THE COMPETITIVE POSITION OF MAJOR U.S. POTATO PRODUCING REGIONS*

Richard A. Levins and Max R. Langham

This study utilizes a spatial equilibrium model to examine the equilibrium farm-level prices and production levels which may be expected for the major potato-producing regions in the United States, both in the short run and the long run under competitive conditions. The model encompasses both the temporal and spatial dimensions of the United States potato industry. The reactive programming [4] algorithm was used to determine the equilibrium prices and quantities. Input requirements for the model include supply functions, demand functions, and intermediate marketing costs.

ESTIMATES OF MODEL PARAMETERS

The crop year was divided into the six time periods used by the United States Dept. of Agriculture (USDA) in reporting potato production figures [7]. These time periods are: fall (October-December), winter (January-March), early spring (April 1-May 15), late spring (May 16-June 30), early summer (July 1-August 15), and late summer (August 14-September 30). The names of the producing regions in Table 1 provide some indication of location of production in each time period. A geographic location may be found in [1, p. 7].

Supply Function

Potatoes at the farm level differ as to quality and relative desirability for table stock and processing uses. This study abstracts somewhat from the real world and treats all potatoes as a homogeneous product at the farm level. Data reported by USDA [7] were used to estimate production levels and farm-level prices for each supply region.

Acreage response elasticities with respect to price were estimated for each of the 16 supply regions (Table 1) as a basis for synthesizing supply functions linear in natural logs. The following partial adjustment model was used to estimate the elasticities:

(1) $A^*(t) = B_0 + B_1\, P(t\text{-}1) + u(t)$,

subject to the following specification concerning adjustment to long-run equilibrium acreage:

(2) $A(t) - A(t\text{-}1) = d\,[A^*(t) - A(t\text{-}1)]$, $0 < d < 2$, and

where:

- d is the "coefficient of adjustment," a parameter;
- B_0 and B_1 are parameters,
- $A^*(t)$ = the long-run equilibrium acreage in period t,
- $A(t)$ = the actual acreage planted in period t,
- $P(t)$ = farm level price in period t, and
- $u(t)$ is a disturbance term assumed to be spherical and normally distributed.

Since $A^*(t)$ is not an observable variable, equation (2) can be used to estimate $A^*(t)$ in equation (1). The resulting equation is:

(3) $A(t) = d\, B_0 + (1\text{-}d)\, A(t\text{-}1) + d\, B_1\, P(t\text{-}1) + du(t)$.

This equation was fitted for each producing region using ordinary least squares.

The short-run acreage response elasticities were then calculated for each region by multiplying the estimate of dB_1 by the 1960-1971 average of lagged prices divided by the 1960-1971 average of observed

Richard A. Levins is an area extension economist working at the Agricultural Research and Education Center, Bradenton, Fla., and Max R. Langham is professor of food and resource economics at the University of Florida.

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Table 1. **ESTIMATES OF SUPPLY ELASTICITIES FOR POTATOES BY REGIONS**

Producing Region and Time Period	Short-Run Elasticity	Long-Run Elasticity	Producing Region and Time Period	Short-Run Elasticity	Long-Run Elasticity
Northeast Fall	0.0553	0.7126	South Cent. Late Spr.	0.3892	2.19639
North Cent. Fall	0.00537	0.0058	Southwest Late Spr.	0.2620	0.3376
Northwest Fall	0.1575	1.1624	Southeast Early Sum.	0.1118	0.9613
Florida Winter	0.3911	0.8304	South Cent. Early Sum.	0.2922	0.8582
California Winter	0.5397	-20.758	Southwest Early Sum.	-0.1106	-0.9139
Florida Early Spr.	0.2244	0.5079	East Late Sum.	0.0459	0.3987
Texas Early Spr.	1.360	2.4342	Central Late Sum.	-0.0713	-0.5727
Southeast Late Spr.	0.2838	-35.475	West Late Sum.	0.2878	0.4945

acreages planted. The long-run acreage response elasticities were obtained by dividing the short-run elasticities by d. The elasticity estimates are given in Table 1.

The supply equations require output-price elasticities rather than acreage response elasticities. Since these two elasticities are identical if estimated at expected yield values, acreage response elasticities were used.[1]

The short-run elasticities for the Northeast-Fall, North Central-Fall, and East-Late Summer regions were so small relative to their standard errors that it was decided to treat these regions as having fixed supplies in the short run. Furthermore, the price slopes for the Southwest-Early Summer and Central Late-Summer were of the wrong a priori sign expectation (negative instead of positive). However, since the price slopes were not significantly different from zero at the 5 percent level, the production of these two regions also was treated as being fixed in the short run. All fixed supplies were set at the average value of output for the past 12 years.

Output was sufficiently elastic in the other 11 regions to justify the specification of short-run price dependent supply functions. For these regions, functions of the following log-linear forms were used:

$$(4)\quad \ln P = a + b \ln Q$$

where P and Q represent current price and quantity, respectively.

The coefficient of 1 n Q in the log-linear form is the inverse of the output-price elasticity, which was estimated from the parameters of equation (3).[2] The procedure used in estimating the supply functions assumes that output-price elasticity and the output-lagged price elasticities are the same. With constant yields as assumed in this study, the current price and lagged price will be equal for a system in equlibrium.

The calculated average quantities supplied in each region are not the average total production, but an estimate of the average total quantity sold for table stock and processing uses. Thus, those potatoes being used for seed and livestock feed were not included in these averages. The estimates of average quantity sold were taken to be 90 percent of the actual average production in each region.

The long-run elasticities were higher than the short-run elasticities in all regions as one would expect (Table 1). North Central-Fall, Southwest-Early Summer and Central-Late Summer were held fixed in

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[1] Variations in yields occur because of price-induced changes in nonland inputs, so this assumption abstracts somewhat from reality.

[2] The intercept terms for the supply functions were calculated using the average values of P(t-1) and Q(t) (Table 4).

the long run.[3] Two regions, California-Winter and Southeast-Late Spring, showed long-run elasticities of infinity due to the fact that the estimate of d for each of these regions was taken to be zero. For these two regions, it was proposed that they would supply any quantity of potatoes up to the maximum produced in the region over the period 1960-1971 at the average lagged price for that period. Production exceeding the maximum levels was not permitted.

Long-run log-linear supply functions were estimated using the long-run elasticities in the same way that the short-run supply functions were estimated.

Demand Functions

This study recognizes the difference between processed and table stock potatoes by estimating separate demand functions for each product. However, no allowance was made for different types of processed products or of table stock potatoes. Hence, each demand region will have two demand functions, one for aggregated processed products and one for all table stock potatoes.

For purposes of estimating demand functions, the crop year again was divided into the six time periods discussed previously. The United States was divided into three demand regions, East, Central and West.[4] And, a demand function for both table stock and processed potatoes in each of the three geographic regions was estimated for each time period. This is a total of six demand functions per time period. Since there are six time periods, a total of 36 demand functions was required.

Retail price elasticities were estimated prior to estimating the parameters of the demand functions. The following relationship between the quantity consumed of a product and the price of that product was hypothesized to be:

(5) $Q(t) = A_0 + A_1 P(t) + A_2 PS(t) + u(t)$

where:

$Q(t)$ = the quantity consumed of the product in a given region in time period t,

$P(t)$ = the price of that product in the region in time period t,

$PS(t)$ = the price of the alternative product form in the region in time period t, and

$u(t)$ = a disturbance term assumed to be spherical and normally distributed.

The equation was estimated using ordinary least squares.

The basic price data used in estimating the parameters of equation (5) were taken from [8]. Average annual prices for table stock potatoes and for frozen French fries at the retail level in New York City, Chicago, and Los Angeles were obtained for each of the years 1960-1971. The New York City price was taken as representative of the eastern market, Chicago for the central, and Los Angeles for the western. The price of frozen French fries, which was converted to a raw-product-equivalent basis, was taken as representative of all processed products.

Estimates of the quantity consumed of table stock and processed potatoes were needed for each region in each time period. Although no data by regions were available USDA [5] gives a yearly report of the amount of both products consumed on a nationwide basis. Estimates of regional per capita consumption of the table stock and processed potato products forms [6], and estimates of regional population were used as a basis for partitioning this national total among the three regions. Once the quantities consumed in each region for each product were estimated, these quantities were partitioned among the six time periods, assuming that the rate of potato consumption remains constant throughout the year.

The price elasticity of each product-region-time period combination was obtained by multiplying A_1 from the corresponding estimated regression equation times the average price for the product in that region and time period over the years 1960-1971, divided by the average quantity consumed of that product for the region and time period for years 1960-1971. The resulting elasticities are reported in Table 2.

The demand model used here does not distinguish between long- and short-run elasticities as did the supply model. It is believed that the use of annual data results in near long-run elasticities since consumers adjust to price changes rather quickly in

[3] The perfectly inelastic long-run supply for the North Central-Fall region resulted from a positive but near zero estimate of the long-run price slope, while those for the Southwest-Early Summer and Central-Late Summer regions resulted from negative estimates of the price slopes that were not statistically different from zero. Though these assumptions of perfectly inelastic long-run supplies follow from the data and estimating procedure, theory would suggest that they introduce some error in the long-run model solution.

[4] The East includes all states east of the east boundaries of Ohio, Kentucky, Tennessee, and Alabama. The West includes the states of Montana, Wyoming, Colorado, and New Mexico and all other contiguous states to the west. The Central region includes the remaining contiguous states. Equilibrium flows from each supply region of each demand region, and any additional information about the study may be obtained by writing Richard A. Levins, AREC, 5007 60th St. E., Bradenton, Fla. 33505.

Table 2. ESTIMATES OF DEMAND ELASTICITIES FOR PROCESSED AND TABLE STOCK POTATOES BY REGIONS

Market and Product Form[a,b]	Own Price Elasticity
East - TS	-0.2645
East - PR	-0.323
Central - TS	-0.322
Central - PR	-0.044
West - TS	-0.100
West - PR	-2.026

[a]TS refers to the table stock product form.

[b]PR refers to the processed product form.

comparison to producers. Differences between elasticities estimated with annual data and long-run elasticities are, therefore, assumed to be negligible.

In a way quite similar to that for the log-linear supply functions, the demand elasticities were used to estimate log-linear demand functions. The demand for potatoes was assumed not to experience seasonal shifts. Therefore, since the periods covered by the fall and winter marketing periods are roughly of the same duration, the six fall demand functions and the six winter demand functions were identical. By the same reasoning, the six early spring, late spring, early summer and late summer demand functions were identical.

Intermediate Marketing Costs

Freight, handling, and processing costs were taken as estimated by Summers [3] in a 1968 study. The specific costs used were those for standard quality table stock potatoes and frozen products made from standard quality raw potatoes.

Modern storage technology has enabled producers of fall potatoes to market their crop throughout the year. Therefore, the intermediate marketing costs for the fall regions also included estimates of storage costs. The storage costs estimated by Summers and Sparks [2] for least-cost storage procedures in the Northwest supply region in 1969 (Table 3) were used in this study. These costs were

Table 3. ESTIMATED STORAGE COSTS FOR POTATOES

Period	Total Cost
	($/cwt)
Fall to Winter	.28
Fall to Early Spring	.32
Fall to Late Spring	.39
Fall to Early Summer	.49
Fall to Late Summer	.54

assumed to hold for the North Central and Northwest fall producing areas as well.

In order to have the total intermediate marketing costs more accurately reflect the current values, they were adjusted upward by an index of freight rates.[5] Inadmissable routes (e.g., shipments to markets in the winter time period by Florida-Early Spring producers) were kept out of the final solution of the spatial equilibrium model by assigning an arbitrarily large cost to them.

Model Formulation

The model was first formulated with the short-run supply functions in order to determine the short-run equilibrium conditions. The model was then formulated with the long-run supply functions in order to determine the long-run equilibrium conditions. The same demand functions and intermediate marketing costs were used in both formulations of the model.

RESULTS AND DISCUSSION

The short-run and long-run computed equilibrium shipments, farm prices, and market shares are compared with the 1960-1971 average figures for each producing region in Table 4.[6]

The model results showed increased amounts of fall potatoes being stored for marketing in later time periods as one would expect with greater use of rather recent advances in storage technology.[7] In 1970 and 1971, USDA [7] reported that about 59.5 percent of the total fall potato production was available for consumption in the five succeeding time periods. In the short-run solution to the spatial equilibrium problem, this percentage was 65.4. An additional increase to 66.25 percent in the long-run solution was indicated. This increase in potatoes

[5]The assumption was made that all intermediate marketing costs changed in the same proportions as railroad freight rates, and an index of freight rates [5, Table 670] was used as an inflator.

[6]More complete discussion of the model and results are reported in [1].

[7]In modern storage facilities, temperature, humidity, and ventilation are carefully controlled so as to minimize both weight losses and quality deterioration.

Table 4. **ESTIMATED POTATO SHIPMENTS, PRICES, AND MARKET SHARES FOR 1960-1971 (AVERAGE), SHORT-RUN EQUILIBRIUM, AND LONG-RUN EQUILIBRIUM**

Supply Region and Time Period	1960-1971 (Average)			Short-Run Equilibrium			Long-Run Equilibrium		
	Quantity Supplied	Lagged Farm Price	Market Share[a]	Quantity Supplied	Farm Price	Market Share[a]	Quantity Supplied	Farm Price	Market Share[a]
	(1000 cwt)	($/cwt)	(percent)	(1000 cwt)	($/cwt)	(percent)	(1000 cwt)	($/cwt)	(percent)
Northeast-Fall	58,924	2.16	22.20	58,924	3.59	21.39	67,474	2.62	23.12
North Central - Fall	46,481	1.91	17.51	46,481	3.74	16.88	46,481	3.04	15.93
Northwest - Fall	93,020	1.94	35.04	99,052	2.90	35.97	107,784	2.21	36.93
Florida - Winter	1,433	3.87	.54	1,414	3.75	.51	1,092	2.79	.37
California-Winter	2,208	2.77	.83	2,489	3.46	.90	1,625	2.78	.55
Florida-Early Spring	3,853	3.19	1. 45	4,007	3.80	1.45	3,360	2.44	1.15
Texas-Early Spring	248	4.52	.09	176	3.51	.06	78	2.81	.03
Southeast-Late Spring	3,582	3.00	1.35	3,894	4.02	1.41	4,996	3.00	1.71
South Central-Late Spring	894	3.61	.34	903	3.71	.33	603	3.02	.21
Southwest-Late Spring	16,331	2.66	6.15	16,741	2.93	6.08	15,413	2.24	5.28
Southeast-Early Summer	7,018	2.61	2.64	7,323	3.82	2.66	7,667	2.86	2.63
South Central-Early Summer	2,920	3.01	1.10	3,157	3.93	1.15	3,087	3.21	1.05
Southweat-Early Summer	2,156	2.48	.81	2,156	3.73	.78	2,156	3.03	.74
East-Late Summer	6,296	2.12	2.37	6,296	4.88	2.29	7,785	3.61	2.67
Central-Late Summer	8,335	2.37	3.14	8,335	4.83	3.03	8,335	4.13	2.85
West-Late Summer	11,783	1.88	4.44	14,083	3.50	5.11	13,913	2.64	4.78
TOTAL	265,482		100.00	275,431		100.00	291,849		100.00

[a]The market share for a given region was calculated by dividing the quantity supplied from that region by the total quantity supplied from all regions and multiplying the result by 100.

marketed from storage will tend to depress prices in the five time periods succeeding fall.

The model results showed increased United States potato production levels. Total shipments for table stock and processing use were estimated at 10 million hundredweights above the 1960-1971 average in the short-run. The long-run equilibrium sales total exceeded that of the short-run solution by an additional 16 million hundredweights. The inelastic short-run fall supplies led to total fall production levels low enough to allow relatively high short-run equilibrium prices in succeeding time periods. However, increased fall production in the long-run solution led to significant decreases in prices for all producing regions.

CONCLUSIONS

It is felt that the more efficient producers, particularly those in the fall, can profitably continue to supply potatoes when faced with the relative price situation predicted by the model. However, less efficient producers who have depended upon high prices during periods of reduced potato shipments corresponding to their harvest time may find that survival in potato production will become increasingly difficult as the adoption of storage technology makes fall production increasingly competitive with production in other periods.

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