STRUCTURE OF THE U.S. AND WEST TEXAS EARLY SUMMER ONION MARKETS

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In recent years, producers in West Texas have sought alternatives to traditional field crops in an effort to maintain or increase farm income. Declining groundwater supplies available for irrigation and sharply increasing fuel costs have served to reduce returns from traditional field crops. Vegetables, which offer much higher average returns per acre, are one alternative to field crops. However, production of vegetable crops introduces some difficult problems. The price of most vegetables is very erratic from season to season and often within the same season. Though on the average the income received per acre from vegetables is much higher, the risk of loss due to low prices for vegetables is also much higher.

The study was undertaken to specify and estimate the structural relationships underlying the market for an important vegetable crop in the West Texas area so that the factors influencing prices could be identified and evaluated. The analysis is based on econometric models which provide a quantitative measure of the price-determining process.

In 1975, 5,300 acres of onions, which accounted for 24 percent of the state's acreage, were harvested in West Texas. Onions accounted for 20 percent of the vegetable acreage in West Texas and ranked second to potatoes in acreage harvested. The average price received by farmers for onions in 1975 was $17.30 per hundredweight (cwt), the highest on record, yielding a gross value of $24.3 million. The average farm price for onions in West Texas during the period 1960-1975 was much lower — $5.98 per cwt. The West Texas farm price for onions has varied as much as 268 percent from one year to the next [7, p. 27].

GEOGRAPHIC LOCATION OF ONION PRODUCTION

Onions are produced in many regions of the United States, as are most vegetables. Because of the wide geographic dispersion of production, vegetables are harvested in various time periods throughout the year and have been classified by the USDA into seasonal categories based on harvest period. Onions fit into the following four seasonal categories.

Seasonal Category	Harvest Period
Early Spring	April 1 to May 15
Late Spring	May 16 to June 30
Early Summer	July 1 to August 15
Late Summer	August 16 to September 30

No onions are produced in the U.S. from October 1 to March 31 of each year. The market during this period of no production is supplied from stored onions that were harvested in late summer.

Early summer onions are produced in New Mexico, New Jersey, Washington, and West Texas and go into the fresh market. Annual production averaged 2,729 thousand cwt during 1960-1975 which represented 9.4 percent of the total market. West Texas accounted for about 45 percent of the onions produced during the early summer season, although its percentage share of this market ranged from 34 to 56 percent during the 1960-1975 period. Onions are produced in West Texas in both the High Plains and Trans-Pecos areas, most of the acreage being in Deaf Smith, Castro, Pecos, Reeves, Culberson, and Presidio Counties.

The national onion market is actually a group of markets separated by seasonal and regional differences. The regional markets are affected by production in other regions during the same season and by the overlapping of production from other seasonal categories at the beginning and end of each season. Market prices are affected by transportation costs between production and consumption regions as well as by differences in variety, size, and quality of onions produced. Therefore, prices vary from producer to producer in a production area as well as among seasonal categories.

The study is limited to consideration of the market for onions in the early summer seasonal category with particular emphasis on the West Texas sector of the market, although reference is made to the other market groups.

Because onions in the early summer production category in the U.S. are sold mainly for fresh market consumption, the marketing alternatives of producers are severely limited. The early summer onion producer is faced with changes in fresh market conditions between

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TABLE 1. PRODUCTION, UTILIZATION, AND NET EXPORTS AS A PERCENTAGE OF PRODUCTION FOR ONIONS IN THE U.S., 1960-1975

Year	Production			Net Exports	Civilian Consumption	Per Capita Consumption	Net Exports as a Percent of Total U.S. Production
	West Texas Portion	Total Early Summer	Total U.S.				
	------------------------------1000 cwt.				------------------------------	--pounds--	--percent--
1960	1080	2398	26459	732	21971	12.3	2.8
1961	931	2077	23603	545	20186	11.5	2.3
1962	936	2185	25749	400	21498	11.7	1.6
1963	820	2070	25764	877	22137	11.9	3.4
1964	1025	2317	25892	437	21509	11.4	1.7
1965	924	2333	28070	751	21885	11.4	2.7
1966	1290	3000	31341	483	22237	11.5	1.5
1967	1150	3320	38087	1231	23606	12.1	3.2
1968	1400	3344	28844	293	23412	11.9	1.0
1969	1430	2942	28317	798	24674	12.4	2.8
1970	1537	2933	30578	710	24900	12.4	2.3
1971	1575	2875	29594	861	19999	9.8	2.9
1972	1296	2846	28473	674	20288	9.8	2.4
1973	1820	3265	29659	378	19231	9.2	1.3
1974	1586	3061	33045	493	22588	10.8	1.5
1975	1404	2704	31382	715	20706	9.8	2.3

Sources: *USDA, U.S. Fresh Market Vegetable Statistics, 1949-1975,* Economic Research Service, August 1976; Texas Dept. of Agriculture, *Texas Vegetable Statistics,* Texas Crop and Livestock Reporting Service, 1960-1975.

production periods and within a marketing period which affect price. Because the individual producer has little or no control over such conditions, the major decisions he can make to improve profits are production decisions.

PRICE-PRODUCTION RELATIONSHIPS

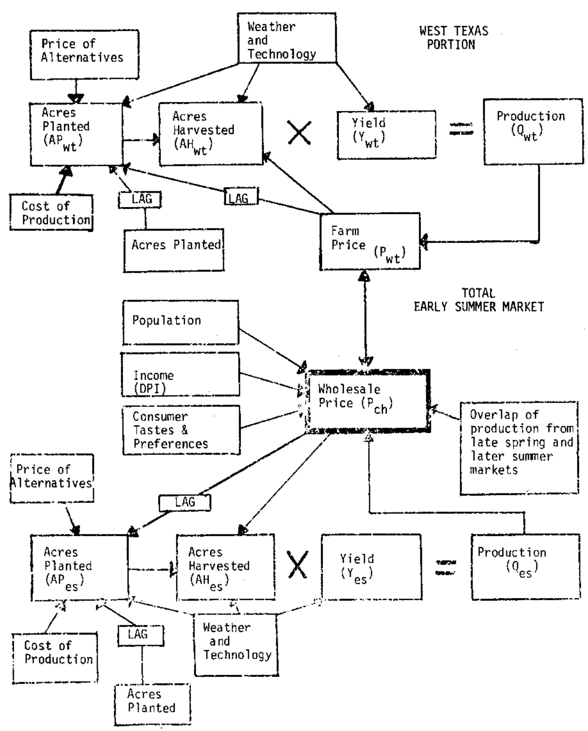
Commercial production of onions in the United States has followed an upward trend since 1960 even though yearly production figures have fluctuated widely (Table 1). The same general pattern holds for total production in the early summer seasonal category and the West Texas part of the early summer market.

Net exports of onions during 1960-1975 ranged from 1.0 to 3.2 percent of total U.S. production (Table 1) and seemed to exert very little influence on the onion market. The foreign component therefore is excluded from the analysis. Civilian consumption of onions has been relatively stable, changing at approximately the same rate as population increases.

The per capita consumption figures reported in Table 1 illustrate the relatively stable demand for onions. Onions have no adequate substitute in the fresh form. Some possible substitutes are processed onions (e.g. dehydrated, frozen). The lack of an adequate substitute and the small expenditure for onions in relation to the consumer's total expenditure on food items are factors contributing to the relatively stable demand.

The major price-production relationships for the U.S. and West Texas early summer onions can be summarized by a flow diagram (Figure 1). Beginning with the West Texas market at

FIGURE 1. WEST TEXAS AND U.S. EARLY SUMMER ONION PRICE-PRODUCTION RELATIONSHIPS



the top of the diagram, acres planted in the West Texas area (AP_{wt}) are influenced by several factors. In the short run, producers may be limited to the number of acres of suitable soil types and adequate supplies of irrigation water. The stock of specialized equipment and other capital items available to producers may limit their ability to enter and/or exit onion production within a single year. Thus, producers may tend to enter onion production and stay if economic conditions remain favorable; if so, the acreage planted in the present production period (AP_{wt}) will be related directly to acres planted in previous years. The ability and willingness of producers to assume the financial risks associated with vegetable crops such as onions also affect production. Fluctuating prices cause financial risks to vary directly with acres planted; therefore price expectations are important and affect the number of acres planted. The most logical price expectations variable is the season average farm price received for onions the previous year. An alternative expectations variable is the price for onions during the planting period, but for early summer onions the price at planting is for late summer storage onions which are not very competitive with fresh onions. Thus, price at planting does not appear to be a reasonable price expectations variable for early summer onion producers. Expected profits for alternative crops are expected to affect the number of acres planted to onions. The variables which seem to best represent profitability from alternative crops are their expected farm prices. Average farm prices for the previous year for potatoes, corn, grain sorghum, wheat, and cotton are expected to be related inversely to the number of acres planted to onions.

The harvested acreage (AH_{wt}) is the direct result of the number of acres planted. Once acres planted has been determined, the main factors that can change harvested acres are unfavorable weather conditions and a low product price at harvest time. The price at harvest will affect acres harvested if it is not high enough to cover the variable expenses of harvesting.

Yield per acre for onions (Y_{wt}) is hypothesized to depend on weather and level of technology. Cold temperatures during the early part of the growing season, hail damage to mature bulbs, and excess rainfall during harvest will decrease yield. The level of technology used in production is critical. Producers who use the most recent technological advances and follow recommended cultural practices usually obtain highest yields, *ceteris paribus*. Production (Q_{wt}) is specified as harvested acres (AH_{wt}) times yield per acre (Y_{wt}).

The farm price of onions (P_{wt}) is determined by supply and demand conditions affecting the market. The demand at the farm level is derived from the retail demand through the wholesale market to the farm level. However, retail price data are not available. Therefore, the farm-level demand is equal to the wholesale demand less selected marketing and transportation costs. Because retail demand conditions are relatively stable, the price of onions is principally affected through the supply side of the market. The average farm price in West Texas should be the same as the wholesale price of onions in the early summer market (P_{ch}) less the cost of transportation and including adjustments for varietal and quality differences for West Texas onions. The price of onions in the early summer market (P_{ch}) is hypothesized to affect directly the price received in West Texas (P_{wt}).

The production overlap of onions from adjacent seasons undoubtedly affects the wholesale price for early summer onions. Both late spring onions and late summer onions sometimes reach the market during the early summer period, but lack of information on quantities sold within the early summer period limits their use as variables. Other variables which affect wholesale price (P_{ch}) are population, income, and consumer tastes and preferences. The only one of these factors that is not strictly quantifiable is consumer tastes and preferences. Therefore, it is not included in the analysis. Income is included as per capita disposable personal income in current dollars (DPI). Therefore, population changes are included in the income variable and population is not used as a separate variable.

The relationships among acres planted, acres harvested, yield, and production in the U.S. early summer onion market are logically the same as those in the West Texas market.

STRUCTURAL RELATIONS

The price-production relationships in Figure 1 were used as the basis for developing a simultaneous equation model of the structural relationships underlying the U.S. early summer onion market and the West Texas sector of that market. Although an updated analysis of the current demand, supply, and price-determining processes of the West Texas and national early summer onion markets is the primary objective, the model also provides forecasts of price, quantity, and other relevant variables.

The structural model contains the following six equations, including four stochastic relationships and two closing identities.

(1) $\hat{P}_{wt} = f(\hat{Q}_{wt}, \hat{P}_{ch})$
(2) $\hat{P}_{ch} = f(\hat{Q}_{es}, DPI)$
(3) $\hat{AH}_{wt} = f(\hat{P}_{wt}, AP_{wt})$
(4) $\hat{AH}_{es} = f(\hat{P}_{ch}, AP_{es})$
(5) $\hat{Q}_{wt} = \hat{AH}_{wt} \times Y_{wt}$
(6) $\hat{Q}_{es} = \hat{AH}_{es} \times Y_{es}$

where

$\hat{P}_{wt}$ = West Texas farm price received for onions (in dollars per cwt)
$\hat{P}_{ch}$ = Chicago wholesale terminal market price for early summer onions (in dollars per cwt)
$\hat{Q}_{wt}$ = quantity of onions produced in West Texas (in 1,000 cwt)
$\hat{Q}_{es}$ = quantity of onions produced in the U.S. early summer category (in 1,000 cwt)
DPI = national disposable income per capita (in current dollars)
$A\hat{H}_{wt}$ = onions harvested in West Texas (in acres)
$A\hat{H}_{es}$ = onions harvested in the U.S. early summer category (in acres)
Y_{wt} = onion yield per harvested acre in West Texas (in cwt)
Y_{es} = onion yield per harvested acre in the U.S. early summer category (in cwt)
AP_{wt} = onions planted in West Texas (in acres)
AP_{es} = onions planted in the U.S. early summer category (in acres).

The six variables identified in the equations with a circumflex (^) are considered endogenous and the others are exogenous.

The farm price of onions in the West Texas sector of the U.S. early summer market (P_{wt}), as presented in equation 1, depends on the wholesale price of onions in the Chicago terminal market and the quantity of onions produced in West Texas. The price of onions in the U.S. early summer market is represented by the price in the Chicago terminal market (P_{ch}). It is related to the quantity of onions produced in the national early summer category and disposable personal income per capita as indicated in equation 2.

The production equation for West Texas onions, equation 3, relates acres harvested to price and acres planted to onions. Equation 4 presents a similar expression for the U.S. early summer market. Competing vegetable and field crops affect the acres planted variable which is predetermined. After the number of acres planted is determined, only a low price at harvest and poor weather conditions will affect the number of acres harvested. The next two relations are identities that define quantity produced as the product of acres harvested and yield per acre.

PARAMETER ESTIMATION

The proposed model is characterized by structural equations in which the endogenous variables are interrelated. The presence of one or more endogenous regressors in a stochastic equation implies a correlation of these regressors and the error term. The use of ordinary least squares would yield biased and inconsistent estimates of structural parameters [9, pp. 225-232]. Several methods are available for parameter estimation of a simultaneous system of equations. Three-stage least squares was selected because it estimates all endogenous variables simultaneously and yields unbiased and consistent estimates which are asymptotically efficient [5, p. 585].

The identities, equations 3 and 4, contain endogenous variables in nonlinear combinations. By the method of Roy and Johnson [6, p. 7] and Christ [1, pp. 120-121] the nonlinear variables were replaced by a linear approximation of the following form.

$$XY = \overline{Y}X + \overline{X}Y - \overline{X}\overline{Y}$$

where $\overline{X}$ and $\overline{Y}$ are the sample means of the two variables X and Y. The linear approximation of the identities in this model can be written as:

$$\hat{Q}_{wt} = \overline{Y}_{wt}A\hat{H}_{wt} + \overline{AH}_{wt}Y_{wt} - \overline{AH}_{wt}\overline{Y}_{wt}$$
$$Q_{es} = \overline{Y}_{es}A\hat{H}_{es} + \overline{AH}_{es}Y_{es} - \overline{AH}_{es}\overline{Y}_{es}.$$

Acres harvested and yield now appear as two separate additive terms in the equations. The identities are not estimated by three-stage least squares procedures (3SLS) because their regression coefficients are known to be one; however, the identities are used in calculating the reduced form.

ESTIMATES OF THE STRUCTURAL EQUATIONS

The model estimated has four stochastic equations (expressed in linear form for estimation purposes) which are all overidentified. The 3SLS estimates of the equations using actual data for 1960-1975 are:

(7) $\hat{P}_{wt} = 1.959 - .001737\,\hat{Q}_{wt} + 1.218\,\hat{P}_{ch}$
(.000811) (.09103)
(8) $\hat{P}_{ch} = 1.836 - .002196\,\hat{Q}_{es} + .003029\,DPI$
(.001154) (.000544)
(9) $A\hat{H}_{wt} = 187.2 + 33.36\,\hat{P}_{wt} + .9111\,AP_{wt}$
(46.06) (.05793)
(10) $A\hat{H}_{es} = 771.4 + 18.70\,\hat{P}_{ch} + .8746\,AP_{es}.$
(63.13) (0.4509)

The West Texas price equation, equation 7, contains signs of the coefficients consistent with the relationships described heretofore. The coefficients of the variables are significant because they are roughly twice the size of the standard errors in parentheses below the coefficients (refers to t-distribution which is not exactly valid; however, Monte Carlo evidence suggests that distortion is usually small [2, p. 109]. The results for the U.S. early summer price equation (8) are similar even though the coefficient of the quantity variable is not significant.[1]

The coefficients for the production equations for the West Texas (9) and the U.S. early summer period (10) have the expected signs. Though the coefficients of the price variable are not significant, the coefficients of acres planted are highly significant.

THE REDUCED FORM EQUATIONS AND EX POST PREDICTION

The reduced form equations for endogenous variables are obtained by solving algebraically the four estimated stochastic structural equations and the two linearized identities. The resulting reduced form equations specify each endogenous variable as a function of all the exogenous variables (Table 2).

The reduced form equations are used to estimate the values for the endogenous variables for each of the 16 years within the study period (Table 3). The actual data for the exogenous variables are used in determining these estimates. The estimated magnitudes for the endogenous variables can be compared with their actual values for the study period to determine the relative efficiency of the model. The criterion of efficiency involves measuring the deviations of the predictions from the actual values of the variables. One method of measurement is given by Theil's Inequality Coefficient [8, p. 28]. The coef-

TABLE 2. REDUCED FORM EQUATIONS FOR THE SIX ENDOGENOUS VARIABLES ESTIMATED BY THREE-STAGE LEAST SQUARES

Equation Number	Endogenous Variable [a]	Constant Term	Regression Coefficient				
			DPI	Y_{wt}	Y_{es}	AP_{wt}	AP_{es}
1.	P_{wt}	12.9758	.00360272	-9.24952	-28.8104	-.000371729	-.000548653
2.	P_{ch}	7.29443	.0029988	0	-23.9792	0	-.000457211
3.	Q_{wt}	-1209.36	.0286165	5252.53	-228.872	.213981	-.00436017
4.	Q_{es}	-2485.87	.0137892	0	10920.	0	.208044
5.	AH_{wt}	244.648	.120187	-304.377	-961.044	.8987	-.0183141
6.	AH_{es}	907.8	.0560762	0	-448.369	0	.846057

[a]For a definition of the variables, see text.

TABLE 3. ACTUAL AND ESTIMATED VALUES OF THE ENDOGENOUS VARIABLES FOR EARLY SUMMER ONIONS FOR THE U.S. AND WEST TEXAS AREAS, 1960-1975

Year	P_{wt} [a]		Q_{wt}		AH_{wt}		P_{ch}		Q_{es}		AH_{es}	
	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated
	-dollars per cwt.-		----1000 cwt.----		-----acres-----		-dollars per cwt.-		---1000 cwt---		-----acres-----	
1960	3.35	2.61	1080	1100	4800	4911	3.02	2.09	2398	2549	10700	11023
1961	5.50	4.10	931	936	3800	3776	3.90	3.08	2077	2156	9140	9153
1962	3.65	5.68	936	879	3900	3647	2.67	4.30	2185	1714	8350	8073
1963	5.30	5.49	820	712	4000	3731	3.75	3.90	2070	1992	9950	9519
1964	3.15	4.78	1025	968	4100	3799	2.62	3.69	2317	2294	10400	9985
1965	5.10	5.71	924	854	4300	4103	3.87	4.29	2333	2233	10200	9825
1966	5.80	3.63	1290	1228	6000	5673	5.45	3.11	3000	2877	13150	12580
1967	4.39	2.15	1150	1535	5000	6626	4.48	2.34	3320	3549	12200	14147
1968	4.69	3.74	1400	1450	8000	7499	3.85	3.51	3344	3276	15000	14383
1969	4.60	5.43	1430	1421	6500	6371	4.22	4.86	2942	2911	12550	12357
1970	5.14	5.01	1537	1704	5300	5993	4.30	4.94	2933	3204	10750	11803
1971	4.73	7.01	1575	1550	6300	6242	5.05	6.35	2875	2890	10950	10975
1972	8.59	8.68	1296	1271	5400	5296	5.78	7.33	2846	2791	10750	10480
1973	7.99	8.54	1820	1722	6500	6293	7.37	7.86	3265	3176	11950	11686
1974	6.46	10.75	1586	1524	6100	5911	5.65	9.38	3061	2964	10800	10689
1975	17.30	12.74	1404	1442	5200	5340	15.70	10.91	2704	2819	9400	9564

[a]For a definition of the variables see text.

[1]Pseudoelasticities estimated as the reciprocals of the price flexibilities [3] are close to one for U.S. early summer onions, which agrees with results obtained by Jesse [4].

ficient computed for each endogenous variable shows that the model gives better results than those which could be obtained from a naive "no-change" model (Table 4).

TABLE 4. THEIL'S INEQUALITY COEFFICIENTS AND NUMBER OF OVERESTIMATION, UNDERESTIMATION, AND TURNING POINT ERRORS FOR THE ENDOGENOUS VARIABLES, 1960-1975

Endogenous Variables [a]	Inequality Coefficients [b]	Overestimation Errors	Underestimation Errors	Turning Point Errors
P_{wt}	0.64	9	7	7
P_{ch}	0.69	10	6	5
Q_{wt}	0.54	6	10	5
Q_{es}	0.58	6	10	5
AH_{wt}	0.42	4	12	2
AH_{es}	0.41	6	10	2

[a]For a definition of the variables see text.

[b]Errorless forecasts for all observations yield a zero value for the coefficient, while a value of 1.00 is obtained when no change is forecast by the model.

The performance of the model is explored further by examining the number of overestimation, underestimation, and turning point errors. Overestimation errors occur when the predicted value of the variable from the model is greater than its actual value. Underestimation errors occur when the actual value is greater than the prediction. A turning point error occurs when the actual change in the variable is in the opposite direction from the predicted change. The model tends to overestimate price variables and underestimate quantity variables on balance (Table 4).

CONCLUSIONS

The six-equation simultaneous model representing demand for West Texas onions, demand for early summer onions, production of West Texas onions, and production of onions in the U.S. early summer period provides estimates of the endogenous variables within the study period. The estimates of the price variables are not as precise as those for the quantity variables, and the estimates of acres harvested seem to be closest to the actual data. On the basis of the relatively close *ex post* prediction results, the equations should work fairly well in projecting values of onion price and quantity for future years, provided the endogenous variables can be projected into the future. Disposable personal income per capita, acres planted in West Texas, and acres planted to early summer onions are affected by economic and physical factors which are quantifiable. However, yield estimates must be based on variables such as technology levels and weather conditions which are more difficult to quantify. Although the model has some predictive capabilities, the primary focus of the research is to set forth the structural relationships present in the West Texas onion producing area and to measure the effect of the early summer onion market on this producing area.

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