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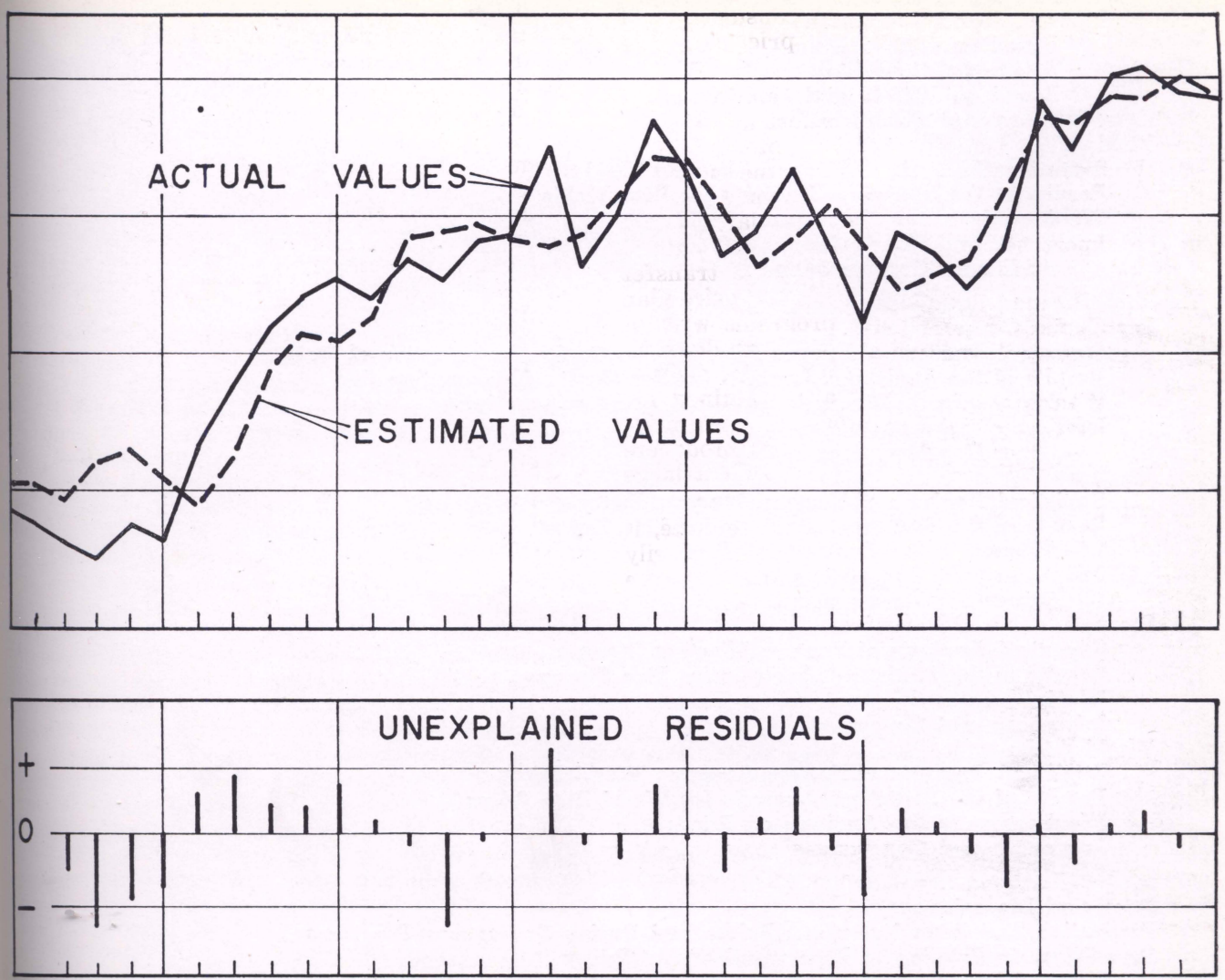
Statistical Analyses of Rice Supply and Demand Before and During Government Programs



TEXAS AGRICULTURAL EXPERIMENT STATION

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CONTENTS

SUMMARY AND CONCLUSION

Aggregate agricultural policies of a nation are expressed in a complexity of opinions and laws which frequently are subject to revision and displacement. The periphery of agricultural policies have been vastly extended during the past 4 decades. Specific price programs, each with its own particular objective, have been sought to give expression to general agricultural policy.

Legislation affecting the rice industry was outlined in Texas Station Bulletin 839, "Legislation Affecting the Rice Industry, 1933-56," and physical factors, production trends, markets, utilization and government loan and purchase operations were included in Texas Station Bulletin 850, "Rice Supply, Demand and Related Government Programs."

This publication reports the results of analyses of the effects of specified factors presumed to be responsible for the variations in the supply of and demand for rice, both domestic and foreign. All analyses were confined to data within the period covered by the 1921-54 crop years.

Statistical analyses involve two supply equations, four demand equations, alternate analyses of price-production variations and probable position of rice under free market, flexible and two-price programs.

Rice acreage and yield were correlated with 1 and 2 years lagged prices, except that time was included as an additional variable in the yield equation.

Acreage was not influenced by preceding crop year prices before World War II, but was affected considerably more when postwar prices were included. Government support prices and an ever expanding market for rice during and immediately after World War II contributed more than other factors to the variations in rice acreage.

The time factor alone accounted for about 87 percent of the variation in yield with no change in its attributable affect when postwar data were included. The most noticeable increases in yield after 1954 resulted primarily from increased usage of fertilizers to compensate for acreage restrictions and marketing quotas.

Domestic per capita consumption of rice is relatively constant. Prices and per capita income had no measurable effect on variations in per capita consumption of rice. Government support prices had no influence on per capita consumption as reflected by no noticeable change in the average rate of per capita consumption after the War. It appears that rice purchases are based in a large measure on "impluse" buying. If this were true, a merchandising campaign should increase the rate of rice consumption above the normal increase resulting from the rate of population growth.

Rice exports presented no serious rice disposal problem until after 1953. In the analyses, however, the price differential between the United States price and the world price was correlated with exports. Post World War II data on world prices were not available. Prior to the War, the price difference accounted for about 41 percent of the variation in rice exports. This would be expected since most of the United States rice was shipped to Cuba. Therefore, the Japanese and United States price difference could not reflect accurately the volume going to Cuba particularly under reciprocal trade agreements. The principal difficulty with United States rice exports after 1933 resulted from United States support prices exceeding too greatly the level of world prices. Also, rice producing countries in Asia had made considerable progress by 1954 toward relocating the rice industry in the Orient.

Rice storage quantities were correlated only with deflated domestic prices. The domestic price variable accounted for about 33 percent of the variation in rice storage during the 1921-40 period and only 1 percent with postwar prices included in the analysis. After World War II, domestic prices were so attractive and guaranteed support prices were at such levels as to discourage rice storage during 1941-53. Government warehouses received surplus stocks of rice after 1953 because of loan and purchase agreements. The volume of rice that is stored, assuming storage facilities are available, is governed solely by the amount of profit expected from holding rice for future sale or the urgency of financial needs at the time of harvest.

World price for the 1921-40 period, using Japanese rice prices, was correlated with the world rice trade, time and the international commodity trade index. The international commodity trade index and time influenced considerably the variation in world prices during the 1921-40 period. World trade in rice, which is about 5 percent of the world production, accounted for less than 1 percent of the variation in world rice prices. The analysis on world price did not include postwar data since reliable Japanese prices were not available after 1940. Asiatic consumers will continue to purchase lower quality rice at lower prices on the world market rather than purchase United States rice if our domestic prices are much greater than the world price level.

The coefficient of variation technique was used to estimate the difference in the variation of rice prices and production during periods before and during government programs. The variation was based on the average price and average production as well as year-to-year deviations during these specified periods. Under direct support prices, rice prices varied less than production, irrespective of the base period. This stability in price and income could be expected since the domestic and foreign demand was relatively constant. Rice production and demand, however, approached equilibrium with the 1953 crop.

A regression analysis to determine demand relationships between rice and potatoes was used in data for two time periods, 1920-40 and 1921-54. Rice showed slight evidence of substitutability for potatoes during the 1921-40 period and showed evidence of complementarity for the 1921-54 period. However, not much confidence can be placed in the two equations connoting complementarity since the two regression coefficients in the equations did not differ significantly from zero.

TABLE 1. DATA USED IN THE FIVE-EQUATIONS OF RICE ECONOMY, 1921-40 AND 1946-54

Year beginning August 1	Domestic					Japanese price corrected to United States currency[1]	United States seasonal average on-farm price	Index of prices paid by farmers, 1935-39 =100	Cost per cwt.		Index numbers of wholesale prices		Hourly earnings of factory workers	Per capita income	Acreage planted	Yield per planted acre
	Adjusted supply	Per capita consumption	Exports including shipments	Ending stocks	World trade				Japanese import duties[2]	Ocean freight, San Francisco to Yokohama	Statist index, 1910-14 =100	All Commodities index B.L.S.				
	Thous. cwt.	Pounds	— — — Thous. cwt. — — —			— Dols. per cwt. —			Cents	Cents			Cents	Dols. per person	Thous. acres	Cwt.
1921	20,891	7.19	11,830	1,338	175,416	5.01	2.18	153	36	60	165.7	94.2	51.5	512.1	990	17.85
1922	20,584	8.23	9,538	2,046	184,237	5.28	2.19	155	36	60	156.8	101.1	48.7	545.0	1,053	17.80
1923	17,354	8.16	7,584	708	192,174	4.94	2.49	166	37	60	161.3	97.9	52.2	621.2	874	17.11
1924	15,045	8.42	5,292	230	202,752	5.40	2.99	169	31	60	169.3	101.2	54.7	610.0	838	17.53
1925	14,876	8.10	4,230	1,323	216,409	5.66	3.30	168	31	60	155.2	102.1	54.7	640.6	853	17.43
1926	20,661	8.80	8,676	1,723	237,428	5.72	2.51	166	36	60	151.0	96.5	54.8	654.8	1,016	18.61
1927	22,814	9.58	8,938	2,538	256,910	4.96	2.02	166	36	60	147.4	96.4	55.0	648.4	1,027	19.50
1928	22,495	8.41	10,692	1,723	232,798	4.36	2.03	167	35	60	140.8	96.2	56.2	656.2	972	20.29
1929	20,261	8.24	9,108	1,169	219,563	4.35	2.22	164	35	60	125.6	91.5	56.6	685.9	860	20.69
1930	21,584	8.98	9,200	1,384	224,778	3.60	1.74	150	37	60	103.9	78.0	55.2	607.2	966	20.93
1931	22,136	8.24	8,876	3,076	238,757	3.65	1.08	130	37	60	98.9	67.5	51.5	516.3	965	20.80
1932	21,769	9.42	8,062	1,984	247,657	1.54	.93	173	29	50	95.3	63.3	44.6	390.9	874	21.43
1933	17,276	6.79	6,092	2,676	243,338	2.17	1.73	126	39	50	97.8	72.4	44.2	365.3	798	21.23
1934	18,977	9.80	6,783	826	244,644	2.50	1.76	131	45	60	100.2	78.4	53.2	412.5	812	21.64
1935	17,448	8.22	5,734	1,288	239,497	2.80	1.60	126	43	60	103.4	80.2	55.0	459.7	817	21.73
1936	21,770	9.94	6,338	2,740	247,301	2.86	1.85	133	44	60	119.9	85.2	55.6	518.5	981	22.85
1937	23,865	9.61	10,154	2,365	237,480	3.03	1.46	129	44	70	116.1	81.6	62.4	552.6	1,116	21.54
1938	24,814	8.79	9,842	3,596	267,839	3.06	1.42	124	43	82	107.3	76.9	62.7	507.8	1,076	21.96
1939	26,512	9.45	9,914	4,276	205,828	2.99	1.62	125	39	70	141.9	78.4	63.3	540.2	1,045	23.28
1940	26,221	9.24	11,413	2,656	235,435	3.22	1.80	126	35	98	165.2	81.7	66.1	578.7	1,090	22.48
1946	25,619	6.96		668			5.00	208		116	246.3	140.2	108.6	1,131.4	1,595	20.37
1947	29,434	7.57		414			5.97	240		116	299.2	157.0	123.7	1,183.3	1,719	20.49
1948	30,831	7.70		1,116			4.88	260		134	319.4	157.2	135.0	1,289.6	1,826	20.96
1949	34,507	7.94		2,329			4.10	251		134	359.0	152.1	140.1	1,271.3	1,882	21.63
1950	35,717	8.91		3,316			5.09	256		134	466.1	173.2	146.5	1,369.4	1,632	23.71
1951	39,127	7.80		1,392			4.82	282		146	467.7	173.4	159.0	1,476.9	1,998	22.92
1952	39,106	8.29		682			5.87	287		96	446.1	169.8	167.0	1,519.6	2,006	23.98
1953	49,725	8.31		6,898			5.19	279		158	434.1	170.0	177.0	1,580.3	3,174	24.08
1954	40,804	8.52		29,695			4.57	281		open	443.0	169.4	181.0	1,581.6	2,462	23.90

[1]Not available after 1942.
[2]All tariffs were dropped after World War II.

Statistical Analyses of Rice Supply and Demand Before and During Government Programs

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THIS IS THE LAST OF A SERIES of three publications which evaluate federal price support programs relating to the rice industry. Bulletin 839 reviews legislation affecting the rice industry, while Bulletin 850 outlines government operations and discusses the physical factors, production and marketing of rice.

This publication discusses efforts to determine statistically the extent to which principal economic forces affect the supply of and the demand for rice, both foreign and domestic. The quantitative factors chosen for the analyses were not entirely relevant in explaining the variation in the dependent variables. However, when the equations were fitted to postwar data, considerable improvement in the relevancy of the factors was evident.

Because of the extremely complex nature and relatively unique characteristics of the rice industry, the task of discovering the measurable factors that account for the changing demand for rice is extremely difficult.

Recent trends in quantitative research in economics have demonstrated the need for structural estimation when the end is one of advice on policies of the government and the firm. This has led to greater emphasis on the estimation of the parameters of the basic economic relations as opposed to the more superficial analysis of market barometers. The more scientific approach through statistical analyses in quantitative economic research has been generated by the desire and need to provide those responsible for choice with reasonably accurate estimates of the future path of each revelant variable given the alternative courses of policy action.

If these analyses only serve the purpose of depicting some of the complexities and magnitudes of the problems facing the rice industry and engender further thought and patience toward deducing value judgements and investigating qualitative concepts, it shall have made some contribution.

OBJECTIVES OF THE STUDY

The practical purpose of quantitative analyses is to be able to forecast with a certain degree of probability the economic results of decisions in order to lay before those responsible for choice the consequence of alternative courses of action. Therefore, the main objective will be to use these statistical estimations in evaluating quantitatively those factors which appear to influence fluctuations in the supply of and the demand for rice. In order to derive empirically the effect of each of these factors and to study the mutual interdependence of the variables in the various sectors of the rice economy, it is necessary to establish a complete determinate system of relations that ties many economic variables together. This type of approach will require 5 to 10 more years of postwar data.

The quantitative characteristics of the rice model outlined in this publication, if properly construed and applied, should enable the analyst to more easly forecast, with a specified level of probability, the most probable magnitudes of such factors as price, production and consumption under specified conditions. Such knowledge of the structural relations and parameter estimates is obviously a prerequisite for intelligent formulation of government policy and for resource allocation by the firm or entrepreneur.

A corollary objective is the detection and delineation of the weaknesses in the methodologies. These weaknesses, however, can be improved in future statistical research as new and more efficient use of economic research tools and a broader knowledge of the interrelationships of the variables affecting the rice economy are achieved. This study might be fruitful in pointing out advantages in combining the tools of economic theory and statistics into a common approach relative to problem-solving in the rice industry. Too, these analyses are intended to point up the inadequacy and spuriousness of the basic model data.

ECONOMIC FRAMEWORK OF ANALYSES

Agricultural economists have formulated and developed a vast reservoir of analytical tools for examining the forces of demand for farm products during the past 3 decades.

In a majority of cases, the single equation approach suffices to measure the demand relationships sought. However, if there are two or more variables within a single equation that are interdependent, which implies that they are determined simultaneously by the same set of economic forces, then they should be solved simultaneously if an unbiased etsimate of the price elasticity of demand is desired. However, an unbiased estimate of the price elasticity of demand can be obtained statistically: (1) if consumer income is not affected by a change in the current price or consumption of the commodity, (2) if there is not more than one outlet (consumption, industry, exports, by-products, etc.), (3) if the supply of a

competing commodity is not affected by a change in the current price of the given commodity, (4) if production is not affected by the price during the current marketing year and (5) if consumption is not affected by a change in the current price or by the demand for storage or exports.

STATISTICAL FRAMEWORK OF ANALYSES

Considerable difficulty was encountered in obtaining the necessary data for the world price and export equations. Data used in the 6 equation model are shown in Table 1 and all data are presented on rough rice basis for the sake of continuity in the analyses.

Data that were the most difficult to obtain were Japanese prices at Yokohama, Japanese import duties and ocean freight charges on Japanese rice imports. These data might not be as reliable as other data shown in Table 1, nevertheless, they were used in equations 4.0 and 6.0.

In the world price equation, X_2, the statist index was used as a demand shifter. The variable was used to place rice on a comparable purchasing power with other important commodities in world trade. In equations 1.0, 1.1, 2.0 and 2.1, 1-year and 2-year lagged prices were used to determine whether prices immediately preceding a crop year affected acreage changes. The lagged prices were deflated by the index of prices paid by farmers in order to hold production costs constant.

Factory earnings were used as an index of marketing costs in equations 3.0 and 3.1. This was done to represent as close as possible transportation and labor costs. Transportation and labor costs are considered to be very salient factors in ascertaining marketing costs. Per capita income was used as a demand shifter in both equations.

In the export equation, 4.0, the difference between the world price and the domestic price plus ocean freight charges and Japanese import duties was deemed sufficient to estimate most of the variation in exports.

The deflated domestic price was used in equations 5.0 and 5.1 to estimate storage. The all-commodities index was used to deflate the prices. This was done to place rice on a comparable basis with other domestic market commodities.

All other variables in the equations are self explanatory.

The world price and export equations were fitted only to data during 1921-40. The other four equations were fitted to the 1921-40 and 1946-54 data. Postwar data could not be used in the equations relating to world price and exports because the Japanese price has been under direct government control since 1942. As a consequence, the world price equation was no further use after 1940. The export equation could serve no further use since the world price had to be estimated first before the probable quantities exported could be estimated.

THE ECONOMIC MODEL

The economic model to be presented represents an effort to ascertain the assumed behavior of the various rice market sectors of the economy as affected by government price programs. Economic theory must of necessity be incorporated in the design of an economic model in order to make appropriate choices of pertinent economic variables so far as possible.

The six equation model consists of two supply equations and four demand equations. The two endogenous variables in the supply equations are acreage and yield. The four endogenous variables in the demand equations are per capita consumption, export, storage and the world price.

The model was designed originally to be solved by the limited information method. The limited information approach is thought by some economists to be superior to the classic least-squares approach. This is particularly true when only a few variables are sufficient in each equation of the model to estimate the variation in the endogenous variables. Endogenous variables are those variables which are determined within the system.

Exogenous variables, on the other hand, are independent of the structural relations. They influence the endogenous variables, but are not, in turn, influenced by them. Exogenous and lagged endogenous variables are considered as predetermined variables. In this system, the independent variables in the supply equations are lagged endogenous. That is to say, current rice yields and acreage are assumed to be affected, not by the current market prices, but by the prices in years preceding the current crop year. The least-squares model approach is sufficient if all independent variables are predetermined and will suffice irrespective of the structural relationships if only the degree of association between variables is desired. If an unbiased estimate of the price elasticity of demand is desired in an over-identified system, a simultaneous solution of the equations will yield more reliable estimates of the parameters.

The equations in the model are over-identified if the total number of variables in the system minus the number of variables in a particular equation are in excess of the number of endogenous variables in the system less one. The model is over-identified but the equations were not solved simultaneously because there were not enough post World War II observations for the model.

THE RICE SUPPLY EQUATIONS

The analyses of the two supply equations (acreage and yield) are presented first to give a broader perspective of the quantities of rice available for the various market outlets. Only by having formulated initially a mental picture of the source and magnitudes of rice supplies can one appreciate and understand the many ramifications and complexities of the factors affecting the demand for rice.

Acreage

Rice acreage expansion or contraction is considered by the producer in the light of the relative profitability of alternative uses of his resources and the expected returns on his investments. Therefore, the average price received for rice 1 year and for 2 years preceding a crop year were considered for this study to be the most decisive economic factors affecting acreage expansion or contraction.

STATISTICAL ANALYSIS OF FACTORS AFFECTING ACREAGE

The acreage equation that was fitted to the 1923-40 data, presented graphically in Figure 1 was to ascertain the extent to which previous prices influenced the rice producer's decision to plant the same acreage or whether to contract or expand acreage.

The statistical analysis relating acreage to 1 and 2-year lagged prices using only 1921-40 data is:

EQUATION 1.0

$$Y = 792.3 - \underset{(9.74)}{9.684}\ X_1 + \underset{(97.0)}{125.1}\ X_2$$

Y = United States rice acreage (1,000 acres)

X_1 = 1 year lagged prices (dol. per cwt.), deflated by the index of prices paid

X_2 = 2 year lagged prices (dol. per cwt.), deflated by the index of prices paid

The figures in parentheses are the standard errors of the regression coefficients for all equations in this publication.

The statistical analysis relating acreage to 1 and 2-year lagged prices, using 1923-40 and 1948-54 data, presented graphically in Figure 2, is:

EQUATION 1.1

$$Y = -145.9 + \underset{(264.7)}{440.2}\ X_1 + \underset{(246.3)}{486.3}\ X_2$$

RESULTS OF THE STATISTICAL ANALYSIS FOR RICE ACREAGE

The analysis clearly exemplifies the futility of attempting to attribute changes in rice acreage to rice prices received in not more than 2 years preceding a crop year, particularly in the 1921-40 period. The influence of lagged prices was strengthened considerably when the 1946-54 data were included with the 1921-40 data. This contention is vindicated by the value of $R^2_{y.12}$. The following correlation coefficients relate to the acreage analysis:

Coefficients	Values 1921-40	Values 1921-40 and 1946-54
$R^2_{y.12}$	.01	.51
$R^2_{y.2}$	.08	.48
$R^2_{y.1}$	0	.45
$r^2_{y1.2}$	0	.07
$r^2_{y2.1}$	.01	.11
$S_{y.12}$	103.56	355.17

The coefficients of X_1 and X_2 in equation 1.0 do not differ significantly from zero at the 10 percent probability level. The sign of the coefficient of X_1 is not as expected but needs no explanation since it does not differ significantly from zero. The coefficient of X_1 in equation 1.1 is questionable—it could or could not differ significantly from zero. The values of the coefficients of determination ($R^2_{y.12}$, $R^2_{y.2}$ and $R^2_{y.1}$) readily indicate that the lagged price variables accounted for a larger proportion of the variation in acreage during the postwar period than did they in the prewar period. Too, $R^2_{y.1}$ shows that rice prices in the year just preceding the crop year had no effect on decisions as whether to plant the same acreage, expand or to reduce rice acreage. The partial correlation coefficient $r^2_{y2.1}$ also substantiates this contention.

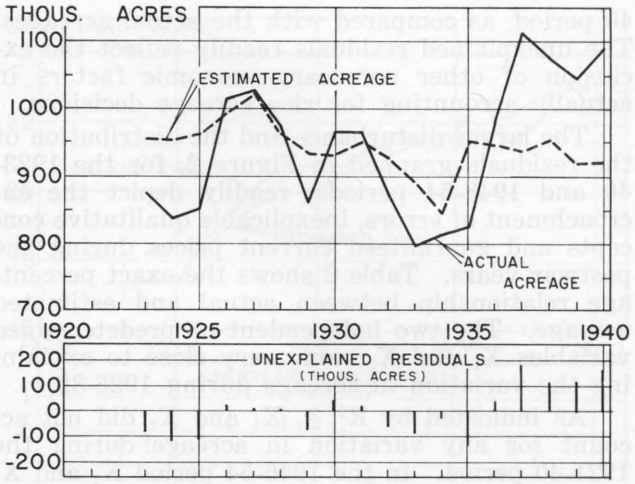

Figure 1. Rice acreage planted, actual, estimated and unexplained residuals, United States, 1923-40.

Patriotic emphasis on food, feed and attractive prices under administered government price programs were the more cogent reasons for the rapid expansion in United States rice acreage during and after World War II.

Figure 1 shows the graph of the estimated acreages, determined by X_1 and X_2 for the 1923-

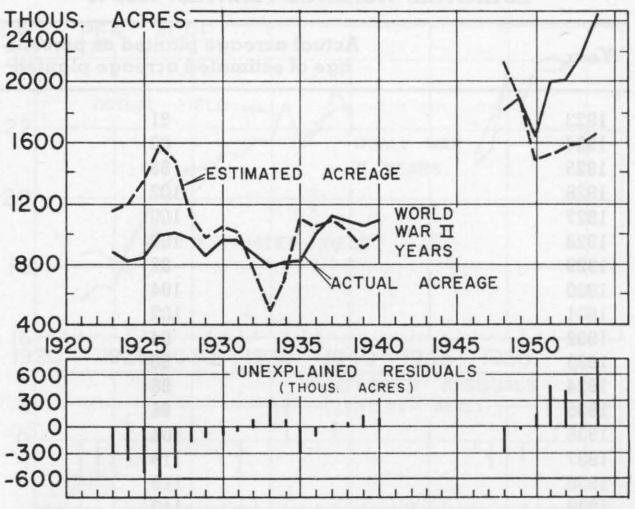

Figure 2. Rice acreage planted, actual, estimated and unexplained residuals, United States, 1923-40 and 1948-54.

40 period, as compared with the actual acreages. The unexplained residuals readily reflect the exclusion of other necessary economic factors in actually accounting for rice acreage decisions.

The larger disturbance and the distribution of the residuals graphed in Figure 2, for the 1923-40 and 1948-54 periods, readily depict the encroachment of errors, inexplicable qualitative concepts and guaranteed current prices during the postwar years. Table 2 shows the exact percentage relationship between actual and estimated acreage. The two independent or predetermined variables X_1 and X_2 came very close to explaining the variation in acreage during 1926-32.

As indicated by $R^2_{y.12}$, X_1 and X_2 did not account for any variation in acreage during the 1921-40 period. In the 1946-54 period X_1 and X_2 did account for 51 percent of the acreage variation. However, the standard error ($S_{y.12}$) of the dependent variable, with postwar years included, was about 3.5 times greater than the standard error of estimate in the 1921-40 period.

WEAKNESSES IN THE ANALYSIS ON ACREAGE

In any regression analyses, the primary purpose in obtaining an estimate of the coefficients is to measure the relationship of each independent variable to the dependent varibale and to predict what might be a reasonable estimate of the coefficients for some specified future period. The weakness, however, in making such use of statistical estimates is the tacit assumption that conditions not included in the analyses do not change through time. Too, not much confidence can be placed in the analyses unless the unexplained residuals are readily explainable by factors not included in the previous choice of independent variables. Equation 1.0 explained only 1 percent of the variation in acreage, but with only 7 years of postwar data included with the 1921-40 period, it accounted for 50 percent more of the variation in rice acreage.

TABLE 2. RICE ACREAGE PLANTED, IN RELATION TO ESTIMATED ACREAGE PLANTED, 1923-40

Year	Actual acreage planted as percentage of estimated acreage planted
1923	91
1924	88
1925	88
1926	102
1927	100
1928	100
1929	92
1930	104
1931	102
1932	94
1933	90
1934	96
1935	86
1936	104
1937	119
1938	113
1939	113
1940	118

INFERENCES AND CONCLUSIONS

To infer from the analysis that rice prices for any particular year preceding a rice crop year have no effect on a producer's decision as to whether to change his rice acreage would be spurious reasoning. In the 1921-40 period, rice producers were reluctant to make any major adjustments in their operations unless they had perhaps 3 or more consecutive years of favorable rice prices. In the 1946-54 period, their decisions were governed to a considerable extent by the government's guaranteed current price. However, the explained variation in rice acreage for the 1921-40 and 1946-54 periods was appreciably higher. This could have resulted from very attractive rice prices immediately preceding a crop year, thus attracting more firms into the rice industry and also enabling the established producers to expand.

Certain general conclusions stand, though, in reconciling the difference between the two periods. These are:

Based on the 1921-40 Data

1. That rice prices would perhaps have to be favorable or unfavorable for 3 or more years preceding a crop year to induce a farmer to expand or contract his acreage.

2. That rice farmers could not respond to price changes as rapidly in the 1921-40 period as they could in the 1946-54 period. This was a result of producers not having the advantages of vast technological advances and innovations that are enjoyed by present-day farmers.

Additional Considerations

1. That many farmers were restricted as to available rice acreage in the 1921-40 period.

2. Reclaiming marsh land with primitive machinery was very expensive.

3. Lack of technological advances and innovations discouraged acreage expansion in the rice industry during this period; new rice varieties were introduced in the late 1930's.

4. Insufficient capital outlays and restricted credit sources in many instances retarded progress in decisions to expand rice acreage.

Based on the 1921-40 and 1946-54 Data

1. Extremely attractive rice prices for the 1946-54 period offered considerable inducement for acreage expansion, as reflected by the difference in the magnitudes of the coefficients of the X's in equations 1.0 and 1.1.

2. Government encouraged expansion of rice acreage through guaranteed price support programs.

3. The analysis indicates that if the acreage equation was fitted to postwar lagged prices only, a much higher percentage of accountable variation in rice acreage would be obtained.

Additional Considerations

1. Technological advances and improvements expedited progress toward expanding the rice acreage once the decision to expand was made.

2. Finally, available land and credit contributed to rapid expansion of rice acreage in the postwar period.

Yield

Very little attention was directed toward yield considerations in the rice industry during 1921-40. However, in the latter part of the period, particularly after the Soil Conservation Act of 1936, considerably more thought was devoted to improving soil productivity and subsequent increases in crop yields.

Considerable impetus was given to yield improvements after World War II. Incidentally, these improvements in yield have coincided with the widespread adoption of significant technological advances and price stabilization accompanying administered prices. These factors concerning yield and non-acreage restrictions inevitably caused the supply curves for rice to shift to the right during 1946-54.

Phenomenal progress has been made in rice yields since 1954, thereby partially compensating for reduction in rice acreage as determined by governmental action.

STATISTICAL ANALYSIS OF FACTORS AFFECTING YIELD

The yield equation was fitted to the 1923-40 data, Figure 3 to determine the extent to which prices preceding a crop year and time affected rice yields. Although physical and biological factors have considerable influence on plant yields, the importance of economic factors cannot be discounted. There always are production costs resulting from insect pests, diseases, water control, fertilizer equipment, birds and various other factors.

The statistical analysis relating yield to 1 year and 2-year lagged prices and time, using only 1921-40 data, is:

EQUATION 2.0

$$Y = 18.918 - \underset{(.7)}{1.068}\ X_1 + \underset{(.7)}{.163}\ X_2 + \underset{(.04)}{.302}\ X_3$$

Y = United States rice yields (cwt. per acre)

Y_1 = one year lagged price (dol. per cwt.), deflated by the index of prices paid

X_2 = two year lagged prices (dol. per cwt.), deflated by the index of prices paid

X_3 = time

The statistical analysis relating yield to the same variables using the 1923-40 data and the 1946-54 data, graphed in Figure 4, is:

EQUATION 2.1

$$Y = 21.294 - \underset{(.547)}{1.622}\ X_1 - \underset{(.512)}{.897}\ X_2 + \underset{(.017)}{.221}\ X_3$$

RESULTS OF THE STATISTICAL ANALYSIS FOR RICE YIELDS

The analysis emphasizes the importance of time in ascertaining the causes for changes in rice yields. Actually, equations 2.0 and 2.1 reflect little other than a directly related time trend.

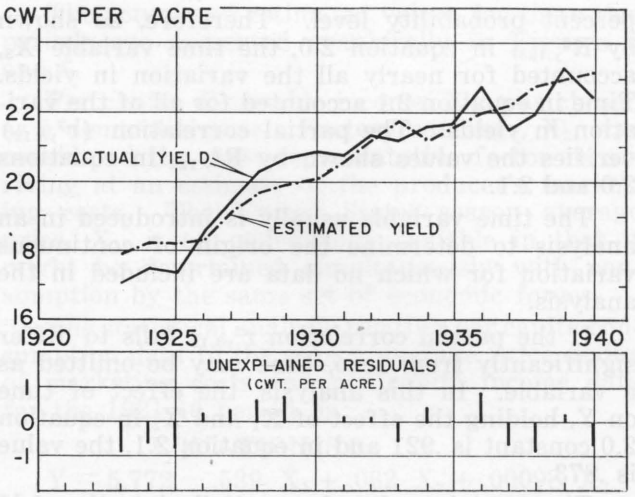

Figure 3. Rice, rough: Yield per acre, actual, estimated and unexplained residuals, United States, 1923-40.

The values of the following coefficients readily reflect the lack of interdependence of yield on rice prices prior to a particular crop year. Lagged prices during the 1921-40 period, as indicated by $R^2_{y.12}$ contributed more to the variation in yield than to the variation in acreage. In the latter period, however, the response of yield to lagged prices was zero.

The following correlation coefficients related to the yield analysis:

Coefficients	Values 1921-40	Values 1921-40 and 1946-54
$R^2_{y.123}$	.867	.873
$R^2_{y.23}$	.853	.828
$R^2_{y.13}$	.876	.861
$R^2_{y.12}$	.260	0
$r^2_{y1.23}$	.099	.262
$r^2_{y2.13}$	0	.086
$r^2_{y3.12}$	.821	.873
$S_{y.123}$	.678	.720

The coefficients of X_1 and X_2, in equation 2.0, do not differ significantly from zero at the 10

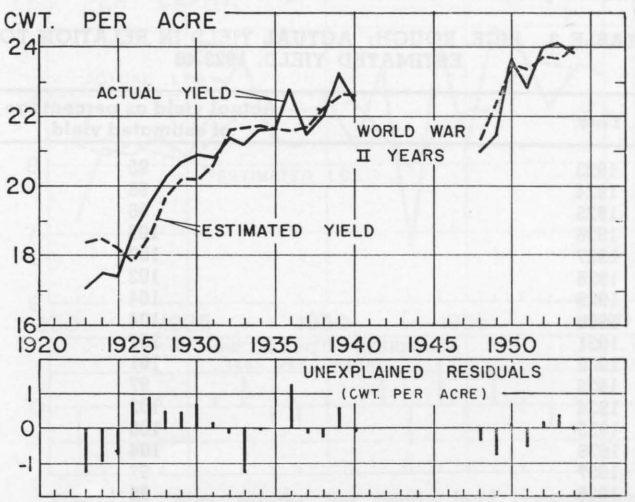

Figure 4. Rice, rough: Yield per acre, actual, estimated and unexplained residuals, United States, 1923-40 and 1948-54.

percent probability level. Therefore, as shown by $R^2_{y.123}$, in equation 2.0, the time variable X_3, accounted for nearly all the variation in yields. Time in equation 2.1 accounted for all of the variation in yields. The partial correlation ($r^2_{y3.12}$) verifies the values shown by $R^2_{y.123}$ in equations 2.0 and 2.1.

The time variable usually is introduced in an analysis to determine the origin of continuous variation for which no data are included in the analysis.

If the partial correlation $r^2_{y3.12}$ fails to differ significantly from zero, time may be omitted as a variable. In this analysis, the effect of time on Y, holding the effect of X_1 and X_2 in equation 2.0 constant is .921 and in equation 2.1, the value is .873.

Time was introduced essentially into the yield equation to account for technological advances, fertilization, plant breeding and variety improvements.

The signs of X_1 and X_2 in equation 2.1, are not as expected, but the coefficients do differ slightly from zero at the 10 percent probability level. The sign of X_2 in equation 2.0 and X_3 in both yield equations have the expected signs.

The negative signs, or an inverse relationship, in both equations might be construed as a reflection of over-expansion in acreage and a subsequent decrease in yield accompanying an increase in the price 1 year, 2 years, or both, preceding a crop year.

The inverse relationship of yield to lagged prices X_1 and X_2, as shown in equation 2.1, is improved when postwar data are used.

In equation 2.0, the value of the coefficient of X_2, (.163) is construed as follows: Y (yield) increases (.163) (100 pounds) per acre for each unit increase (1 dollar per cwt.) in X_2. The magnitudes of the standard errors ($S_{y.123}$) for the two periods were surprisingly close.

Actual yield expressed as a percent of estimated yield in the 1923-40 period, Table 3 reflects the significance of time in explaining variation in yield.

TABLE 3. RICE, ROUGH: ACTUAL YIELD IN RELATION TO ESTIMATED YIELD, 1923-40

Year	Actual yield as percentage of estimated yield
1923	95
1924	96
1925	96
1926	102
1927	102
1928	103
1929	104
1930	104
1931	101
1932	101
1933	97
1934	102
1935	100
1936	104
1937	97
1938	96
1939	101
1940	97

The unexplained yield residuals were reduced appreciably when postwar data were used in the equation. This points up the importance of time in explaining variations in yields. The impacts of administered prices, technological innovations and improvements in plant breeding are reflected readily in the time variable.

The value of $R^2_{y.12}$, for yields in the 1921-40 period was 23 percent as compared with 1 percent for acreage. However, with postwar data included in this period the value of $R^2_{y.12}$ for yields is only a third as large as the acreage value.

WEAKNESSES IN THE ANALYSIS ON YIELD

The factors selected to explain variation in yields during the 1921-40 period overestimated the yield noticeably in 1923, 1924, 1925 and 1938, but underestimated the yield in 1928, 1929, 1930 and 1936. Since lagged prices accounted for only 26 percent of the variation in yields during this period, it is apparent that the analysis reflects primarily a positive time trend.

Yields are, for the most part, inversely related to the index of prices paid by farmers for those factors used in the production of rice. Therefore, since the lagged prices X_1 and X_2 are deflated by the index of prices paid, the unexplained residuals reflected the level of production costs. Time, however, which reflects the impact of technological innovations and advances, might perhaps dampen or accentuate these extraneous forces, depending on the producer's value judgments and anticipations relative to alternative resource uses.

By noting the value of the partial correlation, $r^2_{y2.3}$, which is zero, it can be deduced readily that, relative to prices, farmers were influenced more by the price immediately preceding a crop year than the other price period. This situation was improved very little by adding the 1946-54 data to the 1921-40 data. Prewar data should not have been combined with postwar data because of the lack of homogeneity. However, there were not enough postwar observations to make a separate analysis.

It ordinarily is dangerous to extrapolate or predict on the basis of results obtained from an equation involving time as a variable. A time trend frequently will overshadow economic factors in an analysis, and for this reason, tests should be made to ascertain the advisability of using time as a variable.

INFERENCES AND CONCLUSIONS

The principal implication in the yield analysis is that time played the larger part in yield changes during the 1921-40 period. The influence of time and prices immediately preceding a crop year probably is viewed by the reader as potent factors attributable to yield variations, but, as shown in Table 1, average annual yields varied but little in this period.

Certain general conclusions follow, though. These are:

1. That guaranteed government support prices prior to any crop year did not noticeably affect rice yields.

2. That guaranteed current prices relative to prices paid by producers for input factors had more influence than did preharvest prices.

Additional Considerations

1. That available resources for coping with physical and biological factors play a big part in yield variations.

2. That producers will endeavor to maintain rice production levels, through increased yields, to compensate for acreage reductions under marketing quotas and acreage allotment programs.

THE RICE DEMAND EQUATIONS

The economic forces of demand for agricultural commodities are subject to constant change. Achieving effective results from statistical analyses of demand for any commodity requires that the researcher exercise certain basic knowledge of economic and statistical methodology.

The economic forces ascribable to the variation in the price-determined outlets in the rice industry did not, in most instances, give the estimated variations expected. However, it is doubtful whether the selection of any other factor or combination of factors could have improved appreciably the results that were obtained from the demand equations, particularly in the 1921-40 period.

The price-determined outlets for the demand analyses are: per capita consumption, exports, storage and the world price.

As was discussed under the Economic Framework of Analyses, equations which have two or more variables that are determined simultaneously by the same set of economic forces should be solved simultaneously. This is particularly true if an unbiased estimate of the price elasticity of demand is desired. Consumption, exports and storage are examples of such equations.

Per Capita Consumption

The per capita consumption of rice in the United States perhaps has varied less than has any other product used for human consumption. The per capita consumption of milled rice has seldom been more than .5 pound above or below the average of 5.4 pounds per person. Consequently, the task of selecting economic forces ascribable to the relatively small variation in consumption is very difficult. This could be a result of such qualitative factors as consumer habits and customs.

STATISTICAL ANALYSIS OF FACTORS AFFECTING PER CAPITA CONSUMPTION OF RICE

The per capita consumption equation was fitted separately to data for two periods — to the 1921-40 data and then to the 1921-40 and 1946-54 data.

The actual and estimated values for these two periods are presented graphically in Figures 5 and 6.

Per capita disposable income, X_3, was chosen as a demand shifter. Factory earnings, X_2, was considered the most representative factor in arriving at an estimate of the producer's marketing costs. The United States season average price, X_1, is an endogenous variable in that it might be determined simultaneously with consumption by the same set of economic forces.

The statistical analysis relating per capita consumption data to the season average price, index of marketing costs and per capita income data for the 1921-40 period, is:

EQUATION 3.0

$$Y = 5.772 - \underset{(.4)}{.539}\ X_1 + \underset{(.04)}{.062}\ X_2 + \underset{(.003)}{.00098}\ X_3$$

Y = domestic per capita consumption of rice

X_1 = United States season average price (dol. per cwt.)

X_2 = index of marketing costs (cents per hour)

X_3 = per capita income in dollars

The statistical analysis relating per capita consumption of rice to the same variables as are in equation 3.0, using 1921-40 and 1946-54 data, is:

EQUATION 3.1

$$Y = 6.531 - \underset{(.240)}{.392}\ X_1 + \underset{(.015)}{.029}\ X_2 + \underset{(.00098)}{.00245}\ X_3$$

RESULTS OF THE STATISTICAL ANALYSIS FOR PER CAPITA CONSUMPTION

The consumption analysis reflects clearly the difficulty involved in ascertaining the causal relationships for the variation in the average per capita consumption of rice. It does not seem plausible that factors other than X_1, X_2 and X_3 could contribute to any appreciable improvement in the results obtained.

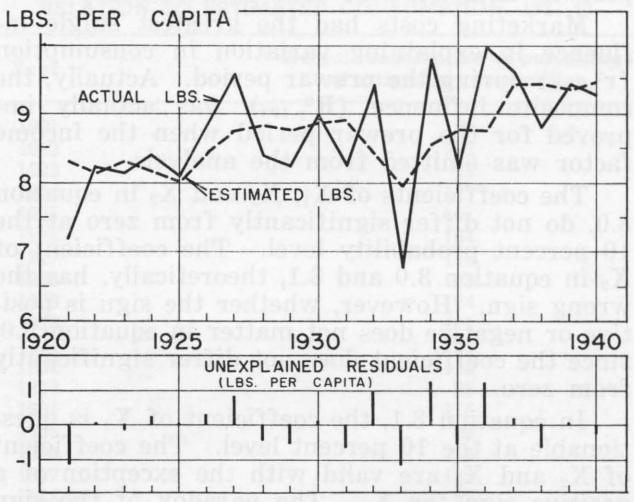

Figure 5. Rice, rough: Per capita food consumption, actual, estimated and unexplained residuals, United States, 1921-40.

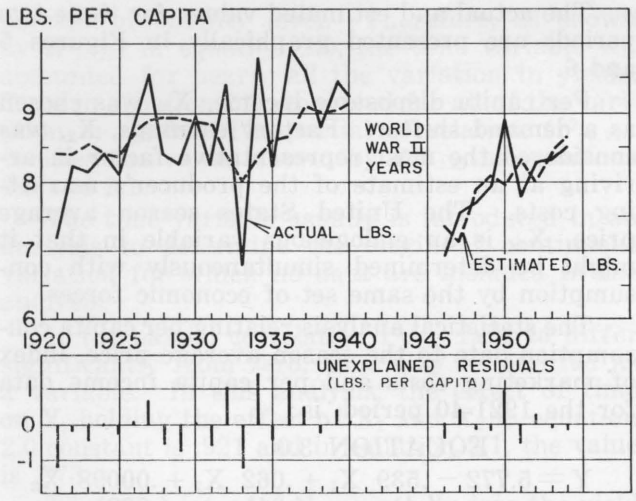

Figure 6. Rice, rough: Per capita food consumption, actual, estimated and unexplained residuals, United States, 1921-40 and 1946-54.

The following correlation coefficients relate to the consumption analysis:

Coefficients	Values 1921-40	Values 1921-40 and 1946-54
$R^2_{y.123}$	.187	.294
$R^2_{y.23}$	.150	.249
$R^2_{y.13}$	.093	.220
$R^2_{y.12}$	.229	.151
$r^2_{y1.23}$	.044	.060
$r^2_{y2.13}$	.104	.196
$r^2_{y3.12}$	0	.168
$S_{y.123}$	.758	.692

Income, for example, as indicated by the partial correlation coefficient ($r^2_{y3.12}$) contributed no influence toward explaining consumption behavior in 1921-40. However, income did show some improvement by including the 1946-54 data with the prewar data. Price and marketing costs, on the other hand, ($R^2_{y.12}$), indicated less influence toward explaining variation in consumption when postwar data were included in the analysis.

Marketing costs had the greatest single influence in explaining variation in consumption ($r^2_{y2.13}$) during the prewar period. Actually, the composite influence ($R^2_{y.123}$) was actually improved for the prewar period when the income factor was omitted from the analysis.

The coefficients of X_1, X_2 and X_3 in equation 3.0, do not differ significantly from zero at the 10 percent probability level. The coefficient of X_2 in equation 3.0 and 3.1, theoretically, has the wrong sign. However, whether the sign is positive or negative does not matter in equation 3.0, since the coefficient does not differ significantly from zero.

In equation 3.1, the coefficient of X_1 is questionable at the 10 percent level. The coefficient of X_2 and X_3 are valid with the exception of a positive sign for X_2. The paradox of the sign of the coefficient of X_2 lies in the fact that the X_2 variable in the equation connotes marketing costs, but vacillates with factory income. When X_2 is perceived as representing only the concept of marketing costs, the sign of the coefficient logically would be negative, but if the reader remains aware of the basis of representation (factory earnings), the sign logically should be positive.

The values of all correlation coefficients and the standard error of estimates, with the exception of $R^2_{y.12}$, were improved considerably when the data for the 9 postwar years were included in the analysis. The smaller value of $R^2_{y.12}$ when postwar data were included can be explained by increases in factory earnings, which are reflected by X_2, not having as much influence on consumption in the extremely high income period after the war as they did in the comparatively low income period prior to the war. The contention that X_2 had less influence in explaining variations in consumption is reflected by $r^2_{y1.23}$, which increased relatively little when the postwar data were included in the analysis.

The actual per capita consumption of rice during 1921-40 was expressed as a percentage of the estimated consumption. The values are shown in Table 4. The estimated consumption values were obtained from equation 3.0.

It is apparent that the variation in per capita consumption, as shown by equation 3.0, was much more erratic at the beginning of the depression in 1929 and during the government programs in 1933, than was the case earlier in the period.

Incidentally, X_1, X_2 and X_3 in equation 3.0 explained an average of 99.9 percent of variation in consumption for the entire period.

WEAKNESSES OF THE ANALYSIS ON PER CAPITA CONSUMPTION

The amount of variation in the per capita consumption of rice, as estimated by equations 3.0 and 3.1, is not sufficient to ascribe any significance to the composite influence of X_1, X_2 and X_3.

Since the value of $R^2_{y.12}$ is larger when income is omitted and that $r^2_{y1.23}$ and $r^2_{y2.13}$ are 4 and 10 percent, respectively, it is apparent that the X_2 variable contributed more toward explaining the variation in consumption. With postwar data included, the value of $r^2_{y2.13}$ increased approximately 100 percent, whereas $r^2_{y1.23}$, increased about 50 percent.

It would be dangerous to attach too much importance to the influence of per capita income on the basis of the higher percentage variation explained by $r^2_{y3.12}$ when postwar data were included. This could result from intercorrelation to some extent. That is, conditions which engendered favorable attributes of income with postwar data included could have contributed simultaneously to the variation in consumption. One logical reason why per capita income could not have exerted as much influence when postwar data were included, is that it contributed nothing toward explaining the variation in consumption in the prewar period.

The analysis would have probably been improved if X_1 had been adjusted by the index of prices paid by farmers. Too, the analysis might have reflected greater influence in explaining the variation if the first differences of logarithms had been used. First differences are particularly useful when extreme values are involved as was the case when postwar values were included in the prewar values.

In Table 4, there were 2 years, 1921 and 1933, for which the values obtained for consumption by equation 3.0 were considerably overestimated, but the values obtained in 1927, 1932, 1934 and 1936 were considerably underestimated. There was a drastic slump in prices received by farmers in 1921. These prices dropped to the second lowest on record in 1933. The lowest index of prices received was the 1932 value of 65.

The estimated values obtained by equation 3.0 were below actual consumption figures for the years in which prices received were below the level of the preceding year. However, the situation was just the reverse in 1934 and 1936. Government programs could have altered the normal course of economic forces in the rice industry during those years.

INFERENCES AND CONCLUSIONS

It would be in error to deduce from the magnitude of the regression coefficients that prices (X_1) affected consumption considerably more than did marketing costs (X_2). The validity must be established by a test of significance at a specified level and by the magnitude of the partial correlation coefficient.

There appeared to be less disturbance in the consumption function when using postwar than when using prewar data. The smaller disturbance is, to some extent, reflected in the values of $S_{y.123}$.

In examining the change in the values of $R^2_{y.13}$ for the two periods, and at the same time noting the change in $r^2_{y1.23}$, it might be inferred that per capita income, X_3, enhanced appreciably the level of explicable variation in rice consumption after World War II. In reality, the income regression coefficient in equation 3.1 did not differ significantly from zero at the 5 percent probability level and barely did differ from zero at the 10 percent level.

Certain general conclusions follow, though. These are:

1. That marketing costs affected the variation in consumption more in the prewar than in the postwar period.

2. That income showed evidence of greater influence on consumption variation in the postwar period.

3. That the season average price had very little influence on domestic consumption of rice by the population as a whole in the United States. This was a result perhaps of the very low price elasticity of demand for rice.

4. That government support prices did not contribute to any change in the variation of per capita consumption of rice.

Other Considerations

1. The results of the consumption analysis would, perhaps, be more revealing and of greater consequence if geographical and ethnological considerations were incorporated into the analysis. Factors that induce a Midwestern consumer to purchase rice are not necessarily relevant in explaining the consumption of rice by a consumer in the South.

2. That increases in aggregate consumption will be realized through population increases rather than from increases in per capita consumption.

Exports

Rice exports have played a very vital role in the relatively prosperous economy that has prevailed in the rice industry since the beginning of World War II.

Exports constituted about 50 percent of total disposition of United States rice stocks during 1940-54. Producers have relied heavily in recent years on foreign imports of United States rice in formulating production decisions. What the future holds in store relative to foreign outlets for United States rice is anyone's guess.

The rate of increase in the total consumption of rice roughly parallels the rate of increase in population. Consequently, foreign rice outlets must continue to absorb a large percentage of United States rice supplies if the high level of production that prevailed in recent years is maintained.

STATISTICAL ANALYSIS OF FACTORS AFFECTING EXPORTS

The export equation was fitted only to the 1921-40 data. These data are presented graphically in Figure 7. Since Japanese rice prices

TABLE 4. RICE, ROUGH: PER CAPITA CONSUMPTION IN RELATION TO ESTIMATED CONSUMPTION, 1921-40

Year	Actual consumption as percentage of estimated consumption
1921	86
1922	101
1923	98
1924	103
1925	101
1926	104
1927	110
1928	95
1929	94
1930	101
1931	92
1932	112
1933	85
1934	115
1935	94
1936	114
1937	102
1938	93
1939	101
1940	97

were not available after 1941, the export equation was fitted only to the 1921-40 data. The export equation involves only one independent variable. The independent variable represents the average annual price differential between the Japanese and the United States rice prices. The Japanese rice price at Yokohama was used as the world price in equation 6.0. The difference between Japanese rice prices and United States domestic prices was considered to be the most decisive single economic factor in governing the rate of export movements into foreign markets. The reason for choosing the Japanese price was that Japan was the heaviest importer of foreign rice supplies.

The statistical analysis relating exports to the annual price differences between the World and United States prices, using 1921-40 data, is:

EQUATION 4.0

$$Y = 7{,}959.534 + 494.855\ X_1$$
$$(550.414)$$

Y = United States exports (1,000 cwt.)

X_1 = Japanese rice price minus the sum of the United States price, Japanese tariffs and ocean freight charges.

RESULTS OF THE STATISTICAL ANALYSIS FOR RICE EXPORTS

The difference between Japanese and United States rice prices did not give satisfactory results in explaining the variation in United States rice exports. There was some doubt as to the accuracy of Japanese price data. Considerable difficulty also was encountered in obtaining Japanese tariffs and ocean freight rates.

If the demand for United States rice abroad is strong enough, as it was immediately after World War II, some rice will be exported irrespective of the differential between the World and United States prices. However, as the available foreign supply approaches the state of only slight disequilibrium relative to the demand in those countries, only then will the price differential be a decisive factor in determining the quantity imported. This however, assumes (1) that no differentation is made between rice qualities which determines whether the outlet is a *quality* market or a *price* market and (2) that the world market demand is more elastic than the United States domestic market demand. Consequently, equation 4.0 is designed primarily to explain export movements of rice under conditions which are nurtured and governed by the law of supply and demand.

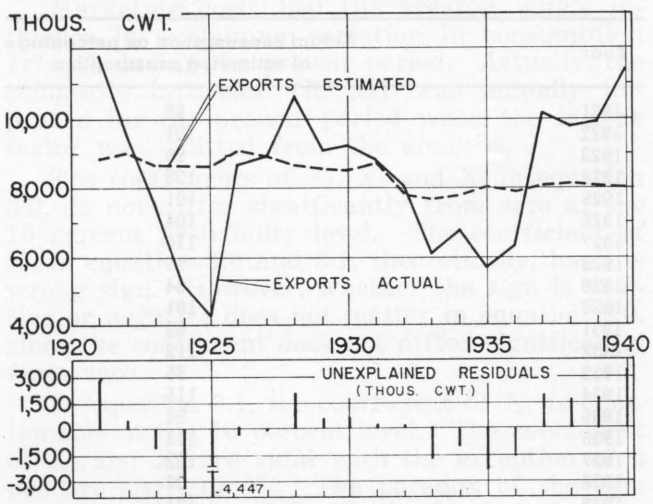

Figure 7. Rice, rough: Exports, actual, estimated and unexplained residuals, United States, 1921-40.

It would have been interesting to have observed the changes in results for the export equation if the 1946-54 data had been available.

The following correlation coefficients relate to the export analysis:

Coefficients	Values 1921-40
r^2_{y1}	.407
S_{y1}	2,109.517

About 41 percent of the variation in exports was attributed to X_1. The sign of the regression coefficient is correct since there is expected to be a direct correlation between increases in exports and increases in the magnitudes of price differentials. This, however, is based on the positive excesses of Japanese rice prices over United States prices.

The coefficient of X_1 does not differ significantly from zero even at the 30 percent probability level. The equation in the main reveals virtually nothing as to the true cause of variation in United States exports. In reality, it would be too difficult to determine whether X_1 is the cause or the effect of variation in exports. The validity of the contention is further attested by the magnitude of $S_{y.1}$.

Actual exports were expressed as a percentage of estimated exports, Table 5. The residuals were extremely large in certain years as a result of extremely large standard errors in the estimates. With the exception of 1927, 1931 and 1932, the estimated exports were unreasonably out of line.

In view of the lack of continuity of estimates relative to prosperous and depression years, the three closely estimated export years could be charged off to chance factors or compensating errors.

WEAKNESSES IN THE ANALYSIS ON EXPORTS

The results of the rice export analysis are indicative of the prevalence of errors in these export data or the inherent weakness in the price-difference factor in explaining the variation.

If the Japanese price data are authentic and the import tariffs and ocean freight rates are accurate, then the weakness obviously lies in the irrelevancy or inadequacy of X_1 in explaining the variation in rice exports.

INFERENCES AND CONCLUSIONS

The standard error of estimate might lead the reader to imply that the weakness in the export analysis is ascribable to inaccuracies in rice ex-

port data. On the other hand, the Japanese price could, for the most part, be irrelevant in explaining the variation in rice exports during 1921-40. In reality, upon reviewing the history of exports during this period, most of the United States rice exports went to Cuba and Puerto Rico except for several years during the 1920's, at which time Japan did receive a relatively large percentage of United States exports.

Exports were not affected directly by government price programs during the period covered by the analysis. The implication is that by having a guaranteed price for rice, producers were encouraged to produce enough rice to satisfy the strong foreign demand for rice which prevailed and would have prevailed in spite of government price programs.

It is believed that a two-price program for rice would increase United States exports, but such a program will inevitably be plagued with international political repercussions. In the absence of a two-price rice program, the domestic price would have to be maintained at prevailing world price levels to expect a reasonable flow of rice through available export channels. Difficulty again will be encountered under this type of governmental action in as much as repercussions would perhaps emanate from domestic producers.

Certain general conclusions follow, though. These are:

1. That if Japanese data were available for the postwar period, X_1 would be more relevant in explaining the variation in exports.

2. That a different world price for the prewar period would improve the analysis.

3. That if an index of foreign production could be developed, it would contribute greatly toward improving the analysis.

Other Considerations

1. If there are no wars, widespread drouths or floods and disease epidemics in the future to disrupt rice production within principal rice producing areas, United States rice exports could be greatly imperiled.

2. Serious consideration should be directed toward ascertaining what the export market potential likely will be prior to planning needed rice acreage.

Storage

The quantity of rice that goes into storage depends primarily on the following considerations: (1) what the price is likely to be at some future date and the extent to which the producer is satisfied with the prevailing market price, (2) if the expected price increment is more than sufficient to offset storage costs, (3) availability of storage facilities, (4) credit resources, (5) alternative use of available funds and (6) the speculative aspects of storage through time.

STATISTICAL ANALYSIS OF FACTORS AFFECTING STORAGE

The economic implications of rice storage are not quite as complex and difficult to reconcile as the other concepts considered in this study. An analysis on rice storage was completed using the 1921-40 and 1946-54 data. The storage equation was fitted to the 1921-40 data and also to the 1921-40 and 1946-54 data. The results obtained with the storage equation for the two time periods are graphically presented in Figures 8 and 9.

The storage equation involved only two variables. The single independent variable was the deflated United States season average price. The price variable was deflated by the all-commodities price index.

The statistical analysis relating storage to deflated farm rice prices, using 1921-40 data, is:

EQUATION 5.0

$$Y = 5{,}633.371 - \underset{(585.676)}{1{,}680.769}\ X_1$$

Y = United States rice storage (1,000 cwt.)

X_1 = deflated United States season average price (dols. per cwt.)

The statistical analysis relating the storage equation to the same variable as in equation 5.0, using the 1921-40 and 1946-54 data, is:

EQUATION 5.1

$$Y = 2{,}753.644 + \underset{(1{,}798.233)}{88.320}\ X_1$$

RESULTS OF THE STATISTICAL ANALYSIS FOR RICE STORAGE

The demand for rice storage is governed by the amount of profit expected from holding the grain for some future sale.

The coefficient of X_1 in equation 5.0 has the expected sign and differs significantly from zero. However, the standard error of the regression coefficient should be smaller.

TABLE 5. RICE, ROUGH: ACTUAL EXPORTS IN RELATION TO ESTIMATED EXPORTS, 1921-40

Year	Actual exports as percentage of estimated exports
1921	133
1922	106
1923	87
1924	61
1925	49
1926	96
1927	100
1928	124
1929	107
1930	108
1931	101
1932	102
1933	79
1934	87
1935	71
1936	80
1937	124
1938	121
1939	122
1940	142

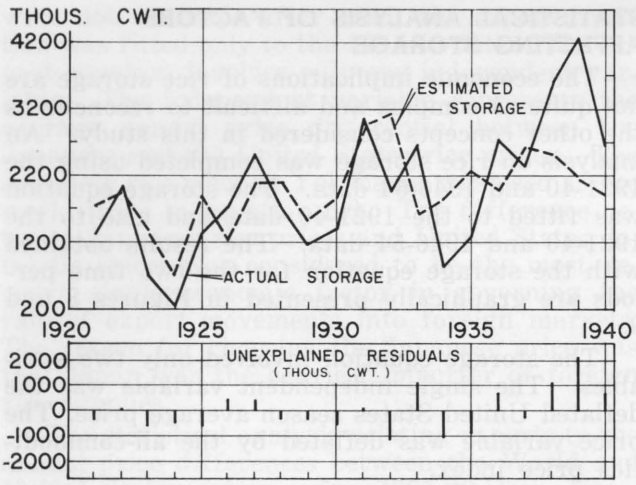

Figure 8. Rice, rough: Storage, actual, estimated and unexplained residuals, United States, 1921-40.

Assuming that storage facilities were available during 1921-40, it appears logical that the quantity stored would be related inversely to a unit change in X_1. That is to say, if the price changed up or down $1.00 per hundredweight, the quantity available for sale or storage, respectively, would be about 1.7 million hundredweight.

Equation 5.1, which included 9 postwar years' data, is of no consequence. The coefficient of X_1 does not differ significantly from zero, even at the 99 percent probability level.

The following correlation coefficients relate to the storage analysis:

Coefficients	Values 1921-40	Values 1921-40 and 1946-54
r^2_{y1}	.325	.009
S_{y1}	864.802	5,416.469

The standard error of estimates is considered fairly large in view of the quantities available for storage during the prewar period. The coefficient of determination is not of sufficient magnitude to explain the behavior pattern of storage by deflated price changes. Price changes as indicated by r^2_{y1} accounted for roughly one-third of the variation in storage.

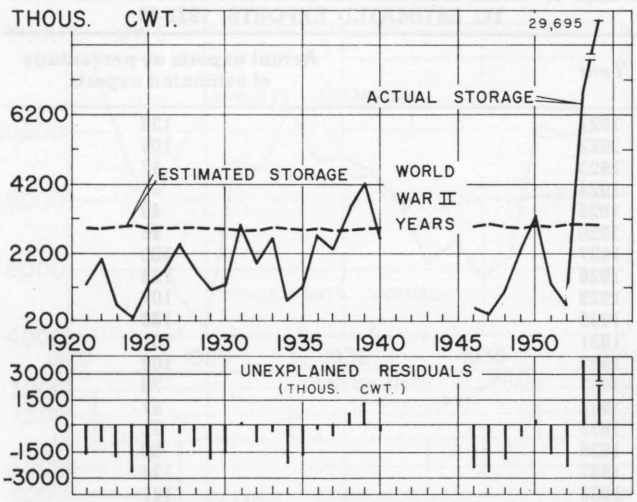

Figure 9. Rice, rough: Storage, actual, estimated and unexplained residuals, United States, 1921-40 and 1946-54.

Unexplained residuals in Figure 9 readily reflect the futility of attempting to explain rice quantities available for storage by price changes during the postwar period.

Actual storage was expressed as a percentage of estimated storage in Table 6. As indicated by the results obtained, X_1 overestimated considerably the quantities available for storage in most of the earlier prewar years with the exception of 1926 and 1927.

The advent of new government farm programs in 1933, 1936 and 1938 could, perhaps have caused the very noticeably underestimated quantities available for storage. The abrupt changes in the percentage roughly parallel the abnormal changes in actual quantities available for storage in Figure 9.

WEAKNESSES IN THE ANALYSIS ON STORAGE

Actual carryover of rice supplies was used to represent storage in equations 5.0 and 5.1. The storage data used were on a rough rice basis and, in reality, these data represent seed rice carryover. The other portion of total carryover is milled rice. In attributing the variation in storage to the deflated price, particularly for the postwar period, certain price relationships should have been considered for storage data in 1951 and 1954. In 1951, the support price was above the season average price, thus eliminating the true forces of supply and demand in determining the free market price. The same situation holds true for the 1954 prices. Also in 1954, the quantity of rice carryover was out of proportion to the carryover recorded for the other years.

Other factors, such as an index of foreign production and the world price, would have perhaps improved the results of the storage analysis.

Storage facilities during 1921-40 were very limited compared with the postwar period. A large percentage of storage facilities in the postwar period were government-owned or leased warehouses. However, a greater proportion of the prewar production of rice went into storage than was the case during 1946-53. The quantity of rice going into carryover stocks in 1954 was about equal to the combined carryover of the 13 preceding years used in the analysis. The heavy foreign demand for United States rice prior to 1954 was the principal factor in accounting for the smaller percentage of rice carryover during and after the war.

INFERENCES AND CONCLUSIONS

The government support price programs for rice affected rice production in two principal ways: (1) rice was produced primarily for a guaranteed price and not necessarily for domestic and export market needs and (2) rapid expansion in the rice acreage eventually piled up carryover stocks in Commodity Credit Corporation warehouses, beginning with the 1953 crop.

Government programs designed to maintain high support prices resulted in rapid increases in rice acreage during and after the war. However, accompanying the rapid expansion in the production of rice was an increasingly strong foreign demand. It was not until 1954 that the United States total production of rice, minus normal domestic requirements, was noticeably in excess of the quantity needed to satisfy export needs.

Certain general conclusions follow, though. These are:

1. That domestic prices alone are insufficient to account for variations in rice storage.

2. That the impact of government programs on quantities going into storage was offset by an abnormally strong foreign demand until 1954.

3. That support prices since 1953 contributed to the increasing quantities of rice moving into Commodity Credit Corporation warehouses. Public Law 480 and school lunch programs have alleviated the burden of excessive rice storage stocks in recent years.

World Prices

Japan imports a larger quantity of rice for home consumption than any other country in the world. The average annual price at Yokohama was, therefore, used in equation 6.0 to represent the world market price for all rice that enters international trade.

Japan will perhaps never be in a position to produce enough rice in any one year to satisfy her domestic requirements.

STATISTICAL ANALYSIS OF FACTORS AFFECTING WORLD PRICES

Data for the world price equation were available only for the 1921-40 period. Actual prices and estimated prices are illustrated graphically in Figure 10. Since rice prices in Japan were placed under the auspices of the Japanese government in 1942, the nine postwar years (1946-54) could not be included in the analysis.

Residual prices illustrated in Figure 10 were not too far out of line except for the depression year 1932. The depressed farm price conditions in the United States had not been reflected wholly perhaps, in the world rice market in 1932. The serious economic conditions prevailing in this country probably caused this extreme difference in the two prices.

The statistical analysis relating world prices to world rice supplies, statist index and time, using only the 1921-40 data, is:

EQUATION 6.0

$$Y = .436 + \underset{(.000007)}{.0000074}\ X_1 + \underset{(.006)}{.024}\ X_2 - \underset{(.04)}{.140}\ X_3$$

Y = Japanese rice prices (dols. per cwt.)

X_1 = supply of rice entering world trade (1,000 cwt.)

X_2 = statist index

X_3 = time

RESULTS OF THE STATISTICAL ANALYSIS FOR WORLD RICE PRICES

Time, total supply of rice entering international trade and the statist index (originally the United Kingdom index) were considered the best combination of variables to determine the variation in world prices.

The statist index was used as a demand shifter and time was used to account for the dynamic growth of population.

The following correlation coefficients relate to the world price analysis:

Coefficients	Values 1921-40
$R^2_{y.123}$	.796
$R^2_{y.23}$	.795
$R^2_{y.12}$	.639
$R^2_{y.13}$	.598
$r^2_{y1.23}$	.005
$r^2_{y2.13}$	.493
$r^2_{y3.12}$	.436
$S_{y.123}$	.568

The coefficient of X_1 has the wrong sign, but does not differ significantly from zero and, for that reason, warrants no explanation.

Variation in the world price of rice was affected more during this period by the statist index than by the composite influence of the other two variables. As indicated by the value of $r^2_{y2.13}$, X_2 accounted for about half of the total variation in prices attributable to the three independent variables. During the entire period, about two-thirds of the observed price values fell within 57 cents of $3.86.

Time was only 6 percent less effective in explaining variations in the price than was the statist index. Time, in equation 6.0, indicated the presence of a negative trend during the period. Depressed economic conditions and a drop in the general level of prices during the period, perhaps, caused the negative time trend. The statist index has the correct sign and indicates that,

TABLE 6. RICE, ROUGH: ACTUAL STORAGE IN RELATION TO ESTIMATED STORAGE, 1921-40

Year	Actual storage as percentage of estimated storage
1921	76
1922	103
1923	52
1924	30
1925	70
1926	136
1927	121
1928	82
1929	75
1930	73
1931	104
1932	63
1933	166
1934	44
1935	57
1936	138
1937	90
1938	142
1939	198
1940	137

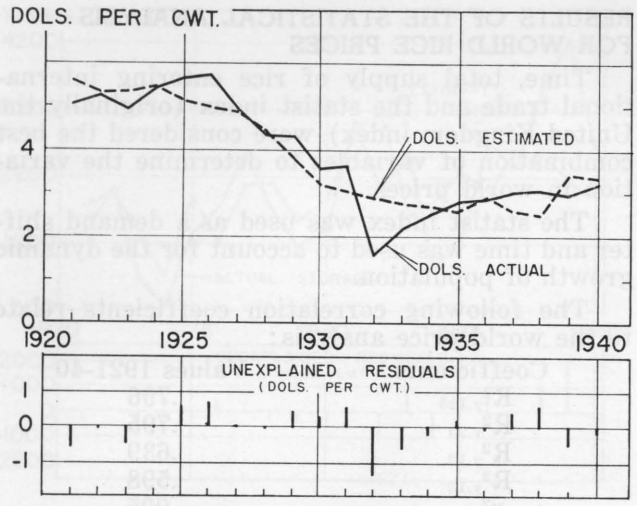

Figure 10. World price, actual, estimated and unexplained residuals, United States, 1921-40.

with a unit change in the index, the price changed approximately 2 cents in the same direction.

World rice prices were expressed as percentages of estimated prices in Table 7. Estimated prices were considerably in excess of actual prices in 1932 and 1933. Rice prices were noticeably underestimated in 1931, 1937 and 1938.

WEAKNESSES IN THE ANALYSIS ON PRICES

In using the price data for 1921-40, several shortcomings are encountered relative to the process of obtaining reliable results from the price equation. For example, the variables are affected by international trade, many different forms of financial structures, different types of governments and internal economies. It is difficult to reconcile the total lack of influence of X_1 in explaining the variation in prices. Data used for the X_1 variable, however, represent only 4 to 5 percent of the world production of rice entering international trade.

Rice prices were not affected directly by government programs during 1921-40. There was no support price program for rice until 1941 and no acreage allotments and marketing quotas until the 1955 rice crop.

An analysis was not made without time as a variable to ascertain whether a systematic variation of residuals through time was evident.

INFERENCES AND CONCLUSIONS

It often is difficult to interpret the magnitudes of coefficients without first converting to elasticities. Inferentially, the negative time trend was, perhaps, a reflection of the declining level of the agricultural industry, as well as the aggregate economy of this country during a number of years, particularly in the 1930's.

Total supplies of rice entering world trade had no influence on prices, as indicated by $r^2_{y1.23}$ and substantiated by the "*t*" test. This certainly implies that rice prices in the world market are controlled primarly by international trade agreements, bartering agreements and governmental policies of the importing and exporting countries. In reality, the influence of X_2 in equation 6.0, which represents directly a group of some 45 principal commodities that flow through world market channels, further strengthens the inference. That is, rice price levels are governed more by the status of the other commodities in the world market than by the separate force of actual rice supplies on the price. This could, perhaps, reflect the economic and political policies of the countries engaged in rice imports. Perhaps a particular Asian country has no alternative choice in her bartering agreements but to accept rice in exchange for the product she exports.

Certain general conclusions follow, though. These are:

1. That the Japanese price (world price) is not exactly relevant for 1921-40 for use in equation 4.0.

2. That time would show a positive trend if postwar data for the Japanese prices were available.

3. That prices are influenced more by Asian rice production than by all rice supplies that entered international trade.

4. That the Japanese price was not affected by United States government farm programs in the 1930's.

5. That the Japanese price might not respond to world market rice supplies in the same manner as would another rice-importing country.

ALTERNATIVE ANALYSES

In the model analyses, no particular consideration was given to rough rice prices *per se*. Prices were considered only as determining endogenous variables and not as a determined endogenous variable.

Interrelationships of rice prices, disposition and possible effects of government price pro-

TABLE 7. WORLD PRICES IN RELATION TO ESTIMATED PRICES, 1921-40

Year	Actual price as percentage of estimated price
1921	89
1922	99
1923	92
1924	99
1925	111
1926	114
1927	101
1928	98
1929	113
1930	112
1931	120
1932	53
1933	78
1934	92
1935	107
1936	98
1937	116
1938	123
1939	86
1940	96

grams are difficult to understand fully unless they are viewed frequently through several types of statistical approaches. Methods of disposing of available supplies of rice and the prices received vitally concern every producer.

Price and Disposition

The most discernible goal of any producer of an agricultural commodity is an available market for his product and a price that will guaranteed a reasonable return (a specified unit price in excess of unit cost) on his investment. In this dichotomy of production is nurtured, in the mind of the producer, the rationale for the time and the place to sell his product. In Table 8, is shown the percentage that the domestic market disappearance and the combination of the domestic and foreign outlets for rice is of the total United States supply.

It is evident from the percentages in columns 1 and 2, Table 8, that exports have been the principal bulwark against rice price and income instability. Carryover is reflected in the difference between the percentage given in column 3 and a 100 percent. During 1938-55, the average annual amount of the United States production of rice moving through foreign markets was roughly 50 percent. The annual average amount that was moved through domestic market channels from 1921-55 was 66 percent, while the average for foreign outlets was only 24 percent. This certainly reflects in recent years the growing importance of foreign markets for United States rice. This assumes, of course, the continued postwar rate of production and the absence of government acreage restrictions.

Percentages shown in Table 8, illustrate the significance of rice exports in maintaining prices received by producers. This, in effect, depicts a higher price elasticity of demand for rice in the world market, as compared with the domestic market.

Production and Price Variations Before and During Government Programs

Rice was not added to the list of basic agricultural commodities until 1941. However, the 1934-40 period was considered in view of the possible indirect effects of government programs in the rice industry.

In Table 9, the first column of percentages are those based on the variations from the mean value of the series and in the other column are shown year-to-year variations.

In each instance, year-to-year variation was considerably greater because the true value of each production and price magnitude was reflected. When the percentages were based on the mean value of the series, extreme values are partially hidden in years of low variation.

During 1920-33, when there were no support price programs, prices varied about three times more than production, based on the average value

TABLE 8. RICE, ROUGH: UNITED STATES DISAPPEARANCE AS PERCENT OF TOTAL SUPPLY, 1921-55

Year	Domestic disappearance as percentage of total supply	Domestic disappearance plus exports as percentage of total supply	Season average price, $ per cwt.
1921	54	94	2.18
1922	63	90	2.19
1923	76	96	2.49
1924	87	98	2.99
1925	87	92	3.30
1926	69	92	2.51
1927	68	89	2.02
1928	66	93	2.03
1929	73	94	2.22
1930	74	94	1.74
1931	68	87	1.08
1932	78	91	.93
1933	78	87	1.73
1934	87	96	1.76
1935	87	94	1.60
1936	83	86	1.85
1937	73	89	1.46
1938	68	85	1.42
1939	67	82	1.62
1940	71	90	1.80
1941	73	98	3.01
1942	68	92	3.61
1943	70	94	3.96
1944	63	95	3.93
1945	61	96	3.98
1946	61	98	5.00
1947	61	98	5.97
1948	57	94	4.88
1949	54	92	4.10
1950	59	90	5.09
1951	48	96	4.82
1952	48	97	5.87
1953	46	86	5.19
1954	40	61	4.57
1955	36	56	4.53

TABLE 9. CRITERION OF STABILITY RELATIVE TO RICE PRODUCTION AND PRICES BEFORE AND DURING GOVERNMENT SUPPORT PROGRAMS, 1920-54[1]

Periods	Variation from the mean of the series	Variation from year-to-year
	Percent	
1920-33	$\frac{\Sigma U}{M_U} = 10.9$	$\frac{\Sigma(U^t - U^{t-1})}{M(U^t - U^{t-1})} = 88.7$
1934-40	$\frac{\Sigma U}{M_U} = 12.9$	$\frac{\Sigma(U^t - U^{t-1})}{M(U^t - U^{t-1})} = 124.4$
1941-54	$\frac{\Sigma U}{M_U} = 25.6$	$\frac{\Sigma(U^t - U^{t-1})}{M(U^t - U^{t-1})} = 69.9$
1920-33	$\frac{\Sigma S}{M_S} = 30.9$	$\frac{\Sigma(S^t - S^{t-1})}{M(S^t - S^{t-1})} = 66.9$
1934-40	$\frac{\Sigma S}{M_S} = 9.4$	$\frac{\Sigma(S^t - S^{t-1})}{M(S^t - S^{t-1})} = 63.6$
1941-54	$\frac{\Sigma S}{M_S} = 17.9$	$\frac{\Sigma(S^t - S^{t-1})}{M(S^t - S^{t-1})} = 52.7$

[1] t = years.
U = United States production.
S = season average price.

in each case, but varied about 21 percent less when based on year-to-year variations.

During 1941-54, it is evident from the results obtained through both bases of reckoning that government support price programs tended to stabilize rice prices but not rice production.

Rice Prices in Relation to Potato and Wheat Prices

Very few agricultural commodities move freely through price determined outlets unhampered by competitive commodities. Rice, in some instances, particularly price-wise and place-wise, could be affected significantly by wheat and potatoes. In view of this possibility, a few observations relative to price comparisons were considered.

Seasonal average prices for rice, potatoes and wheat during 1921-55, as shown in Table 10, were fairly close during 1921-45. However, during 1946-55, rice and wheat prices were higher than potato prices on the per bushel basis, with rice averaging 5 cents higher than wheat prices. This type of behavior is indicative of a favorable domestic and particularly foreign markets for rice and wheat immediately after World War II. The shift from the consumption of starchy foods to a greater per capita consumption of meats, fruits and vegetables contributed to this difference in wheat and rice prices after 1945. This difference was, perhaps, a result of a high level of employment and income. Too, potato prices would be expected to vary more than rice and wheat prices since potatoes do not have the additional advantage of foreign markets.

Wheat and potatoes were chosen to compare with rice since potatoes were considered to be a more competitive food to rice on the domestic market than any other agricultural commodity. Wheat, on the other hand, was considered to be in greater competition with rice for food in the world market than any other food commodity.

The coefficients of variation for rice, potatoes and wheat prices during 1921-45 were 38, 41 and 31 percent, respectively. Potato prices varied about 10 percent more than wheat prices, but varied fairly close to rice prices. During 1921-45, rice and potatoes were closer substitute foods than were they during 1946-54. During 1921-40, however, the domestic market and Cuba absorbed a considerable portion of the United States production of rice.

The coefficients of variation based on the average price of rice, potatoes and wheat during 1946-54 were 11, 26 and 5 percent, respectively. These percentages point up the instability of potato prices relative to rice and wheat prices during this period. Wheat and rice were under government control programs during this period. Rice was not under acreage allotments and marketing quotas until 1955. Wheat, however, was under acreage restrictions in 1950 and 1954. Foreign demand conceivably caused greater variation in rice prices as a result of the disruption of rice production in the principal rice producing areas of Asia.

Table 10 shows the price pattern for rice, potatoes and wheat during 1921-55. It is evident from the table that rice and wheat prices were noticeably higher than potato prices with the exception of 1952, when the average price of potatoes was the highest during the 35-year period. There was a very short potato crop in 1952.

During 1947-54, the coefficient of variation showed that the difference between the free market price and the support price varied about 20 percent from the averages of the two prices during this 8-year period. The support price is derived from the relation between the total and the normal supply. Consequently, the high percentage variation between the two prices is indicative of a disproportionate relationship between the production and demand for rice each year as compared with the preceding year.

TABLE 10. SEASON AVERAGE PRICE PER BUSHEL RECEIVED BY FARMERS FOR RICE, POTATOES AND WHEAT, 1921-54

Year	Season average price per bushel received by farmers		
	Rice	Potatoes	Wheat
		Dollars	
1921	.98	1.13	1.03
1922	.98	.66	.97
1923	1.12	.92	.93
1924	1.34	.69	1.25
1925	1.48	1.70	1.44
1926	1.13	1.31	1.22
1927	.91	1.02	1.19
1928	.91	.52	1.00
1929	1.00	1.32	1.04
1930	.78	.91	.67
1931	.49	.46	.39
1932	.42	.38	.38
1933	.78	.82	.74
1934	.79	.45	.85
1935	.72	.59	.83
1936	.83	1.14	1.03
1937	.66	.53	.96
1938	.64	.56	.56
1939	.73	.69	.69
1940	.81	.53	.68
1941	1.35	.79	.94
1942	1.62	1.14	1.10
1943	1.78	1.28	1.36
1944	1.77	1.47	1.41
1945	1.79	1.40	1.50
1946	2.25	1.20	1.91
1947	2.69	1.61	2.29
1948	2.20	1.53	1.99
1949	1.84	1.28	1.88
1950	2.29	.92	2.00
1951	2.17	1.63	2.11
1952	2.64	1.96	2.09
1953	2.34	.80	2.04
1954	2.05	1.30	2.13
1955	2.04	.94	1.99

DEFLATED PRICES

The season average prices of rice, potatoes and wheat, as shown in Table 11, were deflated by the all-commodities index to place them on an equal purchasing power basis with other agricultural commodities. This deflation indicates more stability in rice prices relative to other agricul-

tural commodities than was true for potatoes and wheat. Potato prices were much more erratic than were rice and wheat prices. This, again, was, perhaps, a result of potatoes having only a domestic market outlet.

As indicated in Table 11, rice prices during the War years were considerably above wheat and potato prices as a result of the government encouraging increased rice production to satisfy domestic, military and foreign demand.

Demand Relationships of Rice and Potatoes

Regression analyses, covering three different time periods, were used to determine to what extent, if any, rice substituted for or was complementary to potatoes.

Equation 7.0 and the statistical results during 1921-40 are:

EQUATION 7.0

$$Y = 1.984 - 5.775\ X_1$$
$$(2.837)$$

Y = ratio of rice prices to potato prices

X_1 = ratio of rice supplies to potato supplies

Statistical coefficients relating to the analysis:

Coefficients	Values	Type of relationship
r	− .433	—
S_y	.329	—
t_{18}	2.036	—
1/b	− .173	substitutes

In equations 7.0, 8.0 and 9.0, the price ratios were used as dependent variables and supply ratios as independent variables. The regression coefficients are, therefore, cross price flexibilities. The sign also is reversed — negative signs indicate substitutabilty and the larger the coefficient the higher is the degree of substitutability. The same conditions are true in the case of complementarity except for a positive sign.

As indicated by the magnitude of the reciprocal of b, there was only a small degree of substitutability of rice for potatoes in this period.

Equation 8.0 and the statistical results during 1921-54 are:

EQUATION 8.0

$$Y = .973 + 2.175\ X_1$$
$$(1.074)$$

Statistical coefficients relating to the analysis:

Coefficients	Values	Type of relationship
r	.337	—
S_y	.455	—
t_{32}	2.025	—
1/b	.460	complements

When data for the 14 war and postwar years were included with prewar data, the relationship changed to a higher degree of complementarity. The "*t*" value with 32 degrees of freedom was about the same as for equation 7.0. The standard error of estimate (S_y) was about .1 point larger. The simple correlation coefficient, however, was slightly smaller.

Equation 9.0, and the statistical results during 1941-54 are:

EQUATION 9.0

$$Y = 1.408 + 1.034\ X_1$$
$$(1.620)$$

Statistical coefficients relating to the analysis:

Coefficients	Values	Type of relationship
r	.181	—
S_y	.502	—
t_{12}	.638	—
1/b	.978	complements

Rice was under support price programs in every year of this period and potatoes were during 1941-49. As indicated by the magnitude of the regression coefficient, the price ratio varied less per unit change in the supply ratio during the support price period than did they during the other two periods. If rice and potatoes were perfect substitutes, their price ratios would be a constant.

TABLE 11. SEASON AVERAGE PRICE PER BUSHEL RECEIVED BY FARMERS FOR RICE, POTATOES AND WHEAT (DEFLATED BY ALL COMMODITIES INDEX), 1921-1955

Year	Season average price per bushel received by farmers (deflated) for		
	Rice	Potatoes	Wheat
	— — — —	Dollars	— — — —
1921	.81	.93	.85
1922	.82	.55	.81
1923	.90	.74	.74
1924	1.10	.57	1.03
1925	1.15	1.32	1.12
1926	.91	1.06	.98
1927	.77	.86	1.01
1928	.76	.43	.83
1929	.85	1.12	.88
1930	.73	.85	.62
1931	.54	.51	.43
1932	.52	.47	.47
1933	.95	1.00	.90
1934	.85	.48	.91
1935	.72	.59	.84
1936	.83	1.14	1.03
1937	.62	.49	.90
1938	.66	.57	.57
1939	.76	.72	.72
1940	.83	.54	.70
1941	1.24	.73	.87
1942	1.32	.93	.90
1943	1.39	1.00	1.06
1944	1.37	1.14	1.09
1945	1.36	1.07	1.14
1946	1.50	.80	1.27
1947	1.46	.88	1.24
1948	1.10	.77	1.00
1949	.97	.68	.99
1950	1.16	.48	1.02
1951	.99	.74	.96
1952	1.24	.92	.98
1953	1.11	.38	.97
1954	.97	.62	1.01
1955	.96	.44	.94

It is apparent that the price ratios varied less under government price programs than did they before the War. However, since the magnitudes of 1/b are so small, it is impossible to determine the true demand relationship. The *"t"* values further substantiate this contention. The regression coefficients, nevertheless, depict more variable supply ratios under government price programs than was the case with price ratios.

WEAKNESSES IN THE ANALYSIS ON DEMAND RELATIONSHIPS

Demand relationships should be determined under conditions of free market prices. Artificial prices do not constitute a valid criterion of demand relationships. The analysis should have excluded the period after potatoes were dropped from the list of support price commodities. However, to have done so, would have reduced the degrees of freedoms below the number necessary to obtain valid results.

The standard error of estimates (S_y) increased more when data for price support years were included. The regression coefficients in equations 8.0 and 9.0 do not differ significantly from zero at the 10 percent probability level. However, the coefficient in equation 7.0, might differ significantly from zero, as indicated by the *"t"* value.

IMPLICATIONS

Rice would substitute for potatoes more under free market conditions and low incomes than under artificial pricing and high personal income.

The analyses do not divulge any significant results relative to the actual relationships. The sign of the regression coefficient does imply a different relationship under free and artificial pricing.

THE RICE INDUSTRY IN THE FREE MARKET AND UNDER ALTERNATIVE PRICE PROGRAMS

It often is difficult for producers of an agricultural commodity to engage in an enterprise that requires an investment as large as rice production if faced with extreme variation in rice prices. This situation is particularly pertinent in an agricultural enterprise where fixed costs are relatively high.

A market for rice, albeit a free or a government support price market, in which there is a reasonable degree of price and income stability benefits for both the producer and the consumer. A reduction in price instability below free market levels makes for greater efficiency on the part of producers and a more constant supply to consumers at less variable prices.

Price programs, irrespective of how they are formulated, must consider price and income elasticities both in the domestic and foreign markets, because of differences in human response to income and price charges and the quality of products demanded in the various markets.

In recent years, foreign import markets for American rice have played a vital role in affording an outlet for approximately 50 per cent of the United States annual production of rice. If the present level of rice production is maintained or increased, foreign rice markets will have to absorb a sizable percentage of the United States annual supply in the next 5 to 10 years. In the absence of foreign outlets for a sizable percentage of the United States annual rice supply, one of two alternatives is available to rice producers. Either producers must reduce production or be subsidized through some type of government price program. It always is difficult to say which particular course of action will be more advantageous to the general welfare of all people. If the annual supply of rice is needed for human consumption both domestically and abroad there is no immediate need for a reduction in the present level of rice production. If available world rice supplies are in excess of the amount which will be taken at a price on the world market that is profitable to all producers, there is but one alternative, some producers will have to shift resources presently devoted to rice production into other uses. When aggregate demand for rice exceeds the annual world supply at support price levels, United States exportable supplies should flow freely into foreign markets unless they are checked through trade barriers or the price structures established by the countries involved. The abrupt fall in rice exports, as was experienced in 1954, calls for a reappraisal of the pricing system in the United States in the light of differences in price and income elasticities of demand in various markets, relevant price programs between countries and the world price.

Several alternative price programs have been proposed or considered for rice. Price programs for rice have been in operation every year since rice was added to the list of basic agricultural commodities in 1941.

The three alternative programs for rice discussed in this section are (1) no support prices, (2) flexible support prices and (3) a two-price system.

No Support Price Program

Rice farmers produced and sold on a free market prior to 1941. The rice industry was relatively small and represented a minute segment of the agricultural economy of the United States before World War II. Even at present, gross income to the rice industry represents less than 1 percent of the gross income from all agricultural commodities. However, producers engaged primarily in rice production are vitally affected by the position of the rice industry in the nation's agricultural economy.

Generally, rice producers were not concerned greatly over world market prices during years of free market conditions since only small quantities of rice were exported during that period. The world market price usually exceeded the United

States domestic free market price by the amount of tariff duties and ocean freight charges for rice. The problem of disposing of exportable rice was not serious before World War II because production remained just slightly above domestic requirements. During this period, Cuba received the greater percentage of United States exportable rice supplies. With a free market, the price is set by the marginal producer and rice supplies tend to approach equilibrium with demand at that price.

On the basis of statistical inferences, it appears that, in the long run, total United States rice production today probably would remain at about the same level or slightly higher, under free market conditions. The basic assumption is that aggregate demand for rice is relatively stable and apparently increases in direct proportion to the dynamic growth of world population. The latter statement assumes no drastic deviation in human consumption habits imposed through government policies and intervention. The immediate consequences of imposing free market conditions on the present rice industry would be smaller returns and needed production adjustments. Over time, the marginal producer would be forced out of the industry, and production would adjust to levels indicated.

The short-run adverse consequences, and the fact that many other agricultural and industrial commodities are subsidized, are probable reasons why the present rice industry is not subjected to free market conditions.

A Flexible Support Price Program

A flexible price program is designed to stabilize income with varying rice production. The rice industry had rigid support prices (90 percent of parity) during 1941-54 and flexible support prices beginning with the 1955 rice crop. It appears (Table 9) that income was stablized more under support price programs than in the unsupported market. The level of support is set by the Secretary of Agriculture based on the relation of actual to normal supply. The percentage of parity is graduated up or down between 75 and 90 percent of parity according to the percentage points that actual supply is below or above the normal supply, respectively.

In the event actual supply exceeds the normal supply by a certain percentage, production controls might be deemed necessary. A reduction in rice supplies under present price programs has been approached through farmers voting in a referendum to cut back acreage and assess marketing quotas. A marketing quota is the quantity of rice that can be produced on the alloted acreage. Acreage allotments and marketing quotas were approved by rice producers in a referendum for the first time in February 1955. There has been an acreage allotment and marketing quota for rice every year since 1954. A flexible price program can be effective in controlling the supply of rice if production is controlled rather than acreage alone. Rice acreage was reduced 24.7 percent for the 1955 crop, but yields increased about 22 percent. Consequently, production was reduced only 3 percent instead of approximately 25 percent as was planned by acreage allotments and marketing quotas. However, a sliding scale price program eventually would solve the continued over-production phase of the program, but inevitably would force many marginal producers out of the industry.

An agricultural commodity with an inelastic demand and depending heavily on foreign import markets in which the demand is more elastic, will encounter difficulty with flexible price support levels set too high in relation to world market prices. This is precisely what happened to rice exports after 1953. There actually are two types of export markets for United States rice. Asian markets are quantity markets and the people in these markets are, therefore, much more responsive to price differentials between United States domestic and world prices than are European people who are in a quality market. For instance, the support price was 35 cents per hundredweight greater than the free market price in 1954 and, as a consequence, United States rice exports were reduced to about two-thirds of the quantity exported in 1953. European consumers in the quality market will pay a premium for United States rice rather than purchase lower quality rice at a discount in the world market. American rice producers are concerned primarily with the Asian quantity markets since they offer the greater opportunity for continued volume sales.

Rice disposal problems have become increasingly difficult since 1954, with substantial government rice purchases in some years since 1953. In those years, there was a transfer of income from taxpayers and consumers to producers. Although Public Law 480 alleviated somewhat the burden of holding Commodity Credit Corporation rice stocks in 1956-57, it represented an additional income transfer from United States taxpayers to foreign consumers. Public Law 480 should not be construed as entirely ineffective in disposing of surplus rice relative to the functioning of normal marketing operations. In reality, the government serves in the capacity of a middleman between American rice exporters and foreign importers. The law merely permits the government to dispose of Commodity Credit Corporation rice through sales to foreign countries by accepting their currency. The foreign currency in turn is used in international currency exchange operations, military procurements, American installations in foreign countries and many other financial transactions.

If an agricultural commodity has only a domestic market, a flexible price program would appear more effective in maintaining the supply of the commodity in line with demand at various price levels. The difficulty resulting from having a domestic and a world market for a commodity arises from a difference in the elasticity of de-

mand in the two markets and keeping government supported prices in line with world prices.

A flexible price program for rice has other shortcomings besides markets, prices and demand concepts. Continued acreage restrictions and marketing quotas eventually would force many rice producers out of the industry because of limited alternative land uses and high production costs.

A Two-Price Program

A two-price system is designed to establish a relatively high price in the domestic market and generally a lower price in the export market.

It is presupposed, under this plan, that domestic consumers will take what they will at a specified price level and that foreign consumers will take the remaining supply at a price they are willing to pay.

If the demand in the domestic market is inelastic and more elastic in the export market, the plan has greater income-producing potentials than has the free market. There will be increased expenditures by domestic consumers for a smaller quantity, but increased returns from larger sales in the export market. It would be difficult to estimate the magnitude of the income transfer from taxpayer to producer under a two-price plan as compared with other price programs without knowing the relevant elasticities of demand. However, if handling, storage, financing, disposition and administration costs are examined for rice under the flexible price program, a two-price plan appears to be more relevant since producers depend so heavily on foreign outlets for a large percentage of their annual rice production.

In considering a two-price system for rice, it should be remembered that rice is used primarily for food and has practically no substitutes. Rice is the basic food for all Asiatic people and United States rice should be in great demand in these countries. However, the price differential between United States and Asiatic rice has been too large in recent years for Asians to buy our higher-priced rice.

A two-price system for rice could recapture Asiatic markets. Since these countries import practically no other food commodity from the United States, rice exports would benefit both the United States producer and the Asiatic consumer. The United States should not encounter any export-import difficulty since only two countries in Asia (Burma and Thailand) export any sizable quantities of rice. If Asiatic markets were privileged to purchase United States rice at prevailing world prices, it is logical to assume that domestic exportable supplies and foreign demand would approach an equilibrium and thus alleviate the burden of purchasing and holding surplus rice in Commodity Credit Corporation warehouses.

Reciprocal trade agreements with Cuba permit unencumbered entry and re-entry of agricultural commodities between the United States and Cuba. These agreements would permit rice, even under a two-price plan, to enter Cuba at the domestic price rather than at lower export price. The trade privilege does not necessarily imply that more rice would be sold—perhaps less would be sold at the domestic price level. The volume sold would depend in part on the extent of bartering agreements. Cuba, however, is not in a position to obtain substantial quantities of United States rice relative to exportable supplies, either by dollar purchases or by bartering.

An inelastic demand and a constant rate of domestic per capita consumption necessitates a price structure that will regain and hold available export markets for United States rice. Results and inferences obtained from the statistical analyses indicate that a two-price program has the necessary pricing mechanism to enable United States producers to compete for world markets and permit present rice producing firms to remain in the industry.

Methods of support prices are mostly political decisions. A thorough evaluation of price programs can be made only with regard to an established set of values and convictions. It is hoped that this analysis will afford a better understanding of the difficulty encountered in arriving at these decisions.

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