Lettuce

C

1981

AN INTRASEASONAL MODEL OF THE CALIFORNIA LETTUCE INDUSTRY

SOPHIA WU HUANG

INTERNATIONAL ECONOMICS DIVISION
US ECONOMIC RESEARCH SERVICE 1981
U.S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

Prepared for presentation at the 1981 annual meeting of the American Agricultural Economics Association, Clemson University, South Carolina, July 26-29, 1981.

AN INTRASEASONAL MODEL OF THE CALIFORNIA LETTUCE INDUSTRY
by Sophia Wu Huang, International Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.20250,
July, 1981.

ABSTRACT

An intraseasonal model of the California lettuce industry, consisting of four seasonal models with 9 equations for each season, is developed and estimated. Some static and dynamic properties of the estimated model are analyzed.

AN INTRASEASONAL MODEL OF THE CALIFORNIA LETTUCE INDUSTRY

By

Sophia Wu Huang

Lettuce is one of the most important vegetable crops in the United States, and California has dominated the industry's production and marketing since the 1920's. As a major fresh vegetable crop grown commercially in California, lettuce has received relatively limited attention from economic analysis. Moreover, the complete quantitative description of demand and supply relationships of the industry remains virtually unexplored. The purposes of this study are to formulate and estimate an econometric model of the California lettuce industry and then investigate the static and dynamic properties of the model.

I. THE INTRASEASONAL MODEL

The economic structure of the California lettuce industry has a relatively simple framework. Fresh consumption is the only utilization outlet. No allocation for other uses has been associated with the industry. There is no storage disposition problem in the marketing of the commodity since lettuce is a highly perishable vegetable. Once harvested, it must be moved rapidly through marketing channels to prevent spoilage. Thus the major components of economic structure in the lettuce industry are the production and shipment of lettuce and the relations that link demand and prices at both retail and farm levels.

Another important aspect in understanding the economic structure of the California lettuce industry is its seasonality. Lettuce is a short seasonal crop. Its seasonal prices are characterized by sharp changes as demand and supply conditions shift from season to season. Also the location of lettuce production and marketing varies among different seasons. Particular areas are identified by the season in which lettuce production and marketing from those areas predominate. Therefore, an appropriate quantitative system to describe the industry structure would be an intraseasonal model. An empirical model for the California lettuce industry estimated by three-stage least squares using sample observations from the period 1950-1977 is presented below.

In the first equation of each seasonal crop, a modified version of the Nerlovian partial adjustment model has been used for the description of acreage response in the California lettuce industry. In this equation, the growers' profit, acreage, and shipment per acre of preceding year are variables in explaining the growers' response relation. A retail demand equation is specified in the third equation which follows the conventional consumer's demand specification but with retail price as a dependent variable. The California lettuce shipment per acre of the second equation is a key relation in connecting the production and marketing of lettuce in the industry. In this equation, farm price subtracted by harvest cost is an important economic variable in determining the volume of lettuce shipment to market. The last behavioral equation of each seasonal crop describes the marketing margin which represents the farm-to-retail price spread relation. From this equation we can obtain the relevant information for the derived demand relation.

Estimation Results of the Intraseasonal Model

Winter crop:

$$ACW = \underset{(5.2610)}{-5.1381} + \underset{(1.3927)}{2.0134}\ LPFCW + \underset{(8.4179)}{38.9737}\ LQAW + \underset{(0.1163)}{0.6971}\ LACW$$

$$QAW = \underset{(0.0914)}{0.0139} + \underset{(0.0259)}{0.0420}\ PFHW + \underset{(0.0012)}{0.0055}\ T$$

$$PRW = \underset{(1.3099)}{4.5566} \underset{(16.5955)}{-42.9312}\ QNW + \underset{(0.4076)}{2.3571}\ DINW$$

$$PMW = \underset{(0.4146)}{-3.1199} + \underset{(0.0883)}{0.5884}\ PRW + \underset{(0.0104)}{0.0523}\ T$$

Spring crop:

$$ACP = \underset{(5.1571)}{3.7236} + \underset{(1.1686)}{2.3314}\ LPFCP + \underset{(7.1287)}{15.9905}\ LQAP + \underset{(0.1256)}{0.6565}\ LACP$$

$$QAP = \underset{(0.0744)}{-0.3226} + \underset{(0.0160)}{0.0189}\ PFHP + \underset{(0.0011)}{0.0121}\ T$$

$$PRP = \underset{(1.0831)}{3.5684} \underset{(15.0950)}{-44.8119}\ QNP + \underset{(0.4772)}{2.9489}\ DINP$$

$$PMP = \underset{(0.6303)}{-3.4751} + \underset{(0.1087)}{0.4681}\ PRP + \underset{(0.0149)}{0.0705}\ T$$

Summer crop:

$$ACS = \underset{(5.0788)}{8.8934} + \underset{(1.3242)}{3.0152}\ LPFCS + \underset{(7.3156)}{31.5235}\ LQAS + \underset{(0.1505)}{0.2789}\ LACS$$

$$QAS = \underset{(0.0991)}{-0.3233} + \underset{(0.0298)}{0.1690}\ PFHS + \underset{(0.0013)}{0.0100}\ T$$

$$PRS = \underset{(0.8030)}{2.1144} \underset{(12.2394)}{-27.4255}\ QNS + \underset{(0.3762)}{2.4940}\ DINS$$

$$PMS = \underset{(0.5500)}{-3.1035} + \underset{(0.1223)}{0.8851}\ PRS + \underset{(0.0154)}{0.0266}\ T$$

Fall crop:

$$ACF = \underset{(3.2820)}{1.8024} + \underset{(1.0646)}{2.5587}\ LPFCF + \underset{(8.0086)}{20.1243}\ LQAF + \underset{(0.1480)}{0.6133}\ LACF$$

$$QAF = \underset{(0.0949)}{-0.2543} + \underset{(0.0325)}{0.0891}\ PFHF + \underset{(0.0012)}{0.0086}\ T$$

$$PMF = \underset{(0.5355)}{-2.7840} + \underset{(0.1373)}{0.7863}\ PRF + \underset{(0.0168)}{0.0292}\ T$$

$$PRF = \underset{(0.9569)}{2.5827} \underset{(14.2365)}{-21.0935}\ QNF + \underset{(0.4147)}{2.2529}\ DINF$$

(The numbers in parentheses are the standard errors.)

Identities:

(5) QN. = (QC. + QO.) / NP.

(6) PM. = PR. - PF.

(7) PFC. = PF. - HA. - HB.

(8) PFH. = PF. - HA.

(9) QA. = QC. / AC.

Variables in the model:

(all prices and values are deflated by consumer price index with 1967 as a base period; endogenous variables are marked with an asterisk *)

* AC. = harvested acreage of lettuce in California (1,000 acres)
* QA. = lettuce shipment per acre in California (1,000 carton/acre)
* PR. = average retail price of lettuce in the U.S. ($/carton)
* QC. = commercial lettuce shipment from California (million cartons)
* PM. = lettuce retail-farm price spread in California ($/carton)
* PF. = lettuce farm price in California ($/carton)
* PFC.= grower's profit of lettuce in California ($/carton)
* PFH.= lettuce farm price subtracted by harvested cost in California ($/carton)
* QN. = per capita shipment of lettuce in the U.S. (carton/person)

QO. = commercial lettuce shipment from states outside California (million cartons)

HA. = harvesting cost of lettuce in California ($/carton)

HB. = preharvesting cost of lettuce in California ($/carton)

NP. = population in the U.S. measured in consecutive 3 months average beginning from January (million persons)

DIN. = per capita disposable income in the U.S. ($1,000/person)

T = time trend (coded 1 = 1951)

(A dot at the end of some variables represents various seasonal crop: W for winter, P for spring, S for summer, and F for fall; any variable heading by a letter L is one period lag of the corresponding variable.)

The model is obviously a block recursive type system; the planted acreage is recursively determined by some predetermined variables, and the remaining three behavior equations form a block of the equation system in which their dependent variables are simultaneously determined. Moreover, the equation system is dynamic in the sense that some important lagged endogenous variables such as farm price and acreage appear in the system. With such a dynamic system, conditions prevailing in one period influence decisions which, along with certain random elements, determine the production in the next period. The production then interacts with demand factors to determine retail price, farm price, and shipment. The farm price will in turn affect the planted acreage and production of the following period.

Although the full implication of the estimated relations will be analyzed in terms of static and dynamic properties of the model, it seems desirable to derive at this point certain measures of performance from the present estimates about the growers' acreage response and consumers' retail demand relations. Among economic information gained from the estimated intraseasonal model, the shortrun supply elasticities are found to be 0.1199, 0.1419, 0.1818, and 0.2066 for winter, spring, summer, and fall crops, and their respective longrun supply elasticities are found to be 0.3957, 0.4130, 0.2521, and 0.5344. On the demand relations, the flexibilities of retail price with respect to quantity are found to be -0.8676, -0.9195, -0.4810, and -0.3719 for winter, spring, summer, and fall crops, and the flexibilities with respect to per capita disposable income are respectively found to be 1.0541, 1.2974, 1.1092, and 0.9459.

II. STATIC AND DYNAMIC PROPERTIES OF THE INTRASEASONAL MODEL

Impact Multiplier

The structure of the California lettuce industry model may be expressed in a general form as containing a set of jointly dependent variables Y_t and exogenous variables X_t:

$$A\, Y_t = B\, Y_{t-1} + C\, X_t + U_t \tag{1}$$

The restricted reduced form can be derived as

$$Y_t = \pi_1\, Y_{t-1} + \pi_2\, X_t + V_t \tag{2}$$

in which $\pi_1 = A^{-1}B$, $\pi_2 = A^{-1}C$, and $V_t = A^{-1}U_t$.

The reduced from coefficients are also called impact multipliers; they measure the immediate response of the endogenous variables to change in the predetermined variables, and also the direct and indirect effects of all predetermined variables on endogenous variables.

The numerical results of impact multipliers derived from the estimated structure for the California lettuce industry are summarized in table 1. The units of measurement for each variable are listed at the bottom of the table to aid in understanding the size of multiplier effects. Among calculated multiplier results, the impacts of change in harvesting cost draw much of our attention because of their potential usefulness in assessing the benefit of programs such as harvesting mechanization. Taking summer lettuce for example, a decrease of harvesting cost by 10¢ per carton may increase the shipment by 527,490 cartons, and the farm price may drop by 0.9¢ per carton due to more availability of lettuce in the market. Moreover, if we make use the sample means of

TABLE 1 IMPACT MULTIPLIERS OF THE MODEL

CALIF. WINTER CROP

	CONST	HAW	QOW	DIW	NPW	T	LHAW	LHBW	LACW	LQCW	LPRW	LPFW
ACW	10.3138	0.0000	0.0000	0.0000	0.0000	0.0000	-2.0134	-2.0134	0.2601	1.1022	0.0000	2.0134
QCW	-1.1093	-1.3034	-0.1223	0.0067	-0.0035	0.1025	-0.7006	-0.7006	0.0905	0.3835	0.0000	0.7006
PRW	6.0457	0.2971	-0.2001	0.0109	-0.0057	-0.0233	0.1597	0.1597	-0.0206	-0.0874	0.0000	-0.1597
PFW	5.6083	0.1223	-0.0023	0.0045	-0.0023	-0.0619	0.0657	0.0657	-0.0084	-0.0359	0.0000	-0.0657

CALIF. SPRING CROP

	CONST	HAP	QOP	DIP	NPP	T	LHAP	LHBP	LACP	LQCP	LPRP	LPFP
ACP	11.0432	0.0000	0.0000	0.0000	0.0000	0.0000	-2.3314	-2.3314	0.4402	0.4723	0.0000	2.3314
QCP	-13.0405	-0.5920	-0.0747	0.0049	-0.0039	0.3372	-0.9874	-0.9874	0.1864	0.2000	0.0000	0.9874
PRP	9.6958	0.1405	-0.2195	0.0144	-0.0116	-0.0800	0.2343	0.2343	-0.0442	-0.0474	0.0000	-0.2343
PFP	8.6323	0.0747	-0.1167	0.0076	-0.0061	-0.1130	0.1246	0.1246	-0.0235	-0.0252	0.0000	-0.1246

CALIF. SUMMER CROP

	CONST	HAS	QOS	DIS	NPS	T	LHAS	LHBS	LACS	LQCS	LPRS	LPFS
ACS	23.8962	0.0000	0.0000	0.0000	0.0000	0.0000	-3.0152	-3.0152	-0.1595	0.9213	0.0000	3.0152
QCS	5.3468	-5.2749	-0.0077	0.0079	-0.0119	0.1718	-1.3090	-1.3090	-0.0692	0.4000	0.0000	1.3090
PRS	5.0783	0.7636	-0.1320	0.0120	-0.0180	-0.0248	0.1895	0.1895	0.0100	-0.0579	0.0000	-0.1895
PFS	3.6869	0.0877	-0.0151	0.0013	-0.0020	-0.0294	0.0217	0.0217	0.0011	-0.0066	0.0000	-0.0217

CALIF. FALL CROP

	CONST	HAF	QOF	DIF	NPF	T	LHAF	LHBF	LACF	LQCF	LPRF	LPFF
ACF	9.7249	0.0000	0.0000	0.0000	0.0000	0.0000	-2.5587	-2.5587	0.3225	0.7386	0.0000	2.5587
QCF	-3.6445	-2.2953	-0.0544	0.0058	-0.0093	0.1545	-0.9524	-0.9524	0.1200	0.2749	0.0000	0.9524
PRF	6.5979	0.2546	-0.1049	0.0112	-0.0179	-0.0171	0.1056	0.1056	-0.0133	-0.0305	0.0000	-0.1056
PFF	4.1939	0.0544	-0.0224	0.0023	-0.0038	-0.0328	0.0225	0.0225	-0.0028	-0.0065	0.0000	-0.0225

Note: Some variables ending with W,P,S and F to winter, spring, summer and fall, and prefixing a L to lagged variables. AC.(Calif. acreage, 1000 acres), QC.(Calif. shipment, million cartons), PR.(retail price, $/carton), PF(farm price, $/carton), HA.(harvest cost,$/carton), QO.(other state shipment, million cartons), DI.(disposable income, billion $) NP.(population, million persons), T(time, 1950 coded 50), HB.(preharvest cost, $/carton).

farm price, shipment and harvesting cost and calculate the change in total cost and gross revenue, an additional grower income of two million dollars can be obtained for the industry as a whole. 1/

The multiplier effects of shipment from other states shown in the third column of the table may reflect the regional competitive status of other states. The impacts of increase 1 million cartons of lettuce shipments from other states are that the shipments of California lettuce could be reduced by 122,300 cartons in winter, 74,700 cartons in spring, 87,700 cartons in summer, and 54,400 cartons in fall. With the changes of lettuce supply, the retail prices per carton could be reduced by 20¢ in winter, 22¢ in spring, 13¢ in summer, and 11¢ in fall, while the farm prices could be reduced by 8.2¢ in winter, 11.7¢ in spring, 1.5¢ in summer, and 2.2¢ in fall. The impacts on seasonal farm prices are different; among them the winter and spring crops are found to have more significant impacts largely because of competition from the production regions in Arizona.

1/ Using sample means of shipment (Q = 16,790,000 cartons), farm price (P = \$2.055 per carton), and harvest cost (H = \$1.031 per carton), the increments of net revenue may be calculated by Q'(P' - H')-Q(P-H); that is, 17,317,490 (2.046 - 0.931) -16,790,000(2.055 - 1.031)=2,116,041.

Longrun Multiplier

The reduced form equation is useful mainly for short-term forcasting. To understand how the system operates under the continuous impact of the exogenous variables, we need a solution that would go beyond the immediate, initial period multiplier results, and trace out the delay and longrun effects of the exogenous variables.

Lagging the equation (2) one period and substituting back repeatedly (t-1) times, we find that

$$Y_t = \pi_1^t Y_0 + \sum_{i=0}^{t-1} \pi_1^i \pi_2 X_{t-i} + \sum_{i=0}^{t-1} \pi_1^i V_{t-i} \qquad (3)$$

This equation specifies not only how the predetermined variables (together with the disturbances) generate the current values of the endogenous variables, but also how the time paths of the exogenous variables and the disturbances determine the time paths of the endogenous variables. Each coefficient in matrix $\pi_1^i \pi_2$, for $i = 0, 1, \ldots, t-1$, gives the multiplier response of an endogenous variable to an exogenous change occurring after each lapse of i time periods. We may call these coefficients "delay multipliers" or "dynamic multipliers", in the sense that the multiplier effects vary with the lags of period assigned.

To observe the longrun dynamic properties of the California lettuce model, a key question to raise at the outset is the stability of the model. In general, we say that a system is stable if in a situation where the values of the exogenous variables are held constant through time and the motion of the endogenous variables approaches at the position of equilibrium. One way of determining whether a system is stable or not is to refer to equation (3) by assigning the period lags to infinity. A stable state of the reduced form equation system is found if and only if the following condition holds:

$$\lim_{t\to\infty} \pi_1^t = 0 \tag{4}$$

It is well known that, when matrix π_1 has distinct eigenvalues, a stable system requires that the spectral radius of matrix π_1, defined as the maximum modulus of eigenvalues, be less than unity. In our intraseasonal model, the estimated non-zero spectral radius of eigenvalues associated with the part of reduced form corresponding to lagged endogenous variables, is found to be smaller than unity: 0.5779 (winter), 0.5157 (spring), 0.2187 (summer), and 0.5749 (fall). The results suggest that the model is stable and enables us to do further analysis on the dynamic behavior of the system in the long run.

After a stable condition has been established for the system, the equation (3) becomes:

$$\lim_{t\to\infty} Y_t = \sum_{i=0}^{\infty} \pi_1^i \pi_2 \, X_{t-i} \tag{5}$$

Suppose further that the exogenous variables do not change over time, say $X_t = X^*$, then the limit of time paths of the endogenous variables turn out to be:

$$\lim_{t\to\infty} Y_t = (I - \pi_1)^{-1} \pi_2 \, X^* \tag{6}$$

in which $(I - \pi_1)^{-1} \pi_2$ is defined to be the longrun multiplier. It describes the corresponding changes in the level of endogenous variables between two stationary states by a unit change in the level of exogenous variables. By stationary state, we mean that the endogenous variables have reached a state of "stationary equilibrium" in which every element in the endogenous vector approaches, in a limited sense, a certain equilibrium value which does not change over time.

The longrun multipliers provide information about the impact of a sustained unit change in an exogenous variable after a long period of time. Since the change in exogenous variable is maintained for a sufficiently long time to allow the endogenous variables to reach equilibrium levels, the longrun multipliers can be referred to as the total changes in endogenous variables over time. The empirical results of longrun multipliers for the lettuce intraseasonal model are listed in table 2. It indicates that the exogenous variables of the model do not have immediate impact on acreage planting, but they do have generated substantial changes in the long run.

III. CONCLUSIONS

The location of production and marketing of California lettuce varies from season to season and so do its seasonal prices. An appropriate quantitative system to describe the industry structure would be an intraseasonal model. This is reflected from the empirical results in which the estimated demand and supply parameters are distinguishable from different seasonal crops. Among the calculated impact multipliers, the effect of decrease in harvesting cost may bring in more shipment of lettuce, and the decrease of farm prices is far less than the decrease of harvesting cost per carton. In other words, the growers could be benefited significantly from reducing harvesting cost method such as harvesting mechanization. The analysis of industry dynamic properties lead to a conclusion that the system is stable, and the longrun multipliers represent the total impacts of exogenous variables resulting the endogenous variables to reach a state of stationary equilibrium.

TABLE 2 LONG-RUN MULTIPLIERS OF THE MODEL

LIF. WINTER CROP

	CONST	HAW	QOW	DIW	NPW	T	LHAW	LHBW
ACW	40.5235	-2.8201	-0.7123	0.0391	-0.0205	-0.0276	-4.7699	-4.7699
QCW	9.4027	-2.2847	-0.3701	0.0203	-0.0106	0.0928	-1.6597	-1.6597
PRW	3.6489	0.5209	-0.1436	0.0078	-0.0041	-0.0211	0.3784	0.3784
PFW	4.6218	0.2144	-0.0591	0.0032	-0.0017	-0.0610	0.1557	0.1557

CALIF. SPRING CROP

	CONST	HAP	QOP	DIP	NPP	T	LHAP	LHBP
ACP	47.1903	-0.2176	-0.6351	0.0417	-0.0335	-0.2153	-4.8139	-4.8139
QCP	-0.5308	-0.6842	-0.3437	0.0226	-0.0181	0.2460	-2.0389	-2.0389
PRP	6.0626	0.1623	-0.1557	0.0102	-0.0082	-0.0583	0.4838	0.4838
PFP	6.6998	0.0863	-0.0828	0.0054	-0.0043	-0.1015	0.2573	0.2573

CALIF. SUMMER CROP

	CONST	HAS	QOS	DIS	NPS	T	LHAS	LHBS
ACS	39.5482	-5.8814	-0.1620	0.0147	-0.0220	0.0889	-3.8589	-3.8589
QCS	12.1423	-7.8284	-0.1580	0.0143	-0.0215	0.2104	-1.6754	-1.6754
PRS	4.0945	1.1333	-0.1218	0.0110	-0.0166	-0.0304	0.2425	0.2425
PFS	3.5739	0.1302	-0.0140	0.0012	-0.0019	-0.0301	0.0278	0.0278

CALIF. FALL CROP

	CONST	HAF	QOF	DIF	NPF	T	LHAF	LHBF
ACF	36.0132	-3.6607	-0.2295	0.0245	-0.0392	0.0706	-6.0188	-6.0188
QCF	6.1414	-3.6580	-0.1398	0.0149	-0.0239	0.1808	-2.2405	-2.2405
PRF	5.5121	0.4058	-0.0954	0.0101	-0.0163	-0.0200	0.2485	0.2485
PFF	3.9619	0.0867	-0.0203	0.0021	-0.0034	-0.0334	0.0531	0.0531

Note: Variables defined as in table 1.