A Model for Estimating Costs of Government Export Programs for Rice

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PRICE SUPPORT PROGRAMS have influenced domestic price levels for rice since 1954. The effects of these programs on individual rice farmers, on the economy of the rice producing areas, and on the cost to the Federal Treasury continue to concern farmers, program administrators, legislators, and the public. Price support policies for rice are subject to many conflicting forces. The development of a workable price support program involves knowledge of complex economic and institutional factors, particularly the interrelationships of supply and demand in both domestic and foreign markets. Currently more than half the rice produced in the United States is exported.

The purpose of this report is to develop an analytical model of the supply and demand relationships for rice that will permit (1) estimation of domestic and export quantity-price relationships for rice, and (2) determination of the effects of changes in Government programs for rice on the cost to the Federal Treasury. A specific knowledge of the rice supply function is necessary to determine program costs. For purposes of this analysis the supply functions are assumed to be given and thus are completely inelastic for any given year.[1]

Procedure

The method used in estimating both the quantity-price relationships for rice and the cost to the Government was conceived by Mehren and Thuroczy.[2] The general model used is illustrated in figure 1. The domestic outlets for rice are food and industry, seed, and carryover. The sum of the demand schedules for each of these outlets is the domestic demand plotted as the line D_d. The demand for world exports is represented by the line D_w. Supply of rice without allotments is assumed to be represented by the line S_1 and the supply with allotments is illustrated by the line S_2.

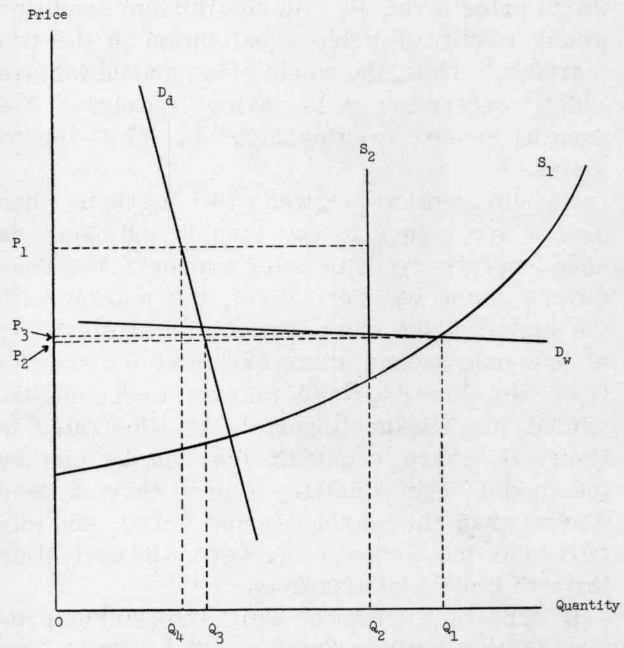

Figure 1.--Equalization of U.S. domestic and world outlets.

[1] A study on aggregate rice supply functions with varying price-allotment levels is in progress.

[2] G. L. Mehren and Nicholas Thuroczy, "The Market for United States Rice: Foreign," Calif. Agr. Expt. Sta., Mimeo Rpt. 163, March 1954.

With the assumed supply and demand schedules and no price support or allotment programs, price would be equal in both the domestic and the export markets at P_2. The total quantity utilized would be Q_1. Under these conditions, sales would be diverted into the domestic outlet only as long as the price level for that outlet exceeded the world price. The remaining supply would be exported. In figure 1, sale of more than the amount Q_3 in the domestic market would reduce domestic prices below the world price level, P_2. An equilibrium condition would result in price equalization in the two markets.[3] Thus, the world price and the factors which determine this price influence the quantity-price relationships in the United States.

To differentiate between two markets when prices are higher in one than in the other, as under certain types of price supports, two conditions must be met. First, the market with the higher price must have the lower elasticity of demand. Second, there cannot be movements from the lower priced market to the higher priced market (no imports). As illustrated in figure 1, these requirements can be met by the model. The domestic demand curve is less elastic than the world demand curve, and imports into the domestic market can be controlled through import restrictions.

If acreage allotments were imposed on producers the supply curve would be limited as shown by the curve S_2. If domestic prices were supported at the level P_1, then the quantity utilized domestically would be Q_4. The remainder of the supply, $Q_2 - Q_4$, could be exported at the price level P_3 (a two-price plan). The quantity $Q_2 - Q_4$ could also be exported at price P_1, given an export subsidy equal to $P_1 - P_3$. In this case the cost of the export subsidy program would be the subsidy ($P_1 - P_3$) times the quantity exported ($Q_2 - Q_4$).[4]

An export subsidy program is a price-supporting mechanism. The subsidy on exports may be equal to the difference between the domestic support price and the "market equilibrium price." A plan in which the subsidy was less than this difference would shift rice into Commodity Credit Corporation loans if the loans were available. If loans were not available, it would lower the domestic price until it was equal to the market equilibrium price plus the subsidy. Under perfect competition a subsidy larger than this difference would raise the domestic price level above the price support level, reduce domestic consumption, and result in larger quantities exported.

The supply and demand relationships for rice are unusually complex, chiefly because domestic prices, world prices, and utilization in several outlets are determined simultaneously not only by the supply of rice, but also by certain demand-shifting factors outside the rice market structure. The rice market structure for the United States logically can be broken down into four major sets of factors: Those that affect (1) domestic production, (2) world production and price, (3) domestic utilization, and (4) domestic exports (commercial and Government). Each of these has some influence on domestic prices and utilization. However, in those years during which prices are effectively supported by a Government price support program, the domestic prices are assumed to be exogenously determined.

Fox suggests that if a commodity has more than one major market outlet, demand estimates should be made for each outlet.[5] Also, Meinken points out that, under certain conditions, the estimation of elasticity of demand with respect to price for a given outlet by the traditional method of a single regression equation results in a statistical bias. This is true if utilization and price are determined simultaneously by a given set of economic forces.[6] In the rice market with no price supports effectively working, utilization and price are determined simultaneously. However, with Government price support programs setting the domestic price levels, prices could be regarded as predetermined variables in the domestic economy,

[3] The U.S. export price represents the price received at our port of exit. Thus, costs for transfer from U.S. markets to world markets are not included.

[4] Additional costs for administering the program are not included in this analysis.

[5] K. A. Fox, "The Analysis of Demand For Farm Products," U.S. Dept. Agr., Tech. Bul. 1081, pp. 11-14, 1953.

[6] K. W. Meinken, "The Demand and Price Structure for Wheat," U.S. Dept. Agr., Tech. Bul. 1130, p. 37, November 1955.

and single regression equations could be fitted individually to each of the domestic outlets. Price support programs have been effectively determining domestic price levels since 1954, although they have been available continually since 1941. World prices were higher than support prices from 1941 to 1953, and mainly influenced domestic prices in that period. Thus, a problem arises in selecting a time period for an analysis. However, some of the price support activities depend upon export subsidies, the effects of which must be determined in the study. From 1954 through 1958, substantial amounts of rice were placed in Commodity Credit Corporation loans and were not redeemed. Under such conditions the loan program influenced domestic prices. These years are not included in the analysis.[7]

Since 1954, Government programs have exerted a strong influence on carryover stocks. For this reason, carryover stocks were assumed to be exogenously determined and an equation was not fitted to the data for this outlet.

World price is a dependent variable in the world rice market and largely dependent on world demand, world production, and other economic and noneconomic factors. The United States produces only about 2 percent of the world rice production and might be thought to have little influence on world prices, whereas world demand and production outside the United States exert a major influence on world prices.[8] However, more than half of the rice produced in the United States is exported. Since this quantity makes up almost 20 percent of total world exports, U.S. exports do influence world prices of rice if world exports exert a major influence on world prices.

The Model

The economic model developed for this study includes two groups of variables: (1) endogenous variables which are generated by the system that the model characterizes; and (2) exogenous variables which affect the rice market structure but are not appreciably affected by it.

The following variables are assumed to have been simultaneously determined by the same set of economic forces during the years included in the analysis:

Q_{dd} = domestic food and industry utilization of rice (in million cwt. of rough rice).

P_e = average price received for U.S. rice exported less the export subsidy (in dollars per cwt. of milled rice).

P_{es} = export price plus export subsidy on rice (in dollars per cwt. of milled rice).

Q_{se} = domestic utilization of rice for seed (in million cwt. of rough rice).

$Q_{e/us}$ = U.S. exports of rice (in million cwt. of rough rice).

Q_e = total world exports of rice (in million cwt. of rough rice).

The following variables are assumed to have influenced the values of one or more of the endogenous variables during the years included in the study, but not to have been influenced by them to a significant degree during any market year:

Y_I = index of U.S. disposable income per capita (base = 1957-59) (in percentage).

$Q_{w/p}$ = per capita world production of rice (in cwt. per capita of rough rice).

T_1 = time, 1934 equals 1.

P_s = export subsidy on rice (in dollars per cwt. of milled rice).

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[7] After the export subsidy program went into effect there could have been some lag in the response of quantity exported commercially due to the time required to regain markets previously lost. In the model this was assumed to be negligible.

[8] It is very difficult to determine a generalized world price for rice. Traditionally in grains, and particularly wheat, world prices were interpreted as the landed (c.i.f.) price in Liverpool--a major market in one of the major importing countries. More recently, world prices in the aggregate are reflected in the c.i.f. prices at a number of West European ports--Liverpool, Rotterdam, Amsterdam, Le Havre, and Bremen. With increasing exports of rice and other grains to Asia, one also should consider landed c.i.f. prices at major ports, such as Bombay and Japan. Because of differences resulting from the location of exporting countries in relation to importing countries and because of the changing patterns of exports and imports (and the nonexistence of a perfect market), there is no such thing as one standardized world price. This does not preclude use of the concept of world prices but the intangibility of the term should be understood and recognized.

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A_p = U.S. planted acres of rice (in million acres).

Q_s = U.S. supply of rice (in million cwt. of rough rice).

Q_c = domestic stocks or carryover of rice (in million cwt. of rough rice).

$Q_{e/ow}$ = total world exports of rice minus U.S. exports of rice (in million cwt. of rough rice).

The following six structural equations are involved in the system:

(1) $Q_{dd} = a_1 + b_{11} P_{es} + b_{12} Y_I$

(2) $P_e = a_2 + b_{21} Q_e + b_{22} Q_{w/p} + b_{23} T_1$

(3) $P_{es} = P_e + P_s$

(4) $Q_{se} = a_4 + b_{41} A_p + b_{42} T_1$

(5) $Q_s = Q_{dd} + Q_{se} + Q_{e/us} + Q_c$

(6) $Q_e = Q_{e/ow} + Q_{e/us}$

Each equation is assumed to be subject to a random error which represents the combined influence of other variables not included in the equation. Since more than one endogenous variable is involved, the first two equations were fitted by the limited-information single equation method, the two-stage least squares method, and the ordinary least squares method. In the first two methods, each equation is handled separately, but the fitting process involves all of the exogenous variables in the system. With the ordinary least squares method each equation is fitted individually without regard to the variables not in the equation.

Table 1.--Estimated coefficients for equations (1), (2), and (4) by method of estimation

Equation number	Method of estimation[1]	$\hat{Y}$	Coefficients for-- P_{es}	Y_I	Q_e	$Q_{w/p}$	T_1	A_p	Constant	$\hat{\delta}^2$	$\bar{R}^2$
(1)....	L.I.S.E.	Q_{dd}	-0.807	0.158					16.704	1.519	[2]
			(3.30)	(7.36)							
(1)....	T.S.L.S.	Q_{dd}	-.792	.156					16.682	1.514	.869
			(3.24)	(7.32)							
(1)....	O.L.S.	Q_{dd}	-.723	.151					16.579	1.505	.870
			(3.33)	(7.77)							
(2)....	L.I.S.E.	P_e			-0.020	-7.251	.188		18.292	.929	[2]
					(4.02)	(2.66)	(4.04)				
(2)....	T.S.L.S.	P_e			- .020	-7.294	.189		18.320	.929	.861
					(4.00)	(2.67)	(4.05)				
(2)....	O.L.S.	P_e			- .020	-7.329	.190		18.343	.929	.861
					(3.98)	(2.68)	(4.07)				
(4)....	O.L.S.	Q_{se}					.020	.992	-.023	.004	.991
							(10.20)	(24.42)			

[1] L.I.S.E. is the "limited information single equation" method; T.S.L.S. is the "two-stage least squares" method and O.L.S. is the "ordinary least squares" method.

[2] The coefficient of determination for the limited information single equation method cannot be obtained.

Equations (3), (5), and (6) need not be fitted by statistical means since they are identities and do not involve statistical coefficients. Equation (4) can be fitted directly by the ordinary least squares method since all the variables on the right side of the equality sign are predetermined.

Data from 1934 through 1963 were used in fitting each of the equations. Because of the adverse effects of World War II on the rice market, the data from 1941 to 1945 were excluded from the analysis. Also, as indicated earlier, data from 1954 to 1958 were excluded.

Results

The results shown in table 1 were obtained when the equations were fitted by the various methods and for the years noted. The numbers in parentheses under the coefficients show the respective t values. The multiple coefficient of determination adjusted for degrees of freedom is shown for each equation estimated by the least squares method. A corresponding coefficient of determination cannot be obtained from the equations estimated by the limited information method.[9]

The coefficients obtained by the three methods are almost identical, indicating possibly that the bias from the simultaneous effect may be small or may be offset by Government programs or other factors. All of the coefficients have the expected signs and all are significantly different from zero at the 95 percent level. The Durbin-Watson test for serial correlation in the residuals of the equations fitted by the least squares method was inconclusive.

The coefficients in table 1 relate to the original units used for the variables in the analysis. The variables can be expressed in terms of the percentage change in one variable relative to a given change in another variable. These are sometimes referred to as elasticities or flexibilities. Price and income elasticities computed for equations (1) and (2) using 1963 data are shown in table 2. Since the functions were linear the elasticities could be different for other years.

Table 2.--Elasticities for domestic and world markets estimated by three different methods of fitting equations for 1963 data[1]

Item	Methods of estimating equation		
	L.I.S.E.	T.S.L.S.	O.L.S.
Domestic:			
Demand elasticity	-0.27	-0.27	-0.27
Income elasticity	.68	.67	.65
World:			
World export elasticity	-1.54	-1.54	-1.54

[1] The 1963 price and quantity are on the same basis as used in fitting equations. The elasticities are representative of the demand at the wholesale level.

The indicated elasticity of demand with respect to price (P_{es}) is low, as expected. A 1 percent change in domestic price affects domestic consumption 0.27 percent in the opposite direction. A 1 percent change in income has about 2.5 times the effect of a 1 percent change in price.

The estimated elasticity of demand for exports with respect to export price, P_e, is about 6 times the elasticity of domestic demand. That is, a 1 percent change in export price is inversely related to a 1.54 percent change in quantity exported. When applied to U.S. exports (about 20 percent of total world exports), a 1 percent change in price is inversely related to an 8.2 percent change in U.S. exports. This analysis shows that the "world demand" for rice is more elastic than the U.S. domestic demand for rice.

One criterion for evaluating any economic model is its ability to predict. The calculated values for each method of estimating the equations and the actual values for 1961-63 are given in table 3. The largest difference between actual quantity and calculated quantity of rice

[9] K. W. Meinken, "The Demand and Price Structure for Wheat," U.S. Dept. Agr., Tech. Bul. 1136, p. 40, November 1955.

Table 3.--Calculated and actual prices and utilization of rice, 1961-63

Item	Method of Estimating Equations	Unit[1]	Year		
			1961	1962	1963
Estimated:					
Q_{dd}..........	L.I.S.E.	Mil. cwt.	26.63	27.12	27.49
Q_{dd}..........	T.S.L.S.	Mil. cwt.	26.61	27.10	27.47
Q_{dd}..........	O.L.S.	Mil. cwt.	26.52	27.00	27.36
Q_{se}..........	O.L.S.	Mil. cwt.	2.32	2.34	2.37
$Q_{e/us}$.......	L.I.S.E.	Mil. cwt.	30.39	34.31	40.69
$Q_{e/us}$.......	T.S.L.S.	Mil. cwt.	30.41	34.33	40.71
$Q_{e/us}$.......	O.L.S.	Mil. cwt.	30.50	34.43	40.82
P_e...........	L.I.S.E.	Dol./cwt.	6.72	7.00	6.70
P_e...........	T.S.L.S.	Dol./cwt.	6.72	7.00	6.70
P_e...........	O.L.S.	Dol./cwt.	6.72	7.00	6.70
P_s...........	L.I.S.E.	Dol./cwt.	2.06	1.95	3.38
P_s...........	T.S.L.S.	Dol./cwt.	2.06	1.95	3.38
P_s...........	O.L.S.	Dol./cwt.	2.06	1.95	3.38
Actual:					
Q_{dd}..........	-	Mil. cwt.	27.85	26.30	26.73
Q_{se}..........	-	Mil. cwt.	2.33	2.37	2.42
$Q_{e/us}$.......	-	Mil. cwt.	29.20	35.10	41.40
P_e...........	-	Dol./cwt.	6.00	6.70	6.80
P_{es}..........	-	Dol./cwt.	8.78	8.95	9.08
P_s...........	-	Dol./cwt.	2.78	2.25	2.28

[1] Quantities are rough rice basis. Export prices are milled basis.

for domestic food and industry (Q_{dd}) is only 4.8 percent or 1.33 million cwt. in 1961. The equation for estimating seed utilization (Q_{se}) is reasonably accurate, with the largest difference between estimated and actual only 2.1 percent or 0.05 million cwt. in 1963. U.S. exports are defined as a residual (exports are taken as all rice not consumed or stored domestically). The largest difference between estimated exports and actual exports ($Q_{e/us}$) is only 4.5 percent or 1.30 million cwt. in 1961. The largest difference in export price, P_e, is 12 percent or $0.72 per cwt. in 1961. In general, the calculated levels of both quantities and prices are close to the actual levels of both.

The calculated export subsidies are below the actual subsidies in each of the 3 years shown in table 4. The difference between calculated and actual subsidies in 1961 and 1962 can be attributed largely to an overestimate of the export price, P_e. In 1963, the difference is slight, but can be attributed to an underestimate of exports. Any of the methods used in fitting the equations produced equations that were equally effective in estimating quantities, prices, or subsidies.

Table 4.--Estimated and actual export subsidies for rice, 1961-64

Item	Methods of estimating equations	Unit	Year 1961	1962	1963
Estimated:[1]					
$Q_{e/us}$ P_s...........	L.I.S.E.	Mil. dol.	45.01	48.11	69.64
$Q_{e/us}$ P_s...........	T.S.L.S.	Mil. dol.	45.03	48.13	69.66
$Q_{e/us}$ P_s...........	O.L.S.	Mil. dol.	45.18	48.28	69.85
Actual...............	--	Mil. dol.	56.4	54.6	71.7

[1] U.S. exports converted from rough rice to milled rice on basis of 3-year average (1961-63) conversion rate (71.9 percent).

Application of the Model to Allotment-Price Support Programs

The model can be useful in evaluating (1) allotment-price variations within any price support program, or (2) different types of price support programs. The equilibrium price and quantity, without allotment-price support programs in effect, could be estimated for a given set of conditions. However, a supply function will be needed for such estimates.

Allotment-Price Variations

Estimates of quantities, prices, and export subsidies for a 10 percent change in allotments or prices from the 1963 allotment-price level are given in table 5. Assuming carryover constant, a 10 percent increase or decrease in price or allotment level had little effect on domestic utilization. The price variation affected domestic use more than the allotment variation. However, the maximum change in domestic use for any of the variations was only 0.76 million cwt., or 2 percent of the estimates. The export variation was small for either an increase or a decrease in price. With little change in domestic use and no change in supply, this result would be expected. With exports defined as residual, most of the change in supply brought about by the increase or decrease in allotments is reflected by a corresponding change in exports. Variations in price affected Treasury costs more than similar variations in allotment levels.

Multiple-Price Programs

For comparative purposes, a set of prices is assumed to exist that would make 1963

Table 5.--Estimated Treasury cost of allotment-price changes with 1963 data[1]

Item	Unit	Estimated for 1963	Support price, percent of 1963: 90 percent	Support price, percent of 1963: 110 percent	Allotments, percent of 1963: 90 percent	Allotments, percent of 1963: 110 percent
Domestic utilization[2].	Mil. cwt.[3]	35.21	35.89	34.45	35.02	35.38
Exports..............	Mil. cwt.[3]	40.71	40.03	41.47	33.85	47.59
Total subsidy.........	Mil. dol.	69.66	42.02	95.72	54.52	86.23

[1] Two-stage least squares equation used in deriving estimates.
[2] Includes carryover stocks.
[3] Rough rice.

parity prices effective in the domestic market and world prices effective in the export market. The estimated domestic utilization and exports with these prices and 1963 conditions are 32.49 million cwt. and 43.43 million cwt., respectively (table 6). The increase in domestic price would decrease domestic use by an estimated 2.72 million cwt. This net decrease would be exported. With no export subsidy, the only Treasury cost would be the cost of administering the program. However, the consumer would have to bear the $85.12 million additional cost of the price increase in the domestic market.

Table 6.--Estimated Treasury cost of alternative rice programs with 1963 data[1]

Item	Unit	One-price program[2]	Two-price program[3]
Domestic utilization	Mil. cwt.	35.21	32.49
Exports	Mil. cwt.	40.71	43.43
Total subsidy	Mil. dol.	69.66	0
Additional cost to consumer	Mil. dol.	0	85.12

[1] Two-stage least squares equations used in deriving estimates with 1963 data.

[2] Estimate of price support program in effect in 1963, support price at $9.08 milled basis or $4.71 rough rice basis.

[3] Domestic price at 1963 parity level ($12.46 milled basis or $6.46 rough rice basis) and export price at the estimated 1963 world level ($6.68 milled basis).

Conclusions

The price elasticity of domestic demand for rice, as represented by domestic food and industry consumption, was -0.27 for 1963. The income elasticity of domestic demand ranged from 0.68 to 0.65 for the same year. The elasticity of export demand was above unity at -1.54 in 1963.

The derived equations were good estimators of quantities utilized for the years 1961-63. However, the equation for estimating U.S. export price overestimated this price by 12 percent in 1961. All three methods used produced equations that were equally effective in estimating quantities, prices, and subsidies.

The model can be useful in evaluating allotment-price variations within a given price support program, or between two or more types of price support programs. A 10 percent increase or decrease in price or allotment from the 1963 allotment-price level has little effect on domestic utilization. Any change in production brought about by a change in allotment level directly affects exports. The only change in domestic use with an allotment change would be seed utilization. A two-price plan, with domestic price at 1963 parity level and export price at world level, would have decreased domestic use by an estimated 2.72 million cwt.

Several areas in the economic model used in this study need additional research and refinement of data. World production of rice, though predetermined in a given year, depends to some extent on previous prices of rice and on specific governmental policies in each country. An indicator of income appropriate to the quantity of rice consumed in world markets probably would strengthen equation (2).