Effects of Control on the Domestic Peanut Industry

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INTRODUCTION

The domestic peanut industry has operated for over 40 years under Government control programs Their principal objective, embodied in legislative acts, has been to maintain the net income of peanut producers at "satisfactory" levels "Satisfactory," however, has not been clearly defined by the Congress Instead of designating targets for producer income, legislators have established price support levels and acreage quotas and have given limited consideration to long run consequences The results have been higher net incomes to peanut producers, large program costs, and the accumulation of large peanut stocks

There has been much debate recently over whether net social benefits accrue from peanut control programs If income transfer is the only objective of control, perhaps it could be accomplished more efficiently under an alternative program

An obvious alternative program is one with no controls—production levels and price are determined in the free market This alternative has traditionally been the standard of comparison for evaluating the effects of controls Song, Franzmann, and Mead (*16*), and Fleming and White (*2*) have attempted to derive free market, price-quantity time paths for the peanut industry using annual econometric models [1] They limit their approach to the demand side of the market Studies by Marshall, Little, and Kline (*10*), and by Nieuwoudt, Bullock, and Mathia (*12*) use linear programming models to develop the supply side but regard demand side variables as determined exogenously A complete treatment of the problem requires that demand and supply be determined endogenously

The domestic peanut industry has operated under Government programs for over 40 years, programs designed primarily to increase producers' income The author evaluates effects of these controls on the industry, and provides an estimate of their indirect costs to consumers

The major novelty of the annual econometric model of the industry used in the analysis is the methodology for estimating the supply function Instead of actual time-series data, the supply function is estimated from pseudodata generated by linear programming models

Keywords

Peanut production
Government policy
Linear programming
Econometric model

This article reports on the effects of controls on the domestic peanut industry from 1952 through 1976, and it presents an approximation of the indirect costs (to consumers) of control programs An annual econometric model is developed in which demand and supply are endogenous The major novelty of the study is the methodology used to estimate the supply function, pseudodata generated by linear programming are used rather than actual time-series data

The econometric model of the peanut industry, incorporating the pseudosupply function, consists of 14 linear equations, 9 of which are behavioral relations The model generates price-quantity time paths for peanuts and three major peanut products peanut oil, peanut meal, and edible peanuts Linearity and expected profit maximization are underlying assumptions

EVOLUTION OF DOMESTIC PEANUT PROGRAMS

Peanuts were added in 1934 to the list of commodities covered by the Agricultural Adjustment Act This addition placed the market for peanuts in the United States under numerous Government controls Initial legislation gave the Secretary of Agriculture authority to determine the quantity to be produced each year and established marketing quotas After 1941, producers were restricted to marketing only those peanuts grown on allotted acreage Specific price support levels, to be announced prior to planting, were authorized beginning in 1941

Controls were abandoned during World War II, except for minimum price guarantees of 90 percent of parity A new Agricultural Adjustment Act reintroduced controls in 1949 This act required the Secretary of Agriculture to announce the price support level, between 75 percent and 90 percent of parity, prior to the beginning of the peanut marketing season, and it established a minimum national allotment of 1,610,000 acres Acreage restrictions and price supports, basic features of post-war

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[1] Italicized numbers in parentheses refer to items in References at the end of this article

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peanut control programs, have continued to the present day [2]

Virtually no revision was made in peanut control programs after 1949 until the passage of the Food and Agriculture Act in 1977 The new program retained price supports and acreage allotments, and imposed poundage quotas at the State and farm level Two support prices were applied—one for peanuts produced within poundage quotas and the other for peanuts exceeding poundage quotas but satisfying the acreage quota In addition, instead of receiving support prices, producers were given the option of contracting with peanut processors at a single price [3]

Table 1 presents the levels of control variables, and actual harvested acreage, production, price, and Commodity Credit Corporation (CCC) losses for peanuts from 1935 to 1976 The control variables are as follows acreage allotments, marketing quotas, price supports, and CCC acquisitions Acreage allotments and support prices were active control variables over much of the study period Marketing quotas, however, have not been active controls but have been gradually adjusted upwards to approximate actual production on allotted acreage Similarly, the control variable, CCC acquisitions, is not active but depends functionally on acreage allotment, support price, and production

Peanut prices and acreage have varied little over time, especially since 1949, principally because of control The level of CCC losses, which has varied, represents a direct cost of imposing control Total CCC losses from 1935 to 1976 were $959 million, or $1 609 billion in constant 1976 dollars This loss represents the largest per unit subsidy for any major crop

MODEL SPECIFICATION

The basic objective of the model specification is to allow a determination of free-market, price-quantity time paths that would result if no controls had been imposed on the peanut industry These paths can be compared with actual price-quantity time paths to determine the net effects of control

The cost of control programs is represented by (1) direct costs—CCC losses incurred in buying and selling commodities for support operations, and program administrative expenses, (2) indirect costs arising when consumers pay higher prices for finished products as a consequence of controls, (3) and welfare costs that accrue when the sum of change in producers' and consumers' surpluses due to controls is negative Any of these costs may become benefits, of course, although generally this has not happened in domestic agricultural control programs

It might be argued that the indirect costs of control programs are not generally costs but benefits—the Government supports raw agricultural prices which encourages production, which leads to lower food prices through outward shifts in supply If the Government supported commodity prices through direct purchases, and sold to food processors at market prices, then this argument might be valid However, Government sales of commodities have generally been carried out through discriminatory disposal programs Instead of being sold to food processors, commodities have been sold for restricted uses, donated, or sold at reduced prices to other countries For peanuts, the Government has discriminated between edible peanut markets and the crushing market—edible peanuts have been contracted for sale by the Government for crushing This policy implies higher prices for edible peanuts and positive indirect costs

The standard approach for approximating free-market time paths is to construct an econometric model, as Heien (*5*) and others have done Typically, both demand and supply side representations are included, control variables are exogenous Stochastic or deterministic simulations are performed with the values of all control variables set equal to zero Simulated free-market time paths result Indirect-control costs can be computed based on differences between actual and simulated time paths

Usefulness of econometric models for measuring indirect control costs depends on the availability of appropriate sample data It is crucial that controls be applied over only part of the sample period, or that the levels of control variables change frequently, which imparts the necessary variation to allow estimation of parameters For the domestic peanut indus

[2] See Song (*16*) and Little (*8*) for a detailed review of the evolution of domestic peanut control programs

[3] As with previous programs, producers' associations continue to act as agents of the Commodity Credit Corporation Loans are made to farmers at the support price and redeemed when peanuts are harvested and delivered All peanuts which cannot be sold at prices greater than the support price become the property of the Commodity Credit Corporation See (*18*) for a review of the new program

Table 1—Levels of control variables, acreage, production, price and CCC losses, 1935-76

Year	Control level				Actual			CCC loss
	Acreage allotment	Marketing quota	Support price	CCC acquisitions	Acreage	Production	Price	
	1,000	*Million pounds*	*Cents/ pound*	*Million pounds*	*1,000*	*Million pounds*	*Cents/ pound*	*Million dollars*
1935	N A	N A	N A	73	1,497	1,153	3 1	0 3
1936	N.A	N A	N.A	0	1,660	1,260	3 7	0
1937	N A	N A	N A	166	1,538	1,233	3 3	2 3
1938	1,448	N.A	N A	253	1,692	1,289	3 3	3 3
1939	1,448	N.A	N A	69	1,908	1,213	3 4	7
1940	1,448	N A	N A	558	2,052	1,767	3 3	7 9
1941	1,448	N A	4 4	378	1,900	1,475	4 7	0
1942	1,610	1,256	6 6	899	3 355	2,193	6 1	0
1943	N A	N A	7 1	0	3,528	2,176	7 1	0
1944	N A	N.A	7 3	0	3,068	2,081	8 0	0
1945	N A	N.A	7.5	0	3,160	2,042	8 3	0
1946	N A	N.A	8 6	55	3,141	2,038	9 1	−6
1947	N A	N A	10 0	528	3,377	2,182	10 1	3 5
1948	N A	N A	10.8	1 167	3,296	2,336	10 5	25 6
1949	2,629	1,700	10.5	763	2,308	1,865	10 4	39 7
1950	2,000	1,286	10.8	835	2,262	2,035	10 9	17 1
1951	1,889	1,300	11.5	540	1,982	1,659	10 4	9 4
1952	1,706	1,300	12 0	106	1,443	1,356	10 9	4 8
1953	1,679	1,326	11 9	294	1,515	1,574	11 1	14 0
1954	1,610	1,348	12 2	0	1,387	1,008	12.2	0
1955	1 731	1,592	12 2	268	1,669	1,548	11 7	17 1
1956	1,650	1,500	11 4	334	1,384	1,607	11 2	20 2
1957	1,611	1,451	11 1	108	1,481	1,436	10 4	6 1
1958	1,612	1,652	10 7	383	1,516	1,814	10 6	21 2
1959	1,612	1,772	9 7	246	1,435	1,523	9 6	11 4
1960	1,612	1,868	10 1	299	1,395	1,718	10 0	16 7
1961	1,612	1,940	11 0	231	1,398	1,657	10.9	12 1
1962	1,613	2,012	11 1	331	1,400	1,719	11 0	21 2
1963	1,612	2,012	11.2	371	1,396	1,942	11 2	28 3
1964	1,613	2,133	11 2	512	1,397	2 099	11 2	30 5
1965	1,613	2,375	11 2	688	1,438	2,384	11 4	44 3
1966	1,613	2,737	11 4	701	1,421	2,410	11 3	43 8
1967	1,613	2,858	11 4	605	1,404	2,473	11 4	48 2
1968	1,613	2,978	12 0	581	1,438	2,543	11 9	38.8
1969	1,612	3,099	12 4	588	1 456	2,529	12 3	36 0
1970	1,613	3,075	12 8	1,062	1,467	2,979	12.8	66 3
1971	1,613	3,107	13 4	1,175	1,454	3,005	13 6	97 3
1972	1,613	3,268	14 3	1,178	1,486	3,275	14.5	58 0
1973	1,612	3,542	16 4	834	1,496	3,474	16 2	5 0
1974	1 612	3,703	18 3	962	1,472	3,668	17.9	3 0
1975	1,612	3,799	19 7	1,012	1,504	3,857	19 6	111 0
1976	1,612	4,009	20 7	841	1,522	3,751	20 0	102 0

Note N A means not applicable

The methodology involves linear programming models representing the producer's decision problem, with commodity prices taken as given

try, prices for peanut products have varied considerably over the years, sufficiently to allow the estimation of demand-side relations Acreage allotments and price supports have not varied substantially over much of the sample period, however, being virtually constant from 1952 to 1976 The result is that, when a supply function is estimated, peanut production is found to be virtually insensitive to changes in price

Available sample information does not allow estimation of the supply side of the model One alternative is to generate a pseudodata set with sufficient variation to allow the estimation of a supply function The generation of pseudodata has been advocated recently by Griffin (*3, 4*) in a study of the petroleum industry It resembles the approach suggested by Shumway and Chang (*14*) for determining supply functions for major U S crops

The methodology involves linear programming models representing the producer's decision problem, with commodity prices taken as given Random variation of peanut prices, with other commodity prices at constant levels, results in a schedule of optimal values for peanut production for alternative prices The supply function can be estimated from this pseudodata set

THE SUPPLY SIDE

U S peanut production is concentrated in three major regions southeastern Virginia and eastern North Carolina, central Alabama and western Georgia, and central Texas and southern Oklahoma Linear programming models were constructed to represent individual producer decisions in each of these regions The models are simple, incorporating basic crop substitutes for each region, but omitting livestock production activities Aggregation gives regional output levels, which in turn sum to national output

Alternative output activities for each decision model include peanut, cotton, and corn production In addition, soybean production is included as an output activity in Virginia-North Carolina Input activities include capital, and land used for peanuts or for other crops These two land classifications allow a resource constraint to be applied to land used for peanut production, which simulates the effects of an acreage allotment Other constraints are placed on total capital and land availability

Individual producers in each region are assumed to maximize expected profits $E_{t-1}(f_t)$ subject to resource constraints Expected profit is defined as

$$E_{t-1}(f_t) = E_{t-1}(p_t)z_t - w_t s_t - r_t k_t \qquad (1)$$

where $E_{t-1}(f_t)$ and $E_{t-1}(p_t)$ are the mathematical expectations of profit and product prices conditional on information available in $t-1$ (prior to harvest), f_t is profit, p_t is a vector of output prices, w_t is a vector of land rental prices, r_t is the price of capital, z_t is a decision vector representing output levels, s_t is a decision vector of land input levels, and k_t is a scalar decision variable for capital input level

Relation (1) is maximized subject to

$$Iz_t - g_t k_t \leq 0 \qquad (2)$$

$$Iz_t - B_t s_t = 0 \qquad (3)$$

$$k_t \leq b_t \qquad (4)$$

$$Is_t \leq c_t \qquad (5)$$

$$z_t, k_t, s_t \geq 0 \qquad (6)$$

where I is an identity matrix, g_t is a vector of technical coefficients transforming capital into output, B_t is a matrix of technical coefficients transforming land into output, b_t is a capital resource constraint, and c_t is a vector of resource constraints on land utilization Constraint (2) limits output according to capital availability Constraint (3) limits output according to land requirements Constraints (4) and (5) restrict capital and land use to available amounts and constraint (6) imposes nonnegativity

Technical coefficients and the levels of resource constraints are constructed using census data on land availabilities, yields per acre, and net farm income Capital coefficients are developed regionally using cost of production surveys performed by the Economic Research Service (now part of ESCS) (*1*), and budget data constructed by McArthur, Saunders, and Steanson (*9*) Cost of production indices are used to approximate technical coefficients for years when no actual data are available

Initially the model was used to solve for the number of producers in each region over the period 1952 to 1976 Acreage controls were entered at actual levels and expected peanut prices were set equal to price supports

Technological change is captured within the model, as are the effects of weather variations on yields

A second solution was then obtained by generating random values for peanut price in each year The peanut price was assumed to be uniformly distributed between a lower bound consisting of the peanut price time path generated by a version of the model which allows acreage to increase along pre-1949 trend and an upper bound consisting of the actual market price for peanuts In this way, random values of peanut prices were kept within "reasonable" limits Expected peanut prices were assumed to equal peanut prices from the preceding period In addition to selection of peanut prices randomly in the new solution, acreage allotment constraints were assumed not binding Free-market time paths were the result

Random selection of peanut prices in the second solution introduces an additional complication As peanut prices depart from historical levels, producer incomes are changed—the b_t value in constraint (4) for each problem is no longer valid beyond 1952 So that this could be allowed for, the capital constraint for each producer is redefined as

$$b_t = (1-\alpha) f_{t-1}$$
$$= (1-\alpha)(p_{t-1} z_{t-1} - w_{t-1} s_{t-1} - r_{t-1} k_{t-1}) \qquad (7)$$

where α represents the marginal propensity to consume from producer income and the subscripts denote lagged values Capital resources available in the current year are a percentage of net income from the previous year for each producer Initially α is set at 0 25

The use of relation (7) as a definition of capital resource availability provides a direct linkage over time from one programming problem to another For this reason, the generation of pseudodata involves the solution of individual dynamic programming problems for each region Twenty-five stages (years) are included in each regional dynamic programming problem, the results yielding the required solutions (q^*, s^*, k^*) for individual producers from 1952 to 1976

After solution of the three regional dynamic programming problems for individual producers, the aggregate pseudo-output of peanuts produced in each year is obtained by multiplying individual peanut production levels by the number of producers in each region and summing to get regional totals

Table 2 presents peanut prices, aggregate pseudo-output of peanuts, and the prices of cotton, corn, and soybeans (the alternative outputs in each problem) A comparison of the data in table 2 with that in table 1 indicates considerable variation in pseudopeanut production as peanut prices change This is enlightening intuitively and consistent with prior expectations—variation has been induced artificially in the pseudodata set

Three facets of the dynamic programming solution deserve special comment First, the levels of the technical coefficients transforming capital and land input into output are revised over time based on actual change in capital and land productivity Technological change is thus captured within the model, as are the effects of weather variations on yields Second, the number of producers is the same in both the controlled and the free-market solution This assumption is, of course, unrealistic because the number of producers would be expected to change in a free market And, third, the assumption that the prices of alternative output activities remains constant over time is questionable Even through peanuts are only partial substitutes in consumption for other commodities, variation in peanut price might have some effect on these markets

From the data in table 2, a linear supply function is estimated Although peanut production is clearly a function of the linear programming parameters dated prior to and through each solution year, the inclusion of all the necessary parameters would introduce collinearity problems, even if the appropriate data were available on an aggregate level Thus, peanut supply is written simply as a function of lagged output prices and lagged production (included to reflect the role of past prices in the dynamics of the programming solution) Omitting the price of corn and soybeans, because of little contribution to explanatory power and lack of statistical significance, leads to the simple supply function

$$z_t = \underset{(2349)}{1157} + \underset{(169)}{776}\, p_{t-1} - \underset{(7283)}{16609}\, u_{1,t-1} + \underset{(155)}{0\ 238}\, z_{t-1}$$
$$R^2 = 0\ 67 \qquad (8)$$

Table 2—Pseudo-output and price for peanuts, actual corn, cotton, and soybean prices

Year	Peanuts		Lagged price of—		
	Lagged pseudo-output	Price	Corn	Cotton	Soybeans
	Million pounds	*Cents/pound*	*Dollars/bushel*	*Cents/pound*	*Dollars/bushel*
1952	1,930	4.8	1 66	37 9	2 73
1953	2,152	5 0	1.52	34 6	2 72
1954	904	4 9	1 48	33 6	2 72
1955	1,302	5 2	1 43	35 1	2 46
1956	411	6 1	1 35	33 7	2 22
1957	393	9 1	1 29	33 1	2 18
1958	1,773	5 4	1 11	30 9	2 07
1959	502	5 7	1 12	34 7	2 00
1960	853	4 9	1 05	31 7	1 96
1961	501	10 3	1 00	30 2	2 13
1962	457	5 5	1 10	32 9	2 28
1963	259	8 9	1 12	31 9	2 34
1964	176	8 5	1 11	32.2	2 51
1965	219	6 3	1 17	31 1	2 62
1966	167	5 8	1 16	29 4	2 54
1967	5,197	10 6	1 24	21 8	2 75
1968	4 355	8 4	1 03	26 7	2 49
1969	1,674	5 5	1 08	23 1	2 43
1970	10 084	11 5	1 16	22 0	2 35
1971	7,140	10 8	1 33	22 9	2 85
1972	13,561	12 2	1 08	28.2	3 03
1973	7,121	11 9	1 57	27 3	4 38
1974	1,003	9 8	2 55	44 6	5 68
1975	4,551	11 7	3 03	42 9	6 64
1976	8,745	18 3	2 54	51 3	4 92

There is no way to produce simulated time paths with the model which would be comparable to historical time paths This inability is, unfortunately, a major shortcoming of the pseudodata approach

where z_t is now defined as scalar peanut production, p_{t-1} is lagged price of peanuts, $u_{1,t-1}$ is lagged price of cotton, the numbers in parentheses are standard errors, and the R^2 value is unadjusted [4]

For relation (8), the elasticity $(d \ln z_t / d \ln p_{t-1}$ evaluated at the mean sample level is 2 1 This "shortrun" elasticity is somewhat larger than similar elasticities estimated using actual time series for other crops However, it compares favorably with Houck, Ryan, and Subotnik's (7) estimates of shortrun regional supply elasticities for soybeans, a crop with characteristics similar to those of peanuts For the Atlantic States, Houck, Ryan, and Subotnik found a supply elasticity of 3 3, for the Plains States, 2 1 These two regions correspond roughly to the three peanut producing regions considered in this study For this reason, normative linear programming does not appear to yield results which are inconsistent with previous empirical findings

THE DEMAND SIDE

The demand side of the model consists of 13 linear equations which represent the markets for peanuts and 3 peanut products peanut oil, peanut meal, and edible peanuts Each product market is linked by production functions to the peanut market so that changes in consumer demands are transmitted directly as derived demands to the primary commodity markets for peanuts [5]

Of the 13 equations included in the demand-side representation, 8 are behavioral relations and 5 are identities The behavioral relations include a stock supply equation for peanuts, a price equation relating peanut price to other prices and other variables, shortrun production functions for peanut oil, and shortrun production functions for peanut meal, demand relations for peanut oil, for peanut meal, and for edible peanuts, and a supply function for edible peanuts Behavioral relations are specified on the basis of static theory, intuition, statistical significance of estimated coefficients, and explanatory power

Appendix table 1 presents identities and three-stage least squares estimates of the behavioral relations of the demand side of the model Definitions of variables in the model are presented in appendix table 2 The sample used for estimation covers the period 1929 through 1976, a total of 48 observations [6] Virtually all of the estimated coefficients were found highly significant statistically and of the expected sign [7]

THE COMPLETE SYSTEM

A combining of relation (8) with the demand side of the model gives the following reduced-form system

$$y_t = d_0 + D_1 y_{t-1} + D_2 x_t + D_3 g_t + e_t \qquad t=1, \quad , T \qquad (9)$$

where y_t is a vector of 14 endogenous variables consisting of z_t from relation (8) and the 13 endogenous demand-side variables, x_t is a vector of 11 exogenous variables not subject to control, consisting of p_{t-1} and $u_{1,t-1}$ from relation (8) and the exogenous variables from the demand side, g_t is a vector of 3 demand-side control variables, consisting of Government stocks, net Government purchases, and the price support level, e_t is a vector of stochastic residuals, d_0 is a vector of reduced-form intercepts, and the D_i, $i=1,2,3$, are coefficient matrices of reduced-form parameters

System stability conditions require that D_1 possess characteristic roots with absolute values less than unity

[4] Changing the starting values for the pseudo random number generator used to produce the data had little effect on the estimated parameters of relation (8) The use of several pseudodata sets for estimation also did not generate estimated parameters significantly different from those presented in relation (8)

[5] Although the product markets considered are not actually finished product markets, they are treated essentially as such in this study because of the complexity of dealing with final products Peanut oil is used in shortening, cooking oil, margarine, mayonnaise, and salad dressing Edible peanuts are consumed as peanut butter, candy, and roasted peanuts

[6] A lengthy time series was necessary to obtain sufficient price-quantity variation

[7] The estimated coefficients on quantity in the demand relations for peanut oil and meal are not highly significant statistically Because the markets for soybean oil and meal are so large, and because peanut oil and meal are close substitutes for soybean oil and meal, large changes in peanut oil or meal production would not be expected to have a large effect on own price The estimated coefficients are retained, however, because simulations are performed outside the range of the historical data Also, behavioral relations with price written on the left-hand side as an endogenous variable are justified theoretically, according to Heien (6), based on Samuelson's (13) indirect utility argument

The demand side of the model can be used to generate simulated time paths which should approximate historical time paths, given peanut production levels

If any of the moduli of D_1 exceed unity, the system is unstable, misspecification is implied, the assumptions of estimation are violated, total multipliers fail to exist, and the values of y_t explode as $t \to \infty$. Computation of the eigenvalues for D_1 yield the nonzero values 0.78; −0.25−0.09*i*, −0.25+0.09*i*, 0.49, and 0.41. Hence, relation (9) composes stable system with cyclical time paths which converge over time to a steady state.

In addition to stability, it is necessary that relation (9) be a valid representation. Clearly, the traditional validation tests cannot be performed on relation (9) because the supply function is estimated using pseudodata, there is no way to produce simulated time paths with the model which would be comparable to historical time paths. This inability is, unfortunately, a major shortcoming of the pseudodata approach.

The demand side of the model can be used to generate simulated time paths which should approximate historical time paths, given peanut production levels. Thus, it can be validated separately from the supply side. Although this type of validation ignores simultaneity with the supply side, it does allow for partial validation. Following Naylor (*11*), both retrospective and prospective validations of the demand side are attempted.

For validation, simulated time paths are generated through use of the actual values of y_o as a seed. All exogenous variables, including control variables, are set at actual levels. Generated values for endogenous variables are reintroduced as the values of lagged endogenous variables in later periods. The retrospective validation is carried out over the time period on which estimation is based, 1929 through 1976. A comparison of simulated with actual time paths gives mean absolute errors of less than 10 percent for most variables. Theil (*17*) inequality coefficients less than unity result for 8 of 13 endogenous variables. These results seem acceptable, given the variability in the data set.

Many analysts estimate econometric models over subsamples of available observation sets, reserving several observations for use in prospective validation. However, system (9) is estimated based on all available sample information, so that a prospective validation is not possible. As an alternative, the demand side of the system is re-estimated with data for 1929 through 1971 under the assumption that the same system specification is equally valid over both time periods. Prospective paths then can be generated and compared with actual time paths for 1972 through 1976. Appendix table 3 presents both for the demand side with 1971 endogenous values as a seed. The model tracks fairly well over a period of substantial variation in the data.

INDIRECT CONTROL COSTS AND PRODUCER INCOME

Indirect control costs and producer income effects attributable to Government controls can be evaluated by comparing simulated free-market time paths with historical time paths of the endogenous variables. This comparison is analagous to evaluating a succession of alternative price quantity equilibria, given shifts in the underlying behavioral relations.

So that this evaluation can be performed, simulated free-market time paths are generated by setting $g_t = 0$ for $t = 1, \ldots, T$ in (9) and computing the alternative equilibria y_t over $t = 1, \ldots, T$:

$$\hat{y}_t = d_0 + D_1 y_{t-1} + D_2 x_t \quad t=1 \quad (10)$$

$$\hat{y}_t = d_0 + D_1 \hat{y}_{t-1} + D_2 x_t \quad t=2, \ldots, T$$

The resultant deterministic time paths may be compared directly with the deterministic time paths generated with g_t set at actual values and e_t set at zero. Alternatively, the e_t values of (9) could be utilized to produce $\hat{y}_t$ $t=1, \ldots, T$ and the results compared with the historical time paths of endogenous variables. The former alternative is pursued here because there is no loss in neglecting the stochastic error.

A convenient method for analyzing the deterministic $\hat{y}_t$ produced by relation (10) is to compare the distribution statistics of the simulated time paths with the distribution statistics of actual deterministic time paths of the system. Table 3 presents means and standard deviations for actual deterministic and simulated free-market deterministic time paths produced using relation (10). From the information in the table, the following generalizations can be made: (1) peanut production and domestic disappearance more than double without controls, (2) stocks decrease more than one-half without controls, (3) peanut crushings increase almost eight times while domestic disappearance of edible peanuts changes little.

Government control failed to reduce price variability in the domestic peanut industry This result contrasts with the generally accepted convention that controls lead to greater price stability in commodity markets

Table 3—Means and standard deviations of actual and simulated free market time paths[1]

Variable	Mean		Standard deviation	
	Actual	Simulated	Actual	Simulated
Production				
Peanuts	2,333	5,805	832	3,775
Peanut oil	165	1,380	105 3	1,161
Peanut meal	112	884	64 6	734
Price				
Peanuts	12 7	7 8	2 9	2.8
Peanut oil	18 8	11 2	8 6	5 4
Peanut meal	85 3	73 0	39 9	33 7
Edible peanuts	21 7	14 4	4 2	4 6
Difference between peanut and almonds prices	-12.5	-19 8	9 1	9 5
Peanut stocks	453	205	212	86
Domestic consumption				
Peanuts	2,119	5,620	612	3 625
Peanut oil	130	1,349	77	1,151
Peanut meal	110	886	66	735
Edible peanuts	1,400	1,402	287	236
Peanuts crushed	535	4 217	311	3 516

[1] Units of measurement are in appendix B

without controls, and (4) all mean prices decline in a system with no controls—peanut prices by 38 5 percent, peanut oil prices by 40 4 percent, peanut meal prices by 14 4 percent, and edible peanut prices by 33 6 percent, respectively [8]

Standard deviations of all quantity variables increase without controls, except for edible peanut consumption Conversely, the standard deviations of prices decline without controls These findings suggest that Government control failed to reduce price variability in the domestic peanut industry This result contrasts with the generally accepted convention that controls lead to greater price stability in commodity markets [9]

A more interesting and specialized measure of the effects of control is obtained by computing the indirect costs imposed on consumers by the control program In this study, indirect control costs are defined as the difference between actual costs of peanut products to consumers, and the simulated free-market costs to consumers of the same quantity of peanut products The total cost of peanut products is

$$C = \sum_i C_i = \sum_i \sum_t p_{it} q_{it} \qquad (11)$$

where C_i is the cost to consumers of the ith peanut product over $t = 1,$, T, where $i = 1,2,3$ for peanut oil, peanut meal, and edible peanuts The scalars p_{it} and q_{it} represent price and consumption of peanut products Indirect control costs (D) are defined as

$$D = \sum_i \sum_t (p_{it} - \hat{p}_{it})\, q_{it} \qquad (12)$$

where the $\hat{p}_{it}$ are simulated price equilibria

Table 4 presents actual and simulated costs to consumers of peanut oil, peanut meal, and edible peanuts in current and constant 1976 dollars for 1952 through 1976 Indirect control costs by product type are also given in the table Indirect costs to consumers of peanut products totaled $2.83 billion from 1952 to 1976 in current dollars, and $4 58 billion in 1976 dollars The major source of these costs was in the edible peanuts market—89 percent in current dollars and 91 percent in 1976 dollars

Actual and simulated gross producer income also appears in table 4 Actual producer income (I) is defined as

[8] The simulated mean price for peanut oil at 11 2 cents compares with an actual mean price of soybean oil over the period at 13 0 cents Traditionally, peanut oil has commanded a premium over soybean oil The simulated mean price for peanut meal at $73 00 compares with an actual mean soybean meal price of $95 16 Traditionally, peanut meal has sold at a discount with respect to soybean meal

[9] The fact that price standard deviations are less in the free-market system may be a consequence of the on-off nature of controls throughout the thirties and forties

The peanut control program did increase net producer income, although gross producer income would have been greater in a free market

Table 4—Indirect costs of control and producer income

Time path type	Costs to consumers				Producer income
	Peanut oil	Peanut meal	Edible peanuts	All products	
	Billion dollars current				
Actual	0 66	0 27	7 50	8 43	7 57
Simulated free market	40	23	4 97	5 60	13 03
Difference	26	04	2 53	2 83	5 46
	Billion dollars (1976)				
Actual	97	39	12 33	13 69	11 89
Simulated free market	60	33	8 18	9 11	19 89
Difference	37	06	4 15	4.58	8 00

$$I = \sum_t p_t z_t \qquad (13)$$

where z_t is peanut production Simulated free-market gross producer income is defined similarly, except that p_t and z_t are replaced by $\hat{p}_t$ and $\hat{z}_t$ Under a free market, gross producer income would have totaled $13 03 billion in current dollars and $19 89 billion (1976 dollars) from 1952 to 1976 Under controls, actual gross producer income was $7 57 billion (current dollars) and $11 89 billion (1976 dollars) Clearly, gross producer income would have been higher in a free market This result is attributable to greatly expanded output, even though peanut prices are lower

Although *gross* income to producers would have been higher from 1952 to 1976 with no Government control, it is not clear whether *net* income would have been greater [10] This is an important question because the objective of control was to increase producer net income An evaluation of this issue requires an analysis of the production and cost structure of producers—structures which are embodied in the programming models developed to estimate the supply function

The production and cost structures of the programming models developed in this study are somewhat simplistic—returns to scale are assumed to be constant and only a limited number of production activities are considered Yet they can be used to compute net income to producers with and without controls Net income with controls is determined by adding an additional activity to each regional linear program to represent capital used in peanut production In the initial formulation, capital costs were not allocated per product The regional dynamic programming problems are then solved with acreage allotments and price supports set at actual levels Land and capital costs attributed to peanuts are subtracted from the value of peanut sales to obtain an estimate of actual producer net income from peanuts This process gives an estimate of $3 85 billion in current dollars from 1952 to 1976 for net producer income under controls

Net income to peanut producers in a free market is determined by allowing peanut acreage to vary above allotments and by setting

[10] An important distinction is made between income and net income in this study The former is total revenue, output times price, while the latter is income above costs, representing returns to management

Only a direct payments scheme, and the setting of controls at levels which replicate free-market results, would result in a cost/benefit equilibrium

peanut prices at simulated free-market levels Solution of the regional dynamic programming problems under these conditions gives free-market producer net income of $2 47 billion in current dollars from 1952 to 1976, an amount $1 38 billion less than estimated net income under controls Consequently, the peanut control program did increase net producer income, although gross producer income would have been greater in a free market

CONCLUSIONS

The major objective of Government control programs has been to increase the net income of peanut producers, although specific target levels for income have never been specified by the Congress The principal instruments of control have been an acreage allotment and price support program implemented annually since 1949

Indirect costs of controls to consumers from 1952 to 1976 have been more than $2 83 billion, based on the model Adding this amount to the direct costs of controls from 1952 through 1976 ($0 85 billion) gives total costs of controls as $3 68 billion Control programs added only $1 38 billion to net producer income from 1952 to 1976 From a social cost/benefit point of view, the control program can be seen as unjustified—its costs exceeded the benefits A direct payments scheme would have been more efficient

The major finding is that the acreage allotment and price support programs are inefficient, given the objective of increasing producers' net income Several shortcomings underlie this conclusion, however First the modeling process is subjective The assumption of profit maximization in the dynamic programming problems, decisions on the equations and variables to use, and the validation of the model are normative Second, equations representing other simultaneous markets which should be included in the model are omitted For example, the increase in peanut production in a free market must affect other commodity markets as other crop acreages are displaced by peanuts These omissions may have resulted in the introduction of simulataneous equation bias in the estimates and structural misspecification A model including all of the necessary markets endogenously would be extremely large, however [11]

The new peanut control program establishes an additional instrument for control—a production quota which provides a means of implementing a dual-level price support program The addition of a new control instrument, however, does not change the program—acreage allotments, price supports, and purchase plans remain intact The social costs of the new program, like those of the old, are likely to exceed the benefits Only a direct payments scheme, and the setting of controls at levels which replicate free-market results, would result in a cost/benefit equilibrium

[11] Additionally, export demand for peanut products would have to be considered since free-market U S prices of peanut products decline to world price levels in some years This addition may not, however, significantly alter the findings of this study

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Appendix table 1—Demand-side behavioral relations and identities

Equation	Variable	Estimate or definition[1]
(1)	q_t	$s_{t-1} - s_t + z_t - x_t$
(2)	s_t	$-32\ 9 + 17\ 5\ p_t + 0\ 49\ s_{t-1} + 0\ 84\ r_t$ (26 0) (4 5) (09) (12)
(3)	p_t	$0\ 56 + 0\ 33\ h_t + 0\ 42\ p_{t-1} + 0\ 00049\ q_t + 0\ 037\ p_{1t} + 0\ 011\ p_{2t}$ (30) (05) (07) (00017) (016) (004)
(4)	z_t	$-12\ 9 + 0\ 33\ c_t$ (1 9) (00)
(5)	p_{1t}	$-0\ 48 - 0\ 0042\ q_{1t} + 0\ 46\ v_{1t} + 0\ 00076\ m_t - 0\ 069\ v_{2t} + 0\ 51\ v_{3t} + 0\ 32\ p_{1\ t-1}$ (58) (0054) (11) (00027) (022) (11) (04)
(6)	q_{1t}	$z_{1t} - x_{1t}$
(7)	z_{2t}	$3\ 00 + 0\ 21\ c_t$ (1 60) (00)
(8)*	p_{2t}	$1\ 92 - 0\ 017\ q_{2t} + 0\ 0054\ m_t + 1\ 21\ v_{4t} - 0\ 30\ v_{5t}$ (2 62) (038) (0022) (13) (08)
(9)	q_{2t}	$z_{2t} - x_{2t}$
(10)	q_{3t}	$162 - 1\ 30\ v_{6t} + 0\ 050\ m_t + 0\ 79\ q_{3\ t-1}$ (64) (1 37) (021) (09)
(11)	p_{3t}	$-0\ 87 + 0\ 0028\ q_{3t} + 1\ 44\ p_t$ (73) (0008) (06)
(12)	v_{6t}	$p_{3t} - v_{7t}$
(13)	q_t	$c_t + q_{3t} + q_{4t}$

[1] Standard errors are in parentheses

Appendix table 2—Definitions of system variables

Endogenous variables			Exogenous variables		
Variable	Definition	Unit	Variable	Definition	Unit
c_t	Peanut crushings	Million pounds	h_t	Price support for peanuts	Cents per pound
p_t	Peanut prices	Cents per pound	m_t	Per capita disposable income	Thousand dollars
p_{1t}	Price of peanut oil	do	q_{4t}	Uses of peanuts other than for crushing and edible consumption	Million pounds
p_{2t}	Price of peanut meal	Dollars per ton	r_t	Government stocks of peanuts	do
p_{3t}	Price of shelled peanuts	Cents per pound	u_{1t}	Price of cotton	Cents per pound
q_t	Consumption of peanuts	Million pounds	v_{1t}	Price of soybean oil	do
q_{1t}	Consumption of peanut oil	do *u*	v_{2t}	Price of cottonseed oil	do
q_{2t}	Consumption of peanut meal	Thousand tons	v_{3t}	Price of shortening	do
q_{3t}	Consumption of edible peanuts	Million pounds	v_{4t}	Cottonseed meal price	Dollars per ton
s_t	Stocks of peanuts, end of year	do	v_{5t}	Soybean meal price	do
v_{6t}	Difference between shelled peanut price and the price of almonds	Cents per pounds	v_{7t}	Price of almonds	Cents per pound
z_t	Production of peanuts	Million pounds	x_t	Net exports, and Government sales/purchases of peanuts	Million pounds
z_{1t}	Production of peanut oil	do	x_{1t}	Net exports and other uses of peanut oil	do
z_{2t}	Production of peanut meal	Thousand tons	x_{2t}	Net exports and other uses of peanut meal	Thousand tons

Appendix table 3—Actual and predicted prospective time paths, 1972 76

	1972		1973		1974		1975[1]		1976	
Variable	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
q_t	3,048	2,488	2,887	2,341	3,025	2,523	2,556	2,244	3,098	2,994
c_t	850	813	683	516	590	631	1,447	365	1,108	1,041
q_{3t}	1,694	1,675	1,840	1,824	1,800	1,892	1,870	1,878	1,800	1,953
s_t	392	420	429	434	553	462	1,146	815	1,060	765
p_t	14.5	14 1	16 2	15.5	17 9	17 1	19 6	18 1	20 0	19 9
p_{1t}	18.8	18 4	38 0	35 5	42 6	43 3	33.8	36 6	32 1	32 6
p_{2t}	102	119	170	131	126	123	143 6	138 1	212	172
z_{1t}	269,	250	214	155	188	192	476	107	363	323
z_{2t}	180	177	143	112	123	137	300	80	233	226
p_{3t}	24.9	24.9	28.8	27.5	27.5	30 1	30 3	31 6	30 9	34 6
q_{1t}	174	145 5	149	95 4	157	157 3	378	10	214	277
q_{2t}	189	168	141	114	124	136	298	82	235	224
v_{6t}	−14 4	−14 3	−45 7	−47 0	−17 5	−14 9	−9 7	−8 4	−8 6	−4 9

[1] In 1975, the Government implemented a toll-crushing program to dispose of surplus peanuts Its effects are not captured endogenously by the model