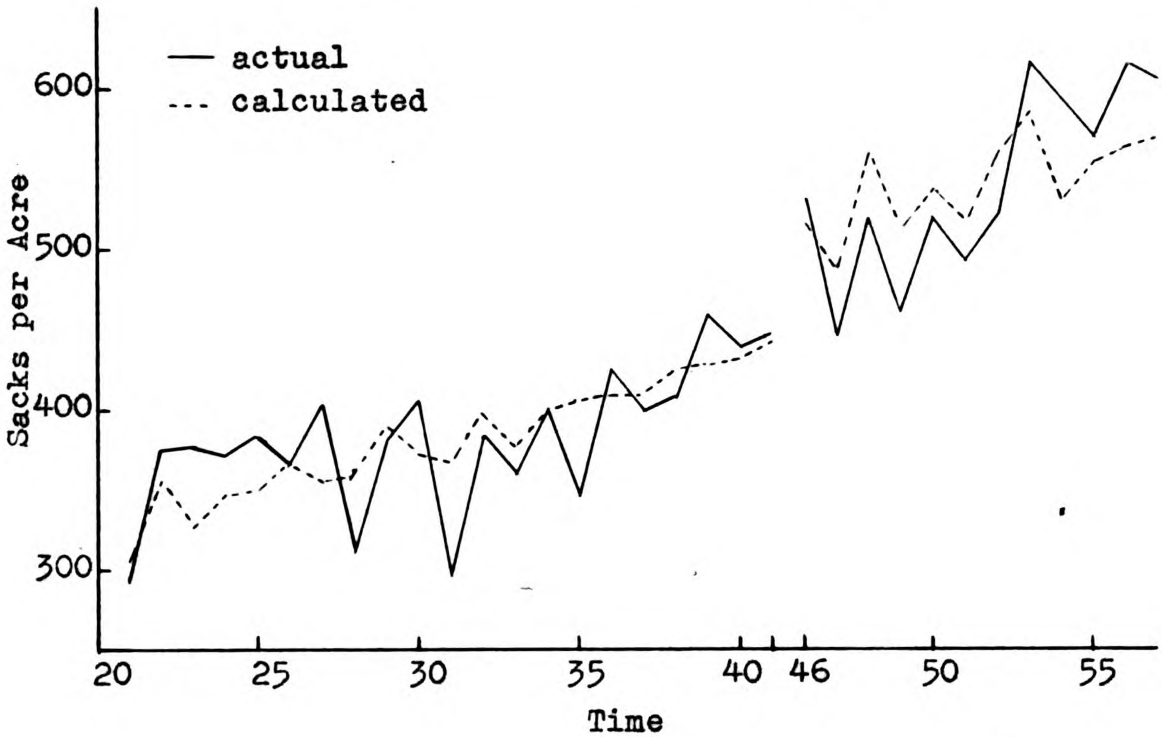
Because of the better statistical fit involved and the problems involved in use of the yield index model 3.31 is considered the better estimate. Actual and yield calculated from 3.31 are presented in Figure 5. Price elasticity of yield computed from 3.31 is .083.

Unharvested Production

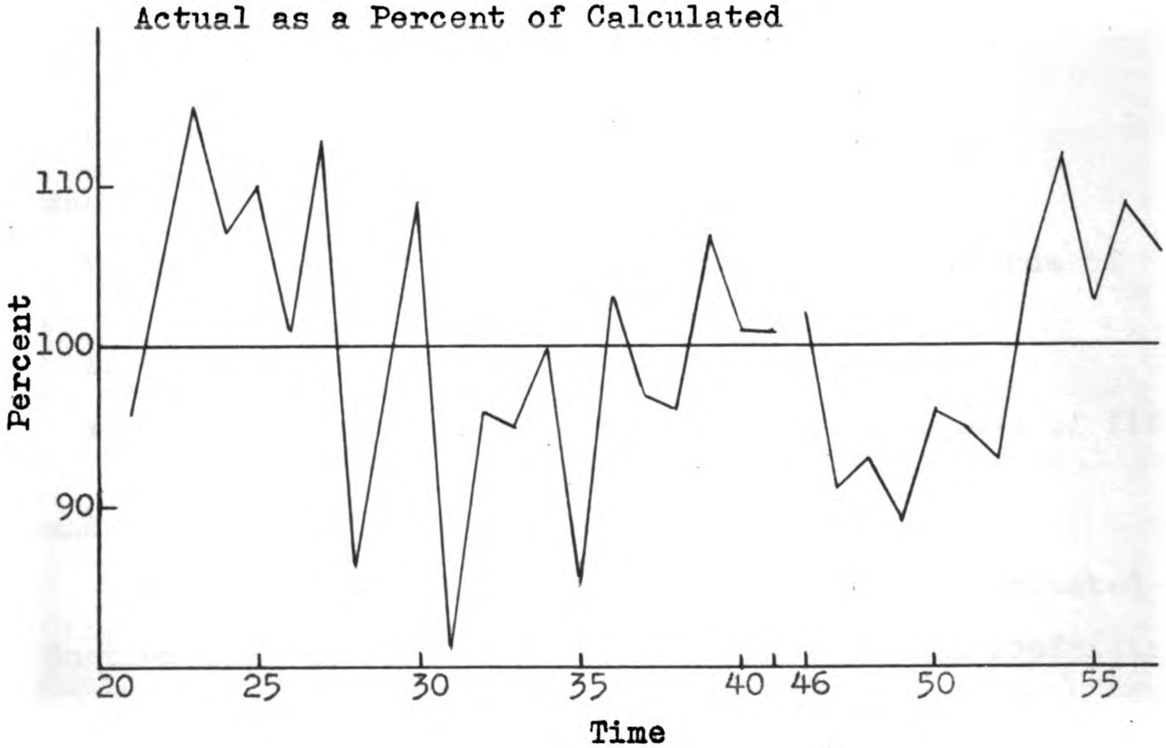
Abandoned production has been of minor importance averaging approximately one percent of the late onion crop in the period since 1928. Data on quantity dumped from storage are not available. Data regarding unharvested production are not available prior to 1928. Actual abandonment occurred in only 12 of the 25 years from 1929-41 and 1946-57. The production of the late onion crop is rather widely separated and harvesting dates vary considerably. This plus the fact that a large portion of the crop is stored on farms makes a market glut unlikely.

Figure 5

Actual and Calculated Late Onion Yield
Per Acre Using Model (3.31)



Actual as a Percent of Calculated



At harvest the size of the late crop is quite uncertain and no reliable estimate of the size or timing of the early spring crop is available. The seasonal pattern indicates a price rise from harvest into January. It has already been shown that the within year variation in onion price is very large. Under these circumstances, some farmers may harvest when costs appear to exceed price on the chance that the crop estimate is wrong or that the early crop will be smaller or later than normal.

Suits and Koizumi estimated unharvested production for the total onion crop using current price, wages for farm labor and quantity available for harvest. Price and unharvested quantity being mutually determining variables they employed the method of instrumental variables to estimate the relationship.

The unharvested production model

(3.32) $\text{Log } Y_4 = a_{32} + b_{11.1}X_{11} + b_{12}X_{12} + u_{32}$

where

Y_4 = quantity not harvested expressed in thousands of fifty pound sacks

X_{11} = time, 1920 = 0

X_{12} = quantity available for harvest in thousands of fifty pound sacks

and the u a random residual.

Use of wage rates in the explanation of unharvested production for the late crop produced a regression coefficient with a sign contrary to that which would be expected. The strong positive trend in wage rates during the period considered corresponds to the upward trend in total demand for onions and renders the relationship between wage rates and unharvested production indeterminate. Use of price received by farmers during harvest did not improve the estimate sufficiently to justify its inclusion. While the signs of the regression coefficients for actual price and price deflated by wage rates were appropriate they were very close to zero and not significant at the .10 level. The growers apparently base their estimate of the price they expect to receive on crop size. The particular marketing pattern which determines price at harvest is of much less concern than crop size in the determination of quantity to be abandoned.

The model is fitted as if quantity available for harvest were predetermined. It is reasoned that abandonment is based on the situation as it exists at harvest and not upon what growers expected it to be when the crop was planted. Usefulness of the model should not be hampered by this procedure. Abandonment has usually been on an area basis indicating that yield may be a factor, however, no relationship between yield and unharvested production could be found at the aggregate level.

Unharvested production is fitted in logs to allow for an increasing rate of abandonment as crop becomes very large.

The equation fitted to data for 1929-41 and 1946-57 by the method of least squares

$$(3.33)\quad \text{Log } \hat{Y}_4 = -\ 2.96 - \underset{(.042)}{.179^*}X_{11} + \underset{(.064)}{.297^*}X_{12} \qquad R^2 = .45,\ s\hat{y}_4 = .96$$

* significant at the .01 level.

The Durbin-Watson statistic of 1.79 indicates insufficient evidence to reject the hypothesis of serial independence of residuals at the .05 level.

Actual and calculated unharvested production are compared in Figure 6.

Production

It has already been demonstrated that yields and acreage are responsive to some of the same factors and at this point will be considered together in a production model. Suits and Koizumi employed this approach in their study of the dynamics of the onion market. They predicted the amount available for harvest using farm price of onions and an index of prices paid in the previous year plus a trend variable. The regression parameters were fitted by least squares to first differences in this form:

$$(3.34)\quad \Delta \log Y_5 = b_{7.4}\, \Delta \log X_7 + b_{8.1}\, \Delta \log X_8 + a_{34} + u_{34}$$

where

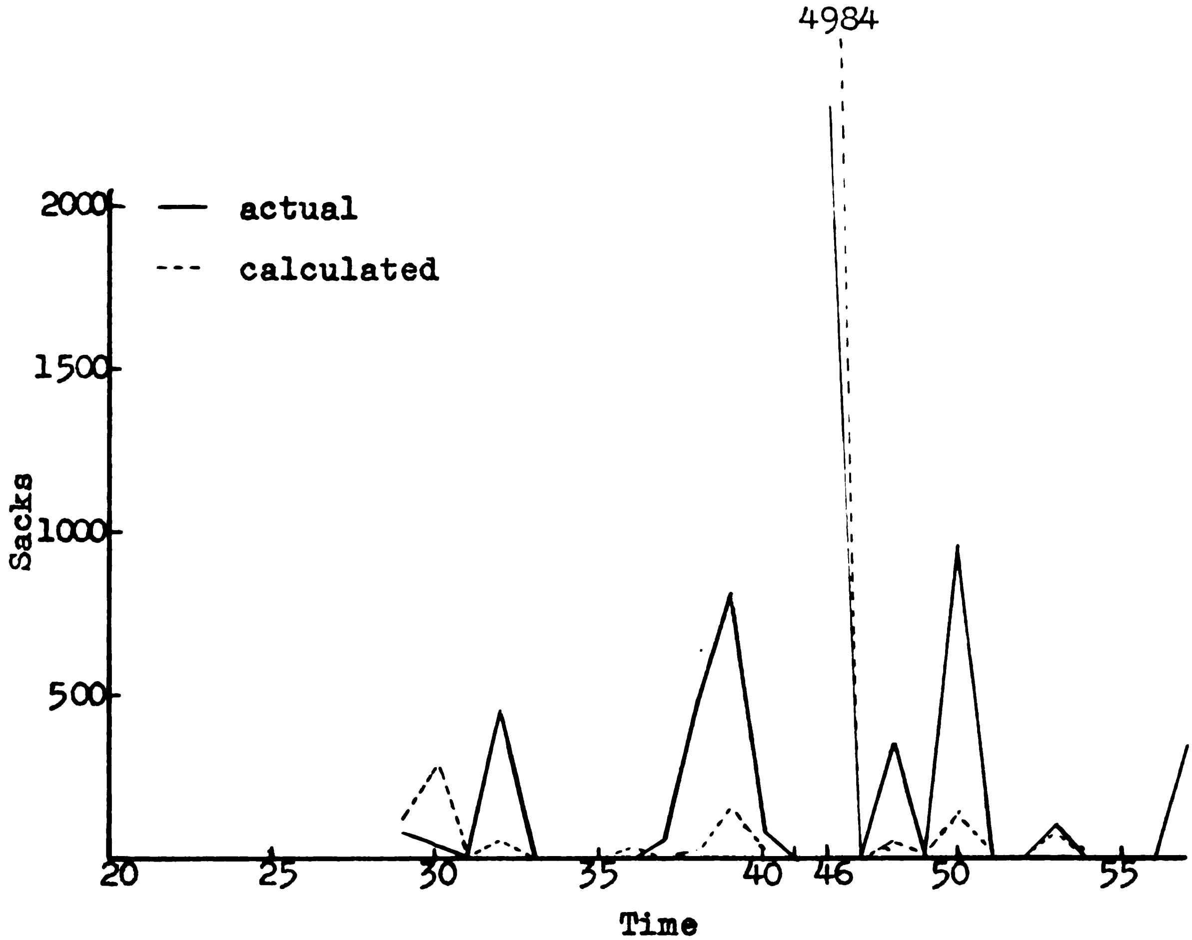
Y_5 = production of late onions in year t in thousands of 50 pound sacks

X_7 = season average price received by farmers for late onions in year t-1

X_8 = index of prices paid for onion production in year t-1

Figure 6

Actual and Calculated Unharvested Late Onion Production Using Model (3.33)



Their supply schedule is

(3.35) $\text{Log } Y_5 = b_{7.4} \log X_7 + b_{8.1} \log X_8 + a_{34}t + a_{35} + u_{35}$

where t = time in years.

The a_{35} term was obtained by substitution of the means of the undifferenced data over the period. The authors state that the parameters are fitted using first differences to 1) avoid bias which may arise from auto-correlation of residuals, and 2) because the prices paid index used was only a crude measure of production costs. They contend that due to the inflexibility of production costs an attempt to measure price elasticity of supply from undifferenced prices would lead to spurious results. They report R = .73 apparently using data for the years 1924-51.

The above described model is applied to the late onion crop using 1921-41 and 1947-57 data. The first difference equation (3.34) fitted

(3.36) $$\Delta \text{Log } \hat{Y}_5 = \underset{(.0398)}{.1613^*} \Delta \text{Log } X_7 - \underset{(.2474)}{.3308^{**}} \Delta \text{Log } X_8 + .0101$$

$R^2 = .36$
$s\hat{y} = .0619$

* significant at the .01 level.

** significant at the .20 level.

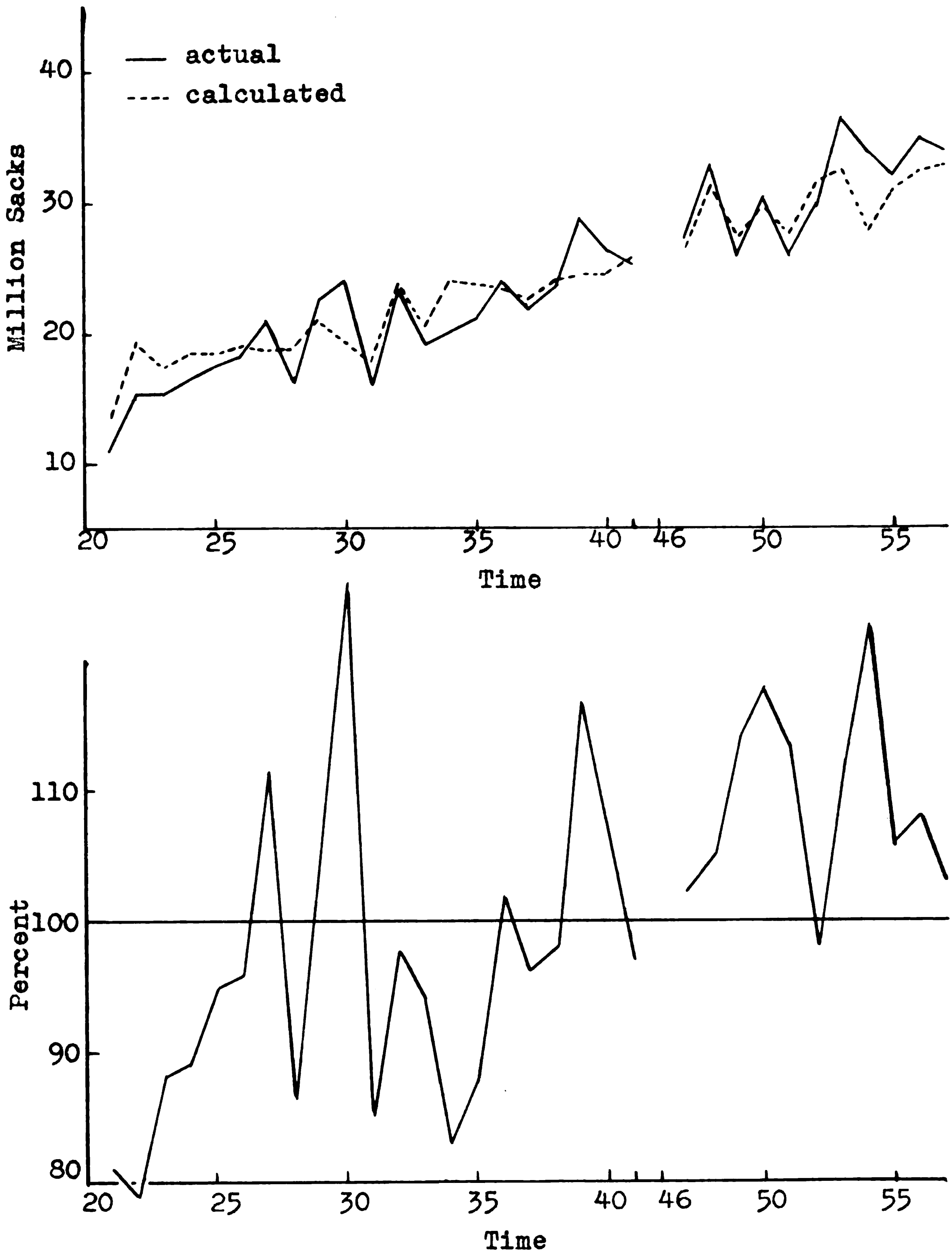
Then the supply schedule (3.35)

(3.37) $$\text{Log } \hat{Y}_5 = .1613 \text{ Log } X_7 - .3308 \text{ Log } X_8 + .0101\ t + 4.4860$$

A comparison of actual and calculated production is provided in Figure 7. The coefficient of determination between actual and calculated production is .78. Figure 7 indicates rather

Figure 7

Actual and Calculated Late Onion Production
Using Model (3.37)



poor performance in the post-war period and the existence of a positive trend in the residuals.

This method indicates a price elasticity of production of .161.

The reasoning behind the use of this form being less than convincing to the author, the following model is considered.

$$(3.38) \quad Y_5 = a_{38} + b_{7.5}X_7 + b_{8.2}X_8 + u_{38}$$

3.38 fitted to data for the years 1921-41 and 1947-57

$$(3.39) \quad \hat{Y}_5 = 13580 + \underset{(9.91)}{28.41^*}X_7 - \underset{(29.25)}{36.89}\,X_8 + \underset{(56.1)}{605.9^*}t \qquad R^2 = .90 \quad s\hat{y} = 2184$$

* significant at the .01 level.

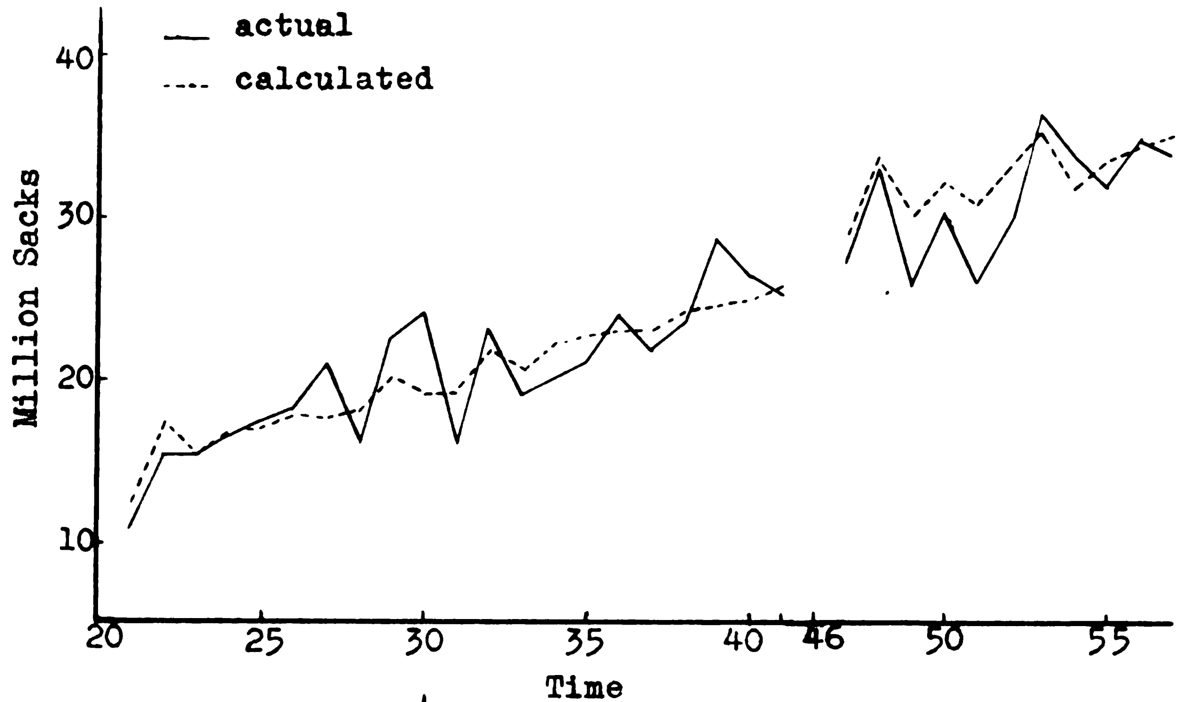
The Durbin-Watson statistic of 2.14 provides insufficient evidence to reject the hypothesis of serial independence at the .05 level.

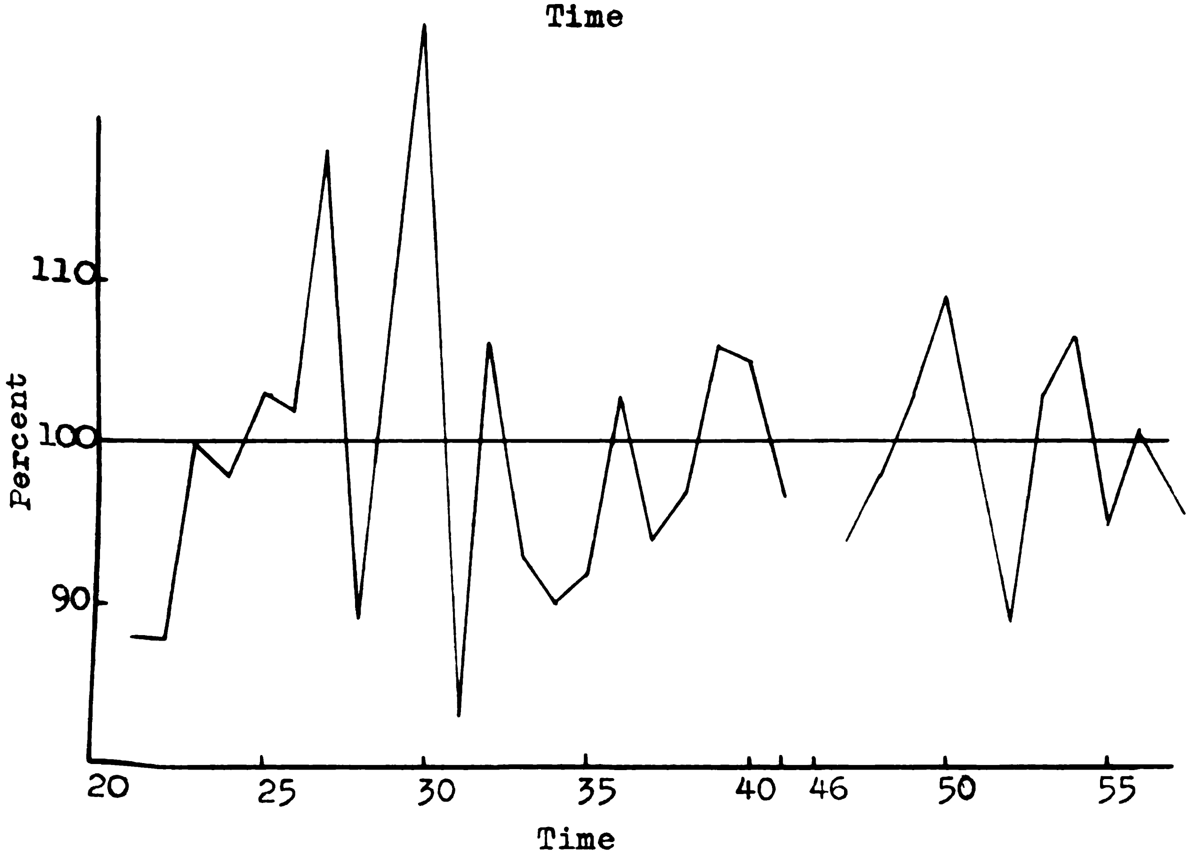
The price elasticity of supply indicated by equation 3.39 is .110. Actual and calculated production are compared in Figure 8. It is apparent that model 3.38 provides the better statistical fit. There is no evidence that the serial correlation argument for model 3.35 is valid. The elasticity estimates are very similar and provides no criterion for judgment.

While the statistical fit obtained in the latter model appears convincing, the high intercorrelations between cost and trend (r = .78) and between quantity and trend (r = .94)

Figure 8

Actual and Calculated Late Onion Production
Using Model (3.39)





cast some doubt upon the usefulness of the model.

The performance of the single equation (3.39) is superior to a combination of the special acreage (3.27) and yield (3.31) estimates.

CHAPTER IV

Some Concluding Remarks

Four models have been constructed to predict late onion acreage on the basis of information available prior to planting time. The models represent methods most used in recent supply analyses. The methods are termed 1) conventional, 2) Hicksian, 3) distributed lags, and 4) a special model constructed for the late onion crop. Yield, unharvested production, and production were analyzed using methods in the latter category.

The percent of variance explained by and estimated price elasticity of supply obtained from each of the models are presented in Table 4.1

The conventional model measures the influence of deflated or "real" price received the previous year. The Hicksian model considers an expected "real" price effect while the distributed lags model measures the effect of expected actual price and provides a means to determine expected price. The special models measure adjustment to price received the previous year, costs the previous year, and considers asset fixity. The four acreage models do not measure quite the same relationships and are not strictly comparable. The "special" acreage, yield, and production models are comparable and the sum of the separately

Table 4.1

Variance Explained by and Elasticity Estimates from Several Late Onion Supply Models

Model	Percent of Variance Explained	Estimated Price Elasticity at the mean
<u>Harvested Acreage</u>		
3.5 Conventional	79	.125
3.17 Hicksian	75	.042
3.25 distributed lags	74	.271
3.27 special	72	.028
<u>Yield</u>		
3.31	84	.083
<u>Unharvested Production</u>		
3.33	45	-
<u>Production</u>		
3.39	90	.110

estimated acreage and yield elasticities is approximately equal to the estimated price elasticity of production.

The range of elasticity estimates is reasonable. Cromarty's estimates of crop supply elasticities range from .13 for wheat to .52 for flue tobacco. It is logical to expect a low supply elasticity for onions because of the high degree of uncertainty involved in onion prices. The difference between the estimates derived from the conventional model measures the effect of changes in real prices and the special model considers actual prices. The special model indicates a cost elasticity of approximately - .026. There is no method by which the separate price and cost elasticity estimates may be combined to compare with the real price based estimate. Nevertheless it is evident that the estimates are not as far apart as the first glance would indicate.

The Hicksian model may be discounted on the grounds that "by definition" it measures little not measured by price the previous year. It amplifies the movements by a constant amount and since the same changes are enlarged the elasticity estimate is bound to be lower than the conventional model. The result is only to compound and enlarge the errors involved in the use of lagged prices.

The use of distributed lags provides what may be termed a long run elasticity estimate. It represents an estimate of the "total" adjustment, that is, the effect given the time necessary to make all the adjustments a permanent price change would call for. It might well provide the best elasticity estimate of the four models given a contract or guaranteed price.

In acreage terms the special model (3.27) indicates that a one cent change in actual price would cause a change of 17 acres in the same direction and a one point change in the cost index would bring about a 14 acre change in the opposite direction. The distributed lags model indicates that a one cent change in expected price would bring about a total response of approximately 165 acres in the same direction.

General Problems

The major problems involved in this study as in nearly all supply analyses are: 1) actual acreage and yield are only crude approximations of intentions, 2) expectations are difficult to ascertain, and 3) a strong positive trend over time exists in many of the relevant variables. These problems are discussed more fully in the following paragraphs.

It was necessary to use a harvested acreage series because of the lack of data on planted acreage prior to 1946. The variable percentage of onion acreage abandoned during the growing season because of weather conditions reduces the accuracy of harvested acreage as a measure of intentions. Figure 9 indicates the correspondence between planted and harvested acreage for the years 1946-1957. The close fit around a 45° line indicates that the distortion is less than one might expect. The difference, being relatively constant, does not affect the relationship to the explanatory variables. The possibility that farmer's intentions to plant as of March 1, reported by the USDA on March 10, might influence planting decisions is also considered. Figure 10 indicates that the relationship between March 1 intentions and planted acreage approaches a one to one relationship for 1946-1957 and does not support the hypothesized reaction that plantings are influenced by announced intentions unless the USDA figures are adjusted to allow for the reaction.

Another aspect of the data problem is the redefinition mentioned in Chapter III. It may be serious; however, there is no means by which its effect may be evaluated. Since onions are a minor crop the collection of statistics is likely to receive less attention than the more important crops. Data for the years since 1946 appear to be more complete and should provide the basis for a more accurate and complete study in the future.

The highly uncertain nature of the late onion prices increases the difficulty in discovering a measure of expected price. Use of price the previous year poses a serious question. A fairly regular two-year price cycle existed until 1952. It is difficult to imagine a well-informed grower not being aware of the unprofitability of basing short time adjustments on price the previous year. The fact that a cycle did exist over an extended period suggests that adjustments were made in response to price the previous year. The disappearance of the cycle in recent years may be the result of awareness on the part of growers of its existence. The performance of the models has been good for the recent years, indicating that the relationships have not changed and that the apparent cycle may have been due to factors other than prices received.

The problem of trend in the variables is common. The use of first differences or relatives renders the problem less obvious but does little to mitigate it. Undifferenced data and a time variable were used in the special models recognizing that the use of a time variable admits omission of certain causal variables which could not be included as such.

General Conclusion

One may conclude that the late onion supply is responsive to prices and costs. The form in which the data are analyzed assumes complete reversability of the relationships. Evidence to the contrary was insufficient to warrant rejection of the assumption. The estimated elasticities are low contrary to the estimates made in some non-empirical studies such as Cochrane's article.[1] He estimated

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[1]Willard W. Cochrane, "Conceptualizing the Supply Relation in Agriculture," Journal of Farm Economics, Vol. 27, No. 5, Dec. 1955, p. 1164.

Figure 9

Planted Acreage as an Indicator of Harvested Acreage

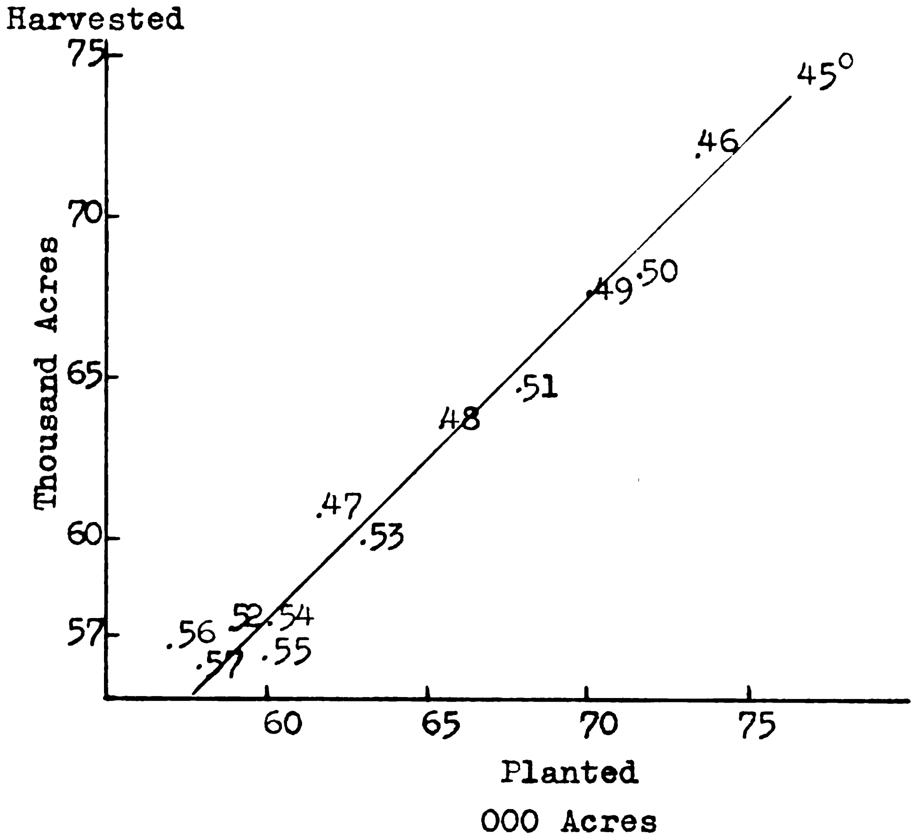
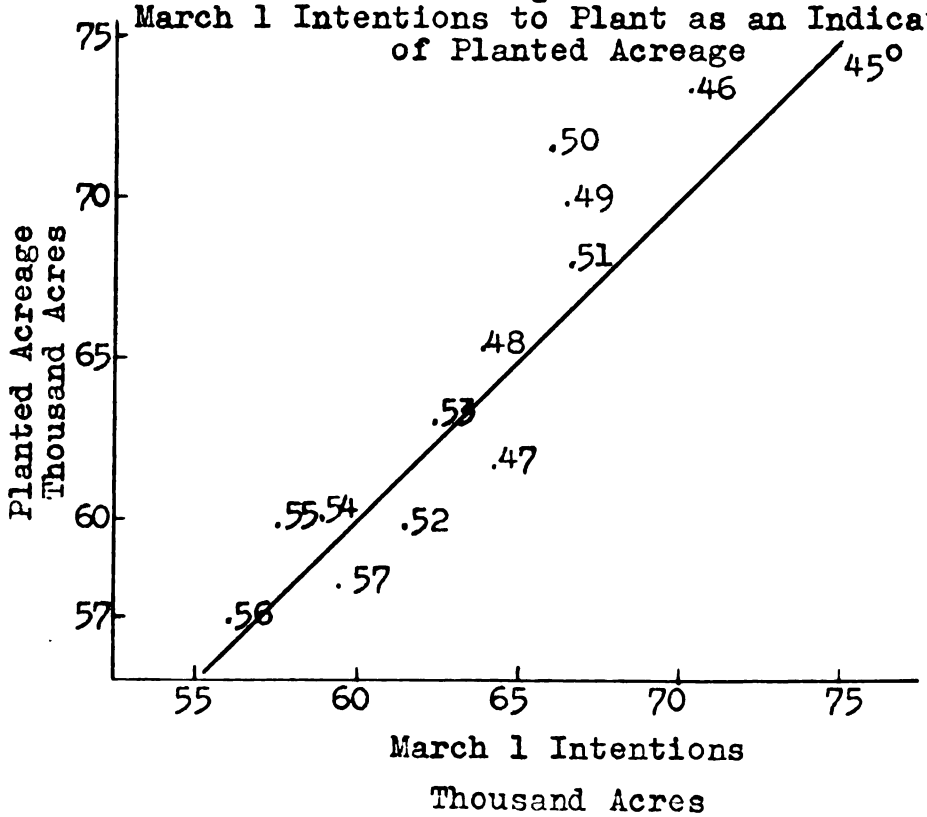


Figure 10

March 1 Intentions to Plant as an Indicator of Planted Acreage



a high supply elasticity (1.0 - 2.0) for certain vegetable crops and specifically for onions, tomatoes, and cabbage. Onion price movements have been more independent of the general price level than many other crops. This fact lends support to the estimates of price effects in this study.

Application

The usefulness of the models for prediction is limited. The standard error of the production estimate is approximately six percent of the recent production level. That is, if the relationships which existed in the period studied continue, the production estimate plus or minus six percent would be expected to include the actual production with a probability of 0.68. Prior to planting, the estimates may well be useful. However, once the crop is planted and weather effects have begun the models can only provide a level from which subjective modifications can be made as required.

Suggested Further Study

The most important area for study in supply analysis at this point seems to be in the area of expectations. Methods presently in use depend on an estimate of expectations about which very little is known. A study of the farmers decision making process could be aimed toward the development of an empirically useful theory of expectations. Analysis of data from the Interstate Managerial Survey presently in process at Michigan State University[2] should provide a basis for the development of a testable theory.

Another area which might provide worthwhile results is the construction of a supply schedule using programming of "model" farms representing homogeneous production areas. An application of this method is the Knudtson and Cochrane study discussed in Chapter II. Errors in time series data would be avoided. Its usefulness would be primarily in the explanation of relationships rather than prediction. It would contribute nothing to the knowledge of price expectation determination; in fact, it would depend upon an "outside" estimate of expectations to be of any use for prediction.

A programming study would require a detailed cost study for onions. The last detailed cost study for Michigan onion production was conducted in 1934-1936 and is no longer useful for a programming study.

It would also be of interest to budget hypothetical farms over time using various expectation models and adaption strategies to determine this relative profitability. Hypothetical forecasts made at planting time could be used to determine the farm organization and then actual prices could be used in the evaluation.

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[2]Earl J. Partenheimer, Expectation Models Used by Farmers (tentative title), work in progress at Michigan State University, 1958.

Studies such as mentioned above would be useful to those interested in supply analysis but could be of special use in the evaluation of outlook work. In addition to providing a guide as to the type of information which would be most helpful to farmers they could be used to provide the price forecaster with error limits, within which his forecast would be helpful, and, outside which the forecast would be detrimental to those who believe him and adjust accordingly.

APPENDIX

Data Series Utilized

DEFINITIONS

Y_1 = Harvested acreage of late onions expressed as percentage of previous year.[1]

Y_2 = Harvested acreage of late onions.

Y_3 = U. S. average yield per acre of late onions.

Y_4 = Unharvested production of late onions in thousands of 50 pound sacks.

Y_5 = Production of late onions available for harvest in thousands of 50 pound sacks.

X_1 = U. S. average price received by farmers for late onions the previous year (cents per 50 pound sack) divided by an index of prices paid by farmers in onion production the previous year times 100.[2]

X_2 = U. S. average price received by farmers for late onions two years previous (cents per 50 pound sack) divided by an index of prices paid by farmers two years previous in onion production times 100.

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[1]Data involving late onions for 1918-1941 were obtained from USDA general publications for commercial vegetables (provided by Statistical and Historical Research Branch, A.M.S.). For 1939-1949 from Commercial Vegetables for Fresh Market, Revised Estimates, Statistical Bulletin 126, USDA, 1953, for 1949-1955 from Vegetables for Fresh Market, Revised Estimates, Statistical Bulletin 212, USDA, 1957; and for the 1956 and 1957 crops from Vegetables for Fresh Market, Annual Summary, 1957.

[2]The index of prices paid in onion production was constructed using USDA indexes of prices paid by farmers for items used in production (1910-14 = 100) as reported in Agricultural Prices, January 15, 1957 and Agricultural Statistics, 1950, with individual series weighted as follows:

Motor vehicles	.15
Farm machinery	.07
Farm supplies	.08
Building and fencing materials	.05
Fertilizer	.15
Wage rates for hired farm labor	.50

X_3 = U. S. average price received by farmers for late onions the previous year (cents per 50 pound sack) divided by an index of prices received by farmers for all crops the previous year times 100.[3]

X_4 = U. S. average price received for late onions two years previous (cents per 50 pound sack) divided by an index of prices received by farmers for all crops two years previous times 100.

X_5 = Expected price from equation 3.15 divided by an index of prices paid in onion production the previous year times 100.

X_6 = Harvested acreage of late onions the previous year.

X_7 = U. S. average price received by farmers for late onions in the previous year in cents per 50 pound bag.

X_8 = Index of prices paid in onion production the previous year.[4]

X_9 = Previous four year average harvested acreage.

X_{10} = Index of yield of 18 field crops.[5]

X_{11} = Time 1920 = 0.

X_{12} = Production available for harvest. Same as Y_5.

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[3]USDA index of prices received by farmers for all crops (1910-14 = 100). Major Statistical Series of the USDA, Agriculture Handbook No. 118, Vol. 1, USDA, 1957.

[4]See footnote 2, p. 66.

[5]USDA index of yield per harvested acre of 18 field crops (1947-49 = 100). Major Statistical Series of the USDA, Agriculture Handbook No. 118, Vol. 2, USDA, 1957, p. 50.

	Y_1	Y_2	Y_3	Y_4	Y_5
	%	Acres	50-lb. sacks	Thousand 50-lb. sacks	Thousand 50-lb. sacks
1921	90.0	37,650	294		11,075
1922	108.8	40,970	374		15,336
1923	99.7	40,840	377		15,337
1924	108.8	44,450	371		16,501
1925	102.5	45,580	384		17,481
1926	109.2	49,790	365		18,181
1927	104.4	51,970	403		20,923
1928	100.5	52,210	310		16,196
1929	113.5	59,240	380	83	22,488
1930	101.2	59,950	406	43	24,308
1931	89.9	53,870	298	0	16,028
1932	112.3	60,520	384	461	23,248
1933	88.3	53,420	360	0	19,212
1934	94.3	50,380	400	0	20,114
1935	120.0	60,470	348	0	21,058
1936	92.9	56,190	424	0	23,850
1937	97.8	54,950	398	64	21,856
1938	105.1	57,750	408	492	23,512
1939	108.7	62,760	459	815	28,796
1940	96.2	60,380	438	90	26,432
1941	93.3	56,350	447	0	25,181
1946	107.6	71,880	531	2,305	38,177
1947	84.5	60,710	447	0	27,140
1948	104.6	63,490	519	368	32,929
1949	110.1	69,900	460	0	30,959
1950	102.4	71,600	520	962	35,308
1951	94.7	67,810	492	0	31,078
1952	86.9	58,900	520	0	29,678
1953	107.0	63,050	616	100	36,518
1954	95.3	60,100	592	0	33,706
1955	99.5	59,800	570	0	32,084
1956	94.6	56,570	616	0	34,856
1957	96.3	55,960	606	348	33,882

	X_1	X_2	X_3	X_4	X_5
1921	23	72	21	62	12
1922	103	23	132	21	268
1923	47	103	51	132	27
1924	65	47	67	51	90
1925	55	65	57	67	49
1926	60	55	61	57	65
1927	44	60	53	61	35
1928	40	44	49	53	37
1929	77	40	89	49	128
1930	39	77	48	89	25
1931	26	39	36	48	19
1932	73	26	135	36	151
1933	24	73	47	135	10
1934	61	24	90	47	122
1935	59	61	69	90	61
1936	49	59	57	69	44
1937	35	49	40	57	27
1938	49	35	55	40	66
1939	39	49	66	55	34
1940	33	39	54	66	29
1941	42	33	62	54	50
1946	61	42	81	51	88
1947	25	61	31	81	14
1948	74	25	89	31	200
1949	29	74	39	89	17
1950	43	29	65	39	58
1951	24	43	34	65	16
1952	44	24	60	34	75
1953	55	44	80	60	68
1954	14	55	23	80	07
1955	25	14	41	23	39
1956	27	25	46	41	29
1957	25	27	43	46	25

	X_6	X_7	X_8	X_9	X_{10}
1921	41,830	50	216	38,500	71.4
1922	37,650	160	156	39,013	74.7
1923	40,970	69	148	39,715	75.1
1924	40,840	104	159	40,323	74.4
1925	44,450	90	164	40,978	74.5
1926	45,580	100	166	42,960	75.1
1927	49,790	73	166	45,165	77.6
1928	51,970	66	164	47,948	78.4
1929	52,210	127	166	49,888	74.0
1930	59,240	65	167	53,303	69.6
1931	59,950	41	161	55,843	75.9
1932	53,870	101	138	56,318	74.8
1933	60,520	27	115	58,395	68.2
1934	53,420	64	105	56,940	60.0
1935	50,380	68	116	54,548	75.7
1936	60,470	59	120	56,198	64.2
1937	56,190	43	124	55,115	84.4
1938	54,950	65	134	55,498	83.2
1939	57,750	53	136	57,340	83.8
1940	62,760	44	133	57,912	87.6
1941	60,380	56	133	58,960	89.5
1946	66,790	164	268	66,275	97.7
1947	71,880	70	285	68,658	92.2
1948	60,710	233	315	69,522	108.6
1949	63,490	99	338	65,718	99.2
1950	69,900	146	339	66,495	102.8
1951	71,600	80	337	66,425	101.7
1952	67,810	160	368	68,200	107.1
1953	58,900	213	390	67,052	107.1
1954	63,050	56	395	65,340	108.4
1955	60,100	99	393	62,465	118.1
1956	59,800	108	397	60,462	122.7
1957	56,570	104	410	59,880	

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