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AN ECONOMIC APPRAISAL OF THE U. S. TUNG OIL ECONOMY

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Tung has been a preferred natural drying oil because of the high gloss finish, durability and water resistance qualities which it imparts to paint, varnish and lacquer products. However, increased competition from chemical synthetics, combined with lower prices for other natural oils since the early 1950's, has brought a decline of domestic tung oil consumption from 72.4 million pounds in 1950-51 to around 32 million pounds in 1968-69.

The mandatory support program, initiated in 1948, obligates the Commodity Credit Corporation to support tung oil prices to growers at a minimum 65 percent of parity or at 24.3 cents per pound in 1968. Large accumulations of CCC stocks, close to 63 million pounds in 1966, triggered a change in CCC inventory policy. A two-tier pricing system was initiated to sell old crop oil. Open market sales of CCC stocks resulted in a low market price of 10.3 cents per pound tank quote during 1968, or about 40 percent of the support price. Competition from imported tung oil was a complicating factor.

The low tung oil prices of 1968 brought objections from Paraguay, via the U.S. State Department, that CCC policy was inconsistent with growth and development of an industry which was a major dollar earner for the Paraguay economy. While imports from Argentina and Paraguay have dropped to around 18 million pounds annually, stocks in all positions are still estimated at about 55 million pounds for 1969.

Because of the severe freeze damage to tung trees in 4 of the past 5 years, domestic producers have requested that the Department of Agriculture provide some additional economic relief for the industry. The type of requests suggested included: (1) an increase in minimum parity, (2) establishment of import quotas, (3) increased funding for crop and utilization research, and (4) some form of direct assistance payments or long-term loans to assist producers in undertaking crop adjustments to reduce the size of the tung industry. More recently, Hurricane Camille partially accomplished the latter request. Estimates of crop damage range from 35 to 50 percent of all trees.

A simplified econometric model was developed which depicts historical demand, supply, and price relationships in the tung nut and oil economy as a basis for projecting consumption, prices, stock levels, domestic production, and government inventory costs for tung oil under several alternative policies and general economic conditions. Alternatives considered include: (1) the impact of two import levels on the domestic tung economy, (2) the impact of an increase in minimum parity to 75 percent, and (3) consequence of a 35 percent crop loss because of Hurricane Camille.

FORMULATION OF MODEL

The general model proposed for tung consists of three behavorial equations and a supply-utilization balancing equation. The framework is basically recursive with simultaneous solutions for consumption, price and inventory adjustments. In matrix notation the system is expressed as:

$$Ay_t + B_1 Y_{t-1} + \ldots + B_i Y_{t-1} + C X_t = U_t \qquad (1)$$

where

A = a matrix of coefficients for the current endogenous variables

B_i = a matrix of coefficients for endogenous variables lagged i periods

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C	=	a matrix of coefficients for exogenous variables
Y_t	=	a vector of current endogenous variables
Y_{t-i}	=	a vector of endogenous variables lagged i periods
X_t	=	a vector of exogenous variables
U_t	=	a vector of errors

To illustrate more precisely the conceptual structure, a simplified supply-demand flow chart is given in Figure 1. Numbers in parentheses depict the major variables to be explained. Solid lines indicate a causal relationship, while broken lines show quantity flows. Arrows give the directions of influence or flow. A double line intersecting any solid line suggests a lagged period influence.

As can be noted from Figure 1, more than four equations could be required for a statistical model. Behavioral equations for new tree plantings, tree removals, and yield per tree might have been specified for determining the nature of production adjustments. Also, a relationship for explaining tung oil imports theoretically should be included. However, because of insufficient data for these variables, the model is restricted to equations for domestic consumption demand, total inventory demand, domestic production response, and a supply-use identity incorporating net trade in tung oil.

Production Response Equation

Tung is a perennial tree crop which requires several time periods for production adjustments to occur in response to a changed economic environment (Figure 1). Variables which would be expected to enter the production response function include: expected profitability as related to decisions on new plantings or tree removals and expected profitability from alternative investments. In addition, annual production changes for tung are greatly influenced by annual weather conditions, particularly cold weather, during bloom in the spring. Age distribution of trees and technology also are thought to have some influence [2].

The following production response function for tung was derived by ordinary least squares after trying several alternative statistical formulations:

$$Q_{Tot} = -32.1371 + \underset{(8.97)}{23.0768}\,[P_{to}/F]_{t-7} + \underset{(8.465)}{19.0388}\,[P_{to}/F]_{t-1} \underset{(.382)}{-0.4007}\,T + \underset{(.111)}{0.7271}\,A_t + \underset{(0.015)}{0.1980}\,W_t \qquad (2)$$

$R^2 = 0.971$; D.W. = 2.84

(standard errors given in parentheses)

where

Q_{Tot}	=	domestic production of tung oil in current year, in million pounds
P_{Tot-i}/F_{t-i}	=	two-year average ratio of grower price for tung oil to farm wage rate lagged i periods (proxy for measure of profitability)
W_t	=	Implicit weather index[1]
A_t	=	estimated percentage of trees 16 to 25 years of age[2]
T	=	time trend

The elasticities of 0.675 and 0.404 computed at mean values for the two profitability variables seem reasonable. However, multicollinearity [1] was a problem in identifying the separate effects of age and technology on domestic output. As a predictive equation, the high R^2 is desirable except that much of the year to year variation is due to weather.

Domestic Consumption Demand

The derived demand for tung oil is considered dependent on the production of paints, varnishes and lacquers; on effective costs of competitive or complementary raw materials used in surface coatings; and on the price of tung. Because of the problems of selecting a representative price series, the influence of chemical synthetics as a demand shifter for tung is approximated by a ratio of the natural oils in formulas for protective surface coatings. While the approach leaves much to be desired in unraveling the

[1] Derivation of indirect weather measure reflects variation in oil yields per tree not attributed to technology or age of trees.

[2] Based on interpolation of census data on number of bearing and non-bearing trees at five year intervals.

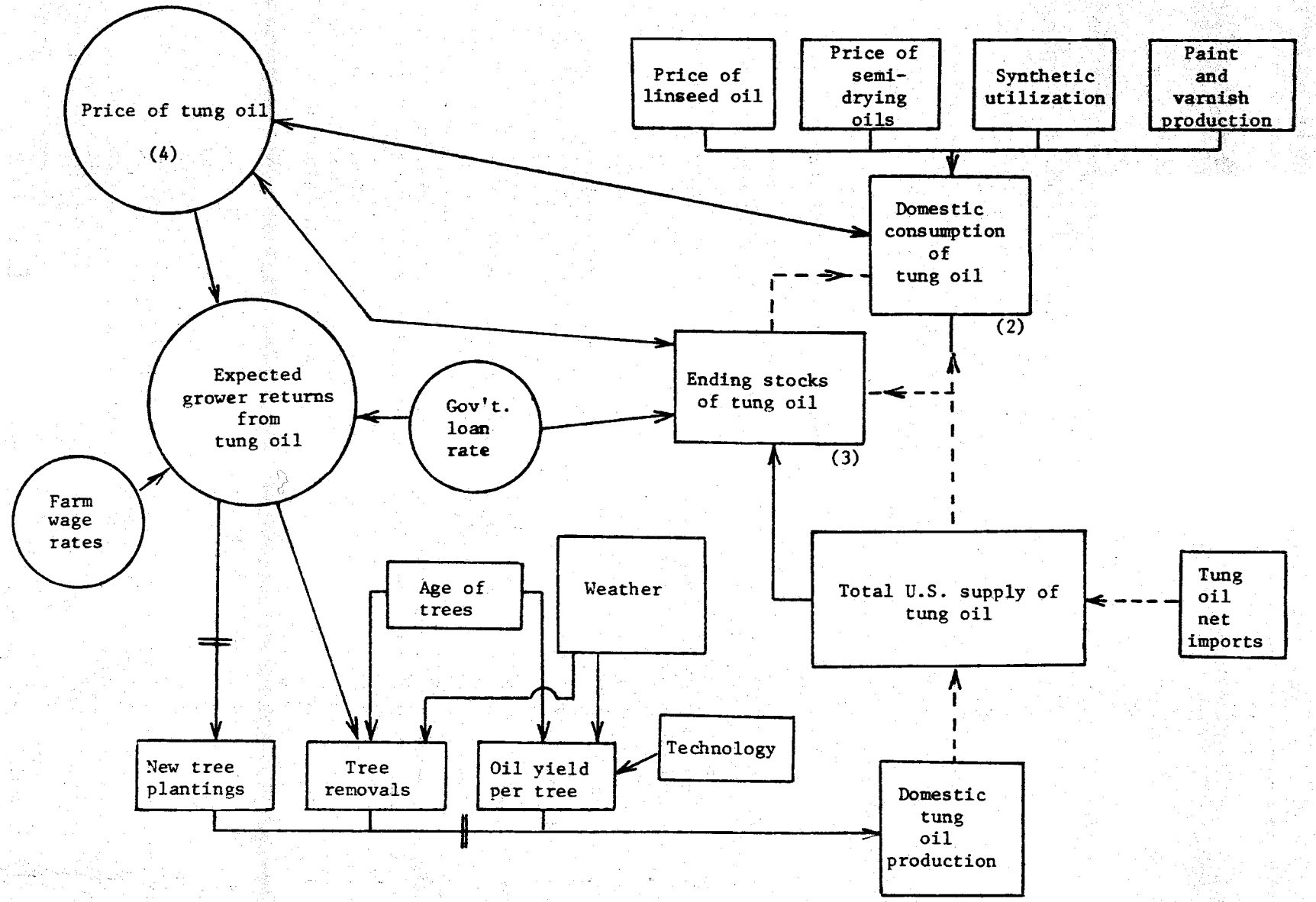


FIGURE 1. SIMPLIFIED DEMAND AND SUPPLY STRUCTURES FOR THE U. S. TUNG OIL ECONOMY

nature of competition with synthetics, the analysis does focus on the degree of competition among tung and other natural drying or semi-drying oils.

Because of the apparent simultaneous relationship among price, consumption and stocks, two-stage least squares estimation was used. The resultant statistical consumption function (Equation 1, Table 1) is expressed as:

$$C_{Tot} = f\,[P_{Tot}, P_{Lot}, U_{ot}, /V_t, V_t] \qquad (3)$$

where

C_{Tot} = domestic consumption of tung oil in current year, millions of pounds

P_{Tot} = price of tung oil in cents per pound, N. Y. drum quote, current year

P_{Lot} = price of raw linseed oil, cents per pound, tank, N.Y.

P_{ot} = weighted average wholesale price for soybean, and all fish oils

U_{ot}/V_t = ratio of all drying oil use to paint and varnish production in current year

V_t = paint, varnish and lacquer production in current year in million gallons

The positive and significant coefficient on linseed oil price is consistent with the expectation of a high degree of substitution effect between two natural drying oils. For an analysis of the market for tung, see [3]. In contrast, the negative and statistically significant sign on the semi-drying oil price coefficient bears out the technical and economic possibilities of combining low price oils with a natural drying oil via synthetic resins [4].

Inventory Demand Equation

In addition to domestic demand for consumption, there is also a domestic demand for stocks. The demand for stocks theoretically would be a function of current market price, expected future price, and stocks at the beginning of the period.

Other variables thought to influence stock levels are large changes in supplies and the Government loan price. As a rule, stocks are accumulated when market price is below support and vice versa.

The functional specification for the stock equation is expressed as follows:

$$S_{Tot} = f\,[P_{Tot}, P^s_{Tot}, S_{Tot-1}, \Delta Q^*_{Tot}] \qquad (4)$$

where

S_{Tot} = Oct. 31. stocks in all hands in current year in millions of pounds

P^s_{Tot} = loan rate for tung oil in current year, cents per pound

ΔQ^*_{Tot} = annual change in total supply of tung in U.S. in current year

The statistical equation for tung, Equation 2 in Table 1, was also fitted by two-stage least squares because of simultaneous relationships. The relative high response of stocks to price change (price-elasticity of 1.89) appears reasonable. However, it may be high in relation to the elasticity for the support price of only 0.289.

Supply-Utilization Identity Relation

To complete the model and close the simultaneous equation system, the following identity equation is required

$$C_{Tot} + S_{Tot} = Q_{Tot} + S_{Tot-1} + NM_t \qquad (5)$$

where

NM_t = imports minus exports of tung oil in the current year in millions of pounds

Reduced form equations

In order to use the model for prediction or projections, Equations 3, 4, and 5, which form the simultaneous portion of the model, must be solved for the reduced form set of relationships. This expresses the endogenous variables as a function of all lagged and exogenous variables in the system. The procedure involves the following simple matrix manipulation:

$$Ay_t + By_{t-1} + CX_t = U_t$$

$$Ay_t - By_{t-1} - CX_t + U_t$$

$$Y_t = A^{-1}\,By_{t-1} - A^{-1}\,CX_t - A^{-1}\,U_t$$

The reduced form equations for consumption, price and stocks are shown in Table 1, Equations 4, 5 and 6. These three equations, combined with the production response equation, complete the recursive system for prediction purposes.

TABLE 1. ESTIMATED STRUCTURAL AND REDUCED FORM EQUATIONS

Equation number	C_{Tot}	S_{Tot}	P_{Tot}	=	X	P_{Lot}	P_{ot}	V_t	(U_{ot}/V_t)	P^s_{Tot}	S_{Tot-1}	ΔQ^*_{Tot}	NM_t	Q^*_{Tot}	DURBIN WATSON	R^2
								Structural Equations								
1	1	0	1.42523 (0.35708) [0.713]	=	−75.5867	4.87412 (0.71360) [1.535]	−2.71829 (0.91237) [−0.674]	.04256 (0.04991) [0.517]	94.55757 (24.36081) [1.737]	0	0	0	0	0	1.87	.937
2	0	1	2.21781 (0.442) [1.892]	=	72.7452	0	0	0	0	.43208 (0.186) [0.288]	.26168 (0.153)	.34240 (.059)	0	0	1.54	.914
3	1	1	0	=	0	0	0	0	0	0	1	0	1	1	- - -	- - -
								Reduced-Form Equations								
4	1	0	0	=	−74.47504	2.96727 [0.935]	−1.65484 [−0.410]	.02591 [0.315]	57.56476 [1.059]	−.16904 [−0.066]	.28885	−.13395	.39122 [0.241]	.39122 [0.158]	- - -	- - -
5	0	1	0	=	74.47504	−2.96727 [−1.593]	1.65484 [0.699]	−.02591 [−0.537]	−57.56476 [−1.803]	.16904 [0.113]	.71115	.13395	.60878 [0.640]	.60878 [0.419]	- - -	- - -
6	0	0	1	=	−.77998	1.33793 [0.842]	−.74616 [−0.369]	.01168 [0.284]	25.95568 [0.953]	.11860 [0.093]	−.20267	.09399	−.27450 [−0.338]	−.27450 [−0.221]	- - -	- - -

NOTE: Numbers in parentheses are standard errors of the coefficients and numbers in brackets are the partial elasticities computed at the mean of the values.

Two-stage least squares used as method of estimating the structural equations.

Validity of Model

The validity of the model was tested to see how well it reproduced the past. The estimation of endogenous variables in the recursive system is started by first estimating production in 1952-53. This estimate of production is used in the reduced form equations for price, consumption and stocks. Estimated prices are then used in projecting production for the next period and so on (Figures 2a to 2d).

POLICY IMPLICATIONS AND PROJECTIONS

With large Government stocks of old crop oil, prospective long-term increases in South American oil production, and greatly reduced grower net incomes from tung, the industry is at a point of economic crisis. The intent of this section is to provide further insight into some of the problems and alternatives facing the industry in the next 5 years.

For purposes of illustration, four alternative situations are projected. The first projects changes for the major endogenous variables based on the following set of assumptions which approximate a continuation of present programs and the current situation:

Variable	Assumption
P^s_{Tot}	65% of parity
F_t	wage rates rise 4 to 5% annually
W_t	35% tree loss in 1969; no severe freeze damage
A_t	age distribution of trees about unchanged
P_{Lot}	held at 1968 level of about 14cents/lb.
P_{ot}	held at 1968 level of 10½cents/lb.
U_{ot}/V_t	held at near 1968-69 levels
V_t	annual growth rate of 4%
NM_t	net imports decline 1 million pounds annually from 1968-69 level of 16 million.

Alternatives 2, 3, and 4 assume the following modifications on alternative 1:

situation 2 =
alternative 1, except that net imports are assumed to be at 19 million pounds during the period 1969-70 to 1973-74

situation 3 =
situation 1, except that 75 percent parity is assumed.

situation 4 =
situation 1, except that no crop damage assumed in 1969 from Hurricane Camille

The illustrative projections are shown in Figures 2a to 2e. Appendix data tables can be obtained from Economic and Statistical Analysis Division, Economic Research Service, U. S. Department of Agriculture. Under the continuation of present programs and conditions (situation 1), domestic production is projected at around 10 million pounds annually. Domestic consumption is expected to continue a gradual decline reaching a level around 26 million pound annual rate by 1974. With the assumed further decline in import levels, total inventories (CCC and private) are projected to decline to a level around 35 to 40 million pounds within the next 5 years. Such a general reduction in overall supplies would be expected to result in some price firming and a reduction in annual costs of CCC inventory operations, perhaps by about $½ million by 1974 from the over $1 million in 1968. CCC costs are estimated for the various projection situations by applying the following simulated equation:

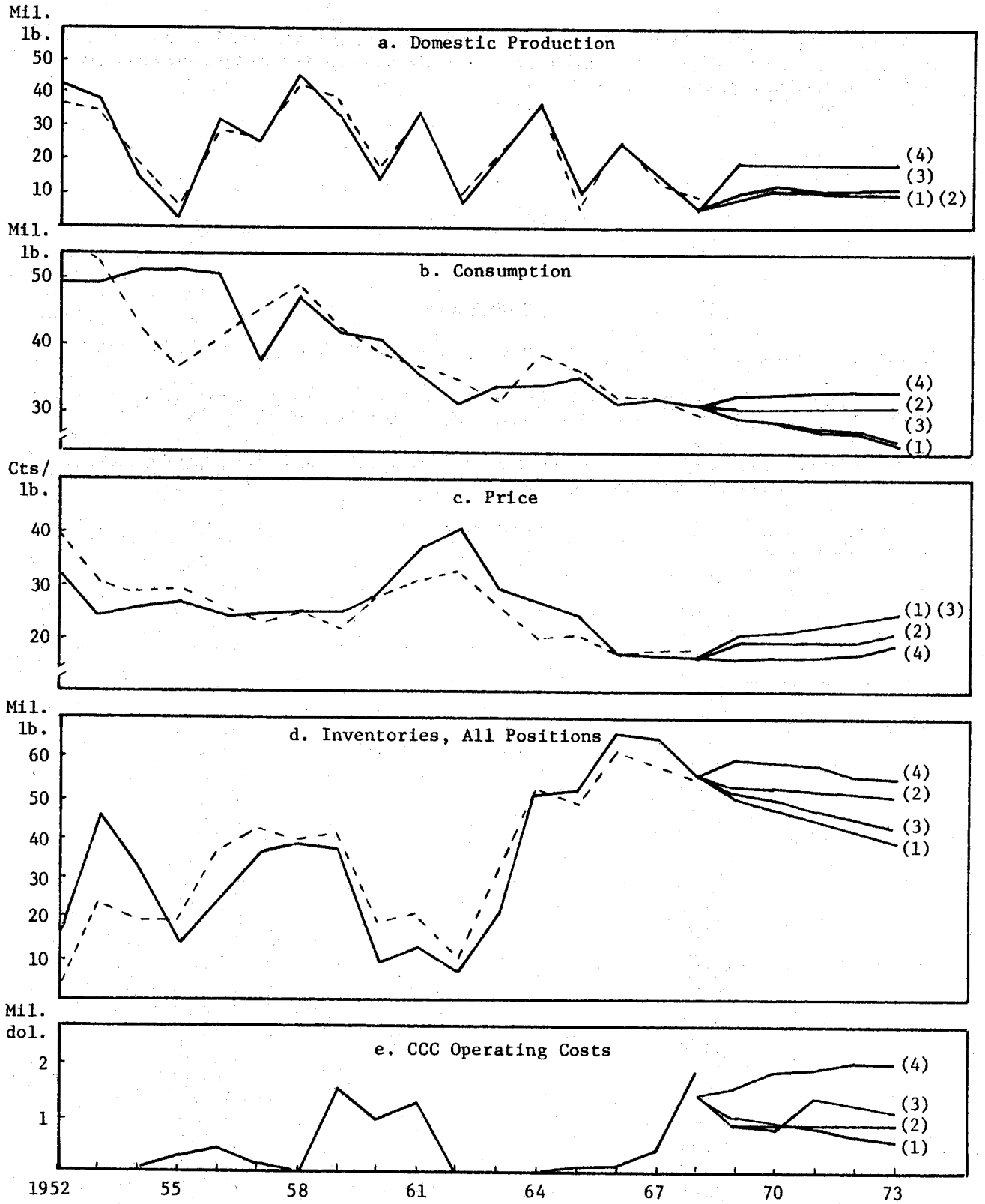
Cost (mil. $) =

$$.0050\, Q_{Tot} - .0025\, (S_{Tot} - S_{Tot\text{-}1}) + (0.03048) S_{Tot} + [P^s_{Tot\text{-}2} - P_{Tot} - 2]\, [Q_{Tot} + S_{Tot\text{-}1} - S_{Tot}]$$

In situation 2, the major impact of stabilizing imports around 20 million pounds for the 1969-70 to 1973-74 period is a projected reduction in market prices of around 15 percent by 1974 with little reduction in Government inventories and higher CCC costs than projected under alternative 1.

The projected impact of an increase in parity to 75 percent would be to increase production and stocks and step up CCC costs.

The last hypothetical situation, which assumes there had been no crop damage from Hurricane Camille, projects the following: (1) domestic production averaging a little less than 20 million pounds annually, (2) a 20 percent drop in prices, and (3) a near doubling of CCC costs over the five-year period beginning 1969-70 (projected increase of around $5½ million).



——— Actual

- - - - Estimated (Recursive)

Numbers in (parentheses) correspond to projected situations in text

FIGURE 2. ACTUAL VERSUS ESTIMATED, AND PROJECTED VALUES OF ENDOGENOUS VARIABLES, 1952-53 to 1973-74

The proceding projections, based on the analysis, are intended to illustrate uses of the analytical framework. Hopefully, they provide some insights, not otherwise available, and roughly quantify some of the alternatives facing the industry in the next 5 years.

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