FACTORS AFFECTING SUPPLY, DEMAND, AND PRICES OF U.S. RICE

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This study estimated the interrelationships of economic and institutional factors that affect supply, demand, and prices for U.S. rice. A model was developed and estimated, using the three stage least squares method. Rice yields are affected by the climatic conditions in each area, technological changes, area in rice, and other factors. Lagged farm price did not appear to influence rice yields during 1950-76. Farm price, Government programs, and carryover affect area. Production response to a price change (elasticity) varies from 0.25 in Texas and Mississippi to nearly 0.5 in Arkansas. Income and population are the major variables affecting food rice consumption. Changes in retail price have a very minor impact on demand. Government exports are more elastic with respect to prices than are commercial exports. The degree of substitution of Government exports for commercial export sales is relatively low.

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Economic analysis
Farms
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Prices
Production rate
Rice
Supply (economics)
Yield

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Texas

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SUMMARY

A specially developed economic model aided this study of the interrelationships of economic and institutional factors affecting the supply, demand, and prices of U.S. rice. The demand section of this study covers the 1950-75 time period while the supply section covers 1950-76.

Rice yields are affected by local climate, technological change, area in rice, and other factors. Lagged farm price, a hypothetical indicator of the price farmers expect, did not appear to influence yields. Prices during the period studied were supported by Government programs at a relatively stable level.

Area harvested has a negative effect on yields. Lagged endogenous variables, farm price, private carryover, and Government carryover, primarily affect total production through their impact on area. Cumulative effects of adverse climate could affect rice area, as was the case when California's 1975-77 drought caused a decline in 1977 rice acreage. Production response to a price change (elasticity) varies from about 0.25 in Texas and Mississippi to nearly 0.5 in Arkansas. Area response elasticity is slightly higher, with about the same proportion among the three States.

Income and population are the major variables affecting food rice consumption; changes in retail price have minor impact on demand. Rapid growth in beer demand affects brewers demand for rice, but this commodity accounts for a relatively small portion of brewers grain. Rice millfeed, a small percentage of total agricultural feed, is influenced by the total quantity of rice milled and the general price level in the feed market. Current seed rice demand is influenced largely by next year's rice acres planted. However, the adjusted farm price and lagged total carryover influence the acreage to be planted.

U.S. and Thailand export prices, Government exports, and U.S. production influence U.S. commercial exports. Government exports are more elastic with respect to price than are commercial exports. Production and carryover are key factors, too. The degree of substitution of P.L. 480 rice for commercial export sales is relatively low. This is because of the different types of markets involved, the quality of production demanded, and credit terms.

Factors Affecting Supply, Demand, and Prices of U.S. Rice

*Warren R. Grant and Mack N. Leath**

INTRODUCTION

This study estimates the economic relationships within the U.S. rice economy which determine the supply, demand, and price for U.S. rice. To do that, we: (1) developed an econometric model based on theory and knowledge of economic relationships in the U.S. rice industry, (2) formulated, estimated, and tested the statistical model for the supply, demand, and price segments of the economic model, and (3) interpreted and applied the statistical model to current conditions. The results will be used to assist in developing forecasts of supply, demand, and prices in the rice industry and to evaluate the probable impacts of alternative public policies affecting the rice industry.

Rice ranks eighth in value of U.S. crop production and is especially important in certain regions. Since the history and current status of the U.S. rice industry is documented elsewhere (<u>1</u>), this report includes little descriptive material. <u>1</u>/

THEORETICAL FRAMEWORK

The supply-demand-price relationships for rice, as with most major U.S. agricultural crops, are complex. Prices and uses in several market outlets are determined simultaneously, not only by the supply of rice, but also by certain factors outside the rice market structure that affect demand. The joint product aspect of rice milling with differing demand relationships for each product produces unique behavioral patterns for uses and prices. Many separate markets compete for rice and rice products, and prices adjust to ration supplies among the various markets. Since these outlets are growing at different rates, a model of the U.S. rice industry must allow for these changes.

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<u>1</u>/ Underscored numbers in parentheses refer to references listed at the end of this report.

Major Relationships

Principal economic relationships and variables involved in the U.S. rice economy are illustrated in figure 1. The upper part of figure 1 indicates the pattern of forces affecting production, yield, and acreage of rice. Weather is particularly important because it affects both yield and acreage. During the period 1955-73, allotments limited acreage to specified levels and Government price supports stabilized prices. With restrictive allotments and price supports above world levels, physical factors, such as weather, cultural practices, insects, and diseases, were more important in determining yearly changes in production than were economic forces. Producers adopted new cultural practices to increase yields. Under these conditions, changing technology was a significant causal factor. Since 1973, supply controls have been less restrictive and producers have been more responsive to economic factors.

Some factors affecting world prices appear in the lower left side of figure 1. The world price of rice is important to domestic producers since this country, where rice production exceeds domestic use, is a major rice exporter, normally exporting about 60 percent of its crop. Except when Government programs interfere, domestic prices normally reflect the world supply-demand situation. The world rice price is determined by world supply-demand of rice, quantity available for export, income in the importing countries, and the supply of competing grains.

The domestic outlets are food, beer, feed, seed, and carryout (fig. 1). Utilization in the first two categories is assumed to depend in part on the level of price, income, population, consumption trends, and prices of competing commodities. Rice used in feed is related to the level of bran or millfeed prices, animal numbers, and prices of competing commodities. Seed use is determined largely by acreage planted. Carryout is the residual after all other uses are filled. However, carryout (ending stocks) is influenced by rice price levels in relation to price supports and total supply.

The Economic Model

The economic model can be represented in a series of two dimensional graphs (sections A through N in fig. 2). These generalized price-quantity diagrams portray the U.S. rice markets at a given moment with all other factors held constant. Total demand for U.S. rice for human consumption is illustrated in section E. This curve is a horizontal summation of the demands for rice for food (section A), commercial milled exports (section B), Government milled exports (section C), and brewers use (section D). Milled rice stocks are ignored in this analysis since they are a relatively minor part of the total use. Total byproduct demand is shown in section H. It represents a horizontal summation of the demand for hulls (section F) and feed (section G). Total human consumption (section E) and total byproduct demand (section H) added together give a derived U.S. mill demand schedule for rough rice (section M). Rough rice, when milled, yields head rice,

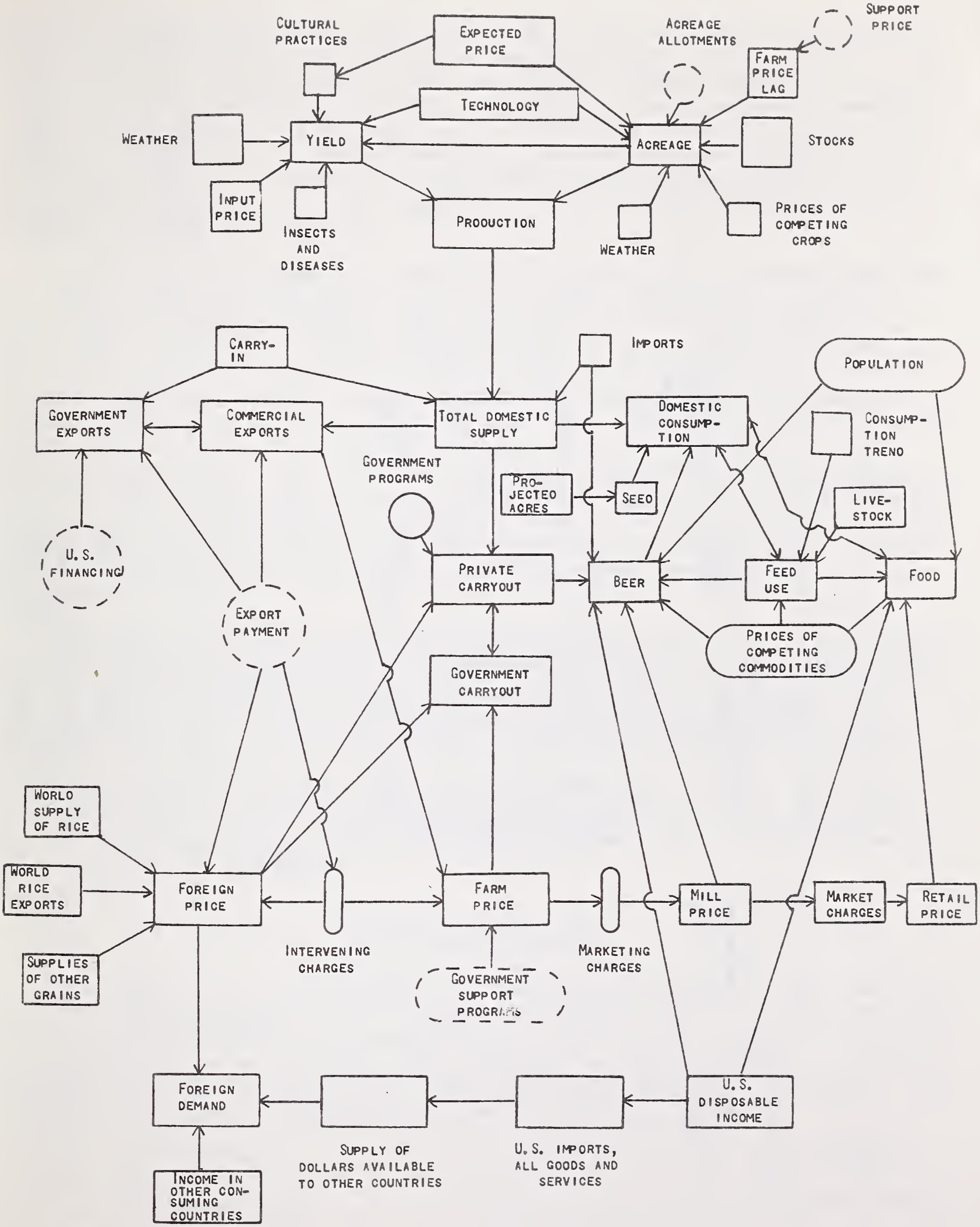

Figure 1. Major relationships in the rice economy

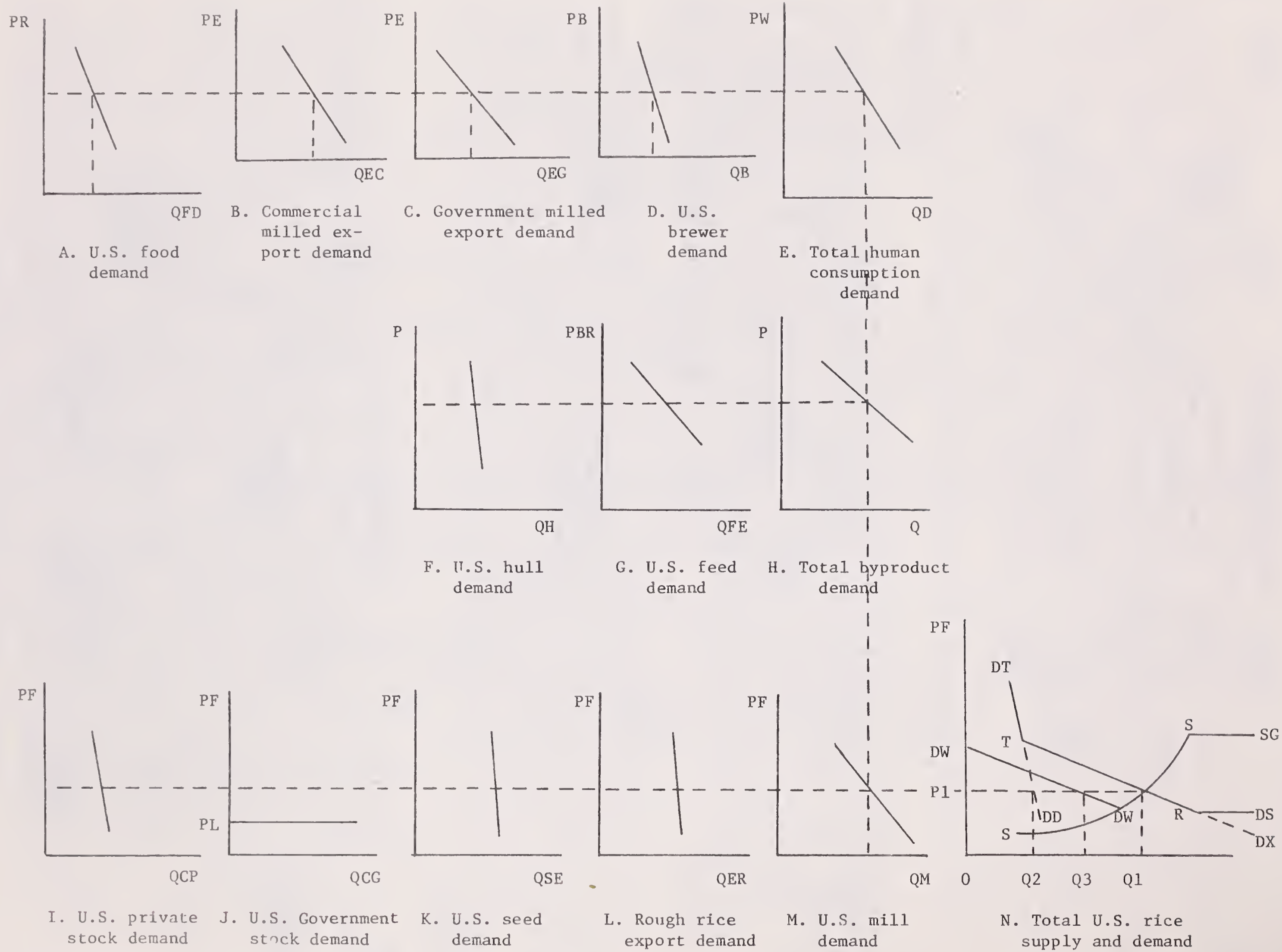

Figure 2. Graphic model of rice and rice byproducts markets

brokens, screenings, polish, bran, and hulls. Head rice mixed with brokens moves through food, commercial exports, and Government exports. Most of the remaining brokens and screenings are taken by the brewing industry. Bran, either separately or mixed with hulls and polish, is used as feed. Remaining hulls are (1) burned to generate steam and the ashes are used in other processes, (2) processed to extract furfural, (3) used for poultry litter, (4) used for mulch, or (5) dumped. Data on hull utilization or prices are not available. However, the total supply of hulls is a fixed proportion of the quantity of rough rice milled.

Mill demand for rough rice (section M) coupled with seed demand (section K), export demand for rough rice (section L), and private and Government stock demand (sections I and J) form the total U.S. rice demand shown in section N. An aggregate supply curve is added in section N to illustrate how the model works. The sum of the various domestic demand schedules (food, brewer, feed, seed, private stocks, hulls) is represented by the line DT-DD. Export demand for U.S. rice is plotted as DW-DW. This demand schedule represents total world export demand with exports from other countries at some predetermined level. The line R-DS represents the Government nonrecourse loan program. Adding the Government nonrecourse loan program to total domestic and export demand gives the line DT-T-R-DS. The supply of rice without allotments and changes in carryover is represented by the curve S-S. Release of Government stocks in the nonrecourse loan program is represented by the line S-SG.

Equilibrium, with no Government programs, would be at P_1. At this price, the quantity Q_2 would be utilized domestically. The quantity Q_1 minus Q_2 (or Q_3) would be exported. The nonrecourse loan acts as a floor price in the event the supply curve shifts to the right or the export demand curve shifts to the left. In either instance, Government stocks would increase.

Production is a function of acres harvested times yield, with U.S. production a summation of the individual State's production. U.S. supply is U.S. production plus Government and private carryin. Rice imports into the United States are negligible.

The Statistical Model

The model used in this study is a simple representation of the underlying economic relationships observed in the rice sector. Economic theory, as illustrated in figure 2, supplemented by knowledge of the economic and institutional characteristics of the rice industry, as shown in figure 1, forms a basis for the construction of the model and classification of variables. The following relations are hypothesized for the U.S. rice industry:

Supply Section

1. $AM_t = F([RM*PF]_{t-1}, T_t^{\frac{1}{2}}, T_t, T_t^2, P3M_t, D57_t, D68_t, D74_t)$

2. $AT_t = F([RT*PF]_{t-1}, [QCG+QCP]_{t-2}, [QCG+QCP]_{t-1}, D54_t, D57_t, D68_t, D74_t)$

3. $AL_t = F([RL*PF]_{t-1}, [QCG+QCP]_{t-2}, D54_t, D68_t)$

4. $AA_t = F([RA*PF]_{t-1}, T_t^{\frac{1}{2}}, T_t, [QCG+QCP]_{t-2}, [QCG+QCP]_{t-1}, D54_t, D68_t, D74_t)$

5. $AC_t = F([RC*PF]_{t-1}, [QCG+QCP]_{t-2}, T_t^{\frac{1}{2}}, D50_t, D54_t, D57_t, D68_t, D74_t)$

6. $YM_t = F(AM_t, T_t^2, R3M_t, T7M_t, P45M_t, P89M_t)$

7. $YT_t = F(AT_t, TE_t, R4T_t, T78T_t)$

8. $YL_t = F(TE_t, T_t, T_t^2, T56L_t, P34L_t, P56L_t)$

9. $YA_t = F(AA_t, T_t^{\frac{1}{2}}, TE_t, P45A_t, P67A_t, P89A_t, SC56A_t, T67A_t, T78A_t)$

10. $YC_t = F(AC_t, T_t^{\frac{1}{2}}, R4C_t, T6C_t, P9C_t, SC5C_t)$

11. $QP_t = (YM_t)AM_t + (YT_t)AT_t + (YL_t)AL_t + (YA_t)AA_t + (YC_t)AC_t$

12. $QS_t = QP_t + QCP_{t-1} + QCG_{t-1}$

Demand Section

13. $QFE_t = F[PBR_t, QM_t, PI_t]$

14. $QSE_t = F[(R*PF)_t, (QCP+QCG)_{t-1}, T_t]$

15. $QFD_t = F[PR_t, YI_t, D59_t]POP_t$

16. $QB_t = F[(PB/PC)_t, YI_t, (QB/POP)_{t-1}]POP_t$

17. $QEC_t = F[(PE/PT)_t, QEG_t, QP_t]$

18. $QEG_t = F[(PE/PT)_t, QP_t, (QCP+QCG)_{t-1}]$

19. $QER_t = F[PF_t, QER_{t-1}]$

20. $QCP_t = F[(PF/PG)_t, QCG_t, QS_t]$

21. $QCG_t = F[(PF/PG)_t, (PE/PT)_t, GP1, GP]$

22. $QH_t = F[(QFD+QB+QEC+QEG)_t, QH_{t-1}]$

23. $QM_t = QFD_t + QB_t + QFE_t + QH_t + QEC_t + QEG_t$

24. $QD_t = QM_t + QCP_t + QCG_t + QER_t + QSE_t$

Price Relationships

25. $PR_t = F[PW_t, T_t, PR_{t-1}]$

26. $PBR_t = F[PW_t, LU_t, PI_t]$

27. $PB_t = F[PW_t, PB_{t-1}]$

28. $PF_t = F[PW_t, T_t]$

29. $PE_t = F[(QWW/POPW)_t, (QWR/POPW)_t, PE_{t-1}]$

30. $PT_t = F[(QWW/POPW)_t, (QWR/POPW)_t, QWE_t, PT_{t-1}]$

31. $PW_t = PE_t + PS_t$

In these relations, equations 11, 12, 23, 24, and 31 are identities. Equation 22 is a technical relationship relating quantity of hulls to total quantity of rough rice milled.

Variables

The model developed for this study includes three groups of variables (1) endogenous variables which are generated by the system that the model characterizes, (2) exogenous variables which are considered to be determined outside the rice industry, and (3) predetermined variables which are exogenous variables plus the lagged endogenous variables. The variables used in the model are defined as follows:

Endogenous Variables--Supply Section 2/

AM_t = 1,000 acres of rice harvested, Mississippi

AT_t = 1,000 acres of rice harvested, Texas

AL_t = 1,000 acres of rice harvested, Louisiana

AA_t = 1,000 acres of rice harvested, Arkansas and Missouri

AC_t = 1,000 acres of rice harvested, California

YM_t = Average yield, Mississippi, hundredweights per acre

YT_t = Average yield, Texas, hundredweights per acre

YL_t = Average yield, Louisiana, hundredweights per acre

YA_t = Average yield, Arkansas and Missouri, hundredweights per acre

YC_t = Average yield, California, hundredweights per acre

QP_t = U.S. rice production, 1,000 hundredweights, rough rice

QS_t = Total U.S. rice supply, 1,000 hundredweights, rough rice

Endogenous Variables--Demand Section

PB_t = Price of brewers rice, f.o.b. mill, California, dollars per hundredweight

PBR_t = Price received for bran, f.o.b. mill, Houston, dollars per ton

PE_t = U.S. export price, U.S. No. 2 long grain, f.o.b. mill, Houston, dollars per hundredweight

PF_t = U.S. farm price of rice, dollars per hundredweight, rough rice

PR_t = Retail price of long grain rice (BLS), dollars per hundredweight

PT_t = Thailand export price, white rice, 100 percent 2nd grade, f.o.b. Bangkok, dollars per hundredweight

PW_t = U.S. mill price, U.S. No. 2 long grain, f.o.b. mill, Houston, dollars per hundredweight

2/ The subscript "t" in the following variables denotes the current crop year. All exogenous and any lagged endogenous variables are assumed as predetermined.

QB_t = U.S. rice quantity utilized by brewers, 1,000 hundredweights, milled rice

QCG_t = U.S. ending rice carryover in Government hands, 1,000 hundredweights, rough rice

QCP_t = U.S. ending rice carryover in private hands, 1,000 hundredweights, rough rice

QD_t = Total utilization of U.S. rice, 1,000 hundredweights, rough rice

QEC_t = U.S. milled rice exports, commercial, 1,000 hundredweights, milled rice

QEG_t = U.S. milled rice exports, Government, 1,000 hundredweights, milled rice

QER_t = U.S. rough rice exports, 1,000 hundredweights, rough rice

QFD_t = 3-year moving average of U.S. rice quantity utilized for food, 1,000 hundredweights, milled rice

QFE_t = U.S. quantity of rice utilized for feed, 1,000 hundredweights, bran and mill feed

QH_t = Quantity of rice hulls, 1,000 hundredweights, hulls

QM_t = Quantity of rough rice milled, 1,000 hundredweights, rough rice

QSE_t = U.S. quantity of rice utilized for seed, 1,000 hundredweights, rough rice

Exogenous Variables--Supply Section

$D50_t$ = Dummy, 1950 = 1

$D54_t$ = Dummy, 1954 = 1

$D57_t$ = Dummy, 1957-58 = 1

$D68_t$ = Dummy, 1968-69 = 1

$D71_t$ = Dummy on heavy rice carryover, 1971 = 1

$D74_t$ = Dummy, 1974 = 1

$P3M_t$ = Average number of days with more than 0.1 inch precipitation during March at Greenville and Stoneville, Mississippi

$P9C_t$ = Average number of days with more than 0.1 inch precipitation during September at Chico and Sacramento, California

$P34L_t$ = Average number of days with more than 0.1 inch precipitation during March and April at Crowley and Lake Charles, Louisiana

$P45A_t$ = Average number of days with more than 0.1 inch precipitation during April and May at Little Rock and Stuttgart, Arkansas

$P45M_t$ = Average number of days with more than 0.1 inch precipitation during April and May at Greenville and Stoneville, Mississippi

$P56L_t$ = Average number of days with more than 0.1 inch precipitation during May and June at Crowley and Lake Charles, Louisiana

$P67A_t$ = Average number of days with more than 0.1 inch precipitation during June and July at Little Rock and Stuttgart, Arkansas

$P89A_t$ = Average number of days with more than 0.1 inch precipitation during August and September at Little Rock and Stuttgart, Arkansas

$P89M_t$ = Average number of days with more than 0.1 inch precipitation during August and September at Greenville and Stoneville, Mississippi

$R3M_t$ = Average March rainfall at Greenville and Stoneville, Mississippi, inches

$R4C_t$ = Average April rainfall at Chico and Sacramento, California, inches

$R4T_t$ = Average April rainfall at Beaumont and Houston, Texas, inches

RA_t = Ratio of rice allotment to maximum acres of rice planted in Arkansas (900,000 acres)

RC_t = Ratio of rice allotment to maximum acres of rice planted in California (525,000 acres)

RL_t = Ratio of rice allotment to maximum acres of rice planted in Louisiana (679,000 acres)

RM_t = Ratio of rice allotment to maximum acres of rice planted in Mississippi (171,000 acres)

RT_t = Ratio of rice allotment to maximum acres of rice planted in Texas (637,000 acres)

$SC5C_t$ = Percent of sky cover in May at Sacramento, California

$SC56A_t$ = Percent of sky cover in May and June at Little Rock, Arkansas

T_t = Time, where 1975 = 75

$T_t^{\frac{1}{2}}$ = Square root of time, where 1975 = $\sqrt{75}$

T_t^2 = Time squared, where 1975 = $(75)^2$

$T6C_t$ = Average June temperature at Chico and Sacramento, California, degrees Fahrenheit

$T7M_t$ = Average July temperature at Greenville and Stoneville, Mississippi, degrees Fahrenheit

$T56L_t$ = Average May and June temperature at Crowley and Lake Charles, Louisiana, degrees Fahrenheit

$T67A_t$ = Average June and July temperature at Little Rock and Stuttgart, Arkansas, degrees Fahrenheit

$T78A_t$ = Average July and August temperature at Little Rock and Stuttgart, Arkansas, degrees Fahrenheit

$T78T_t$ = Average July and August temperature at Beaumont and Houston, Texas, degrees Fahrenheit

TE_t = Dummy variable for technology released in early 1960's, 1962 = 0.5, 1963-75 = 1, 0 otherwise 3/

Exogenous Variables--Demand Section

$D59_t$ = Dummy for beginning of rice council and for admission of Hawaii into United States, 1959-75 = 1

GP_t = Dummy on Government export subsidy, 1958-72 = 1

$GP1_t$ = Dummy, 1950-57 = 1

LU_t = Grain-consuming animal units, million units

PC_t = Average price received by U.S. producers for corn, dollars per bushel

PG_t = U.S. Government support price for rice, dollars per hundredweight, rough rice

PI_t = Index of prices received by producers for feed grain and hay, 1967 = 100

POP_t = 50-State midyear population (adjusted in 1950's for Hawaii and Alaska), millions

3/ Postemergent herbicide (propanil), short-season varieties, and ratoon cropping were recommended by the experiment stations in 1962. However, there was a slight lag before full adoption occurred.

$POPW_t$ = World population, millions

PS_t = U.S. export subsidy on long grain milled rice, dollars per hundredweight

QWE_t = World rice exports, million metric tons, milled rice

QWW_t = Total world wheat production, 1,000 metric tons

QWR_t = World rice production, 1,000 metric tons, rough rice

QP_t = U.S. rice production, 1,000 hundredweights, rough rice

QS_t = U.S. rice supply, 1,000 hundredweights, rough rice

R_t = Ratio of rice allotment to maximum acres of rice planted in the United States (2,818,000 acres). During the years marketing quotas were not in effect, $R_t = 1$

T_t = Time, where 1975 = 75

YI_t = Index of per capita U.S. personal income, 1972 = 100

Data

Secondary data from various sources were used to measure the variables included in the model. The time period was 1950 through 1975 for the demand section and 1950 through 1976 for the supply section. Dummy variables were created to depict changes in Government programs during this period. Data used in estimating the equations are given in the appendix.

EMPIRICAL RESULTS

The model's supply section was considered to be independent of the demand section since supplies available during a particular marketing year are known and fixed at the beginning of the year. Consequently, the parameters of the model's supply section were estimated separately from those of the demand section. The supply section consists of a recursive model for each producing State and ordinary least squares (OLS) was selected as an optimal estimating technique. The demand section is a more general simultaneous-equation model, and the parameters for the various demand equations were estimated using three stage least squares (3SLS). Equations 11, 12, 23, 24, and 31 are identities and were not fitted statistically.

Interpretation of Estimated Coefficients

It can be demonstrated that in the limit, the yield equation errors are uncorrelated with observed acreages so that OLS is the appropriate estimation procedure for each of the recursive supply models. Since the equation errors are normally distributed with zero mean and finite variance, OLS yields maximum likelihood estimates. The 3SLS estimates of the parameters of the demand model are consistent, asymptotically efficient, and have approximately a normal distribution. Therefore, the t-test can be used for approximate statistical inference concerning the estimated coefficients of the supply and demand equations. The t-values associated with each estimated coefficient are shown in parentheses under each estimate.

In interpreting the parameter estimates, an effort will be made to assess the validity of the estimates in relation to economic theory. That is, the extent to which signs and relative magnitudes of the estimated parameters agree with our expectations will be noted. The performance of the model in terms of how well each component predicts values of endogenous variables will be examined in the next section. This section will focus on the coefficient estimates.

Supply Section

The supply section of the model is composed of five independent recursive submodels that contain acreage and yield equations for each of the major rice producing States.

The individual State approach was chosen so that the impact of selected weather variables on average yields could be measured in greater detail. The weather variables evaluated for inclusion in the structural equations may be categorized into four types. They are (1) average monthly rainfall between March and September, (2) average days of precipitation over 0.1 inch during specific months, (3) average temperature during specific months, and (4) percent sky cover during specific months. Two locations were selected within each State's major production area to measure each of the weather variables used. These variables were evaluated using OLS, and the ones that had a significant impact on yield were included in the final structural equations.

Previous research has demonstrated that weather conditions during the planting and harvesting seasons have a major effect on rice yields. Rice planting dates are critical for the varieties grown in the United States. Rainfall and its distribution during March, April, and May can delay seeding and also affect crop development in the early stages. Seeding delay pushes critical stages of plant development beyond the period of maximum day length and sunlight during late June and tends to reduce yield. Yields tend to be at maximum if heading of the crop occurs around June 21. Since rice yields are positively related to the amount of sunlight, sky cover tends to lower yields. Excessive rainfall during the harvest season causes shattering and lodging and usually reduces yield.

Lagged farm price, a hypothesized indicator of farmers' price expectations, was tested but did not appear to influence rice yields during the 1950-76 period. Rice prices were supported and stabilized by Government programs during most years included in the study. Consequently, price variations were too small to have a statistically significant impact on yield. Other variables evaluated were technology and area seeded in rice.

In the rice industry, the flow of new technology was not over the period of this study. A separate variable was included to account for technology released in the early sixties. The impact of this technology was most evident in Texas, where average yield increased from 29 hundredweights per acre in 1961 to over 41 hundredweights per acre in 1963. Other factors thought to be related to technology were represented by trend variables.

The second component of the supply sector is acreage. During the period 1955-75, allotments and marketing quotas were in effect. The Secretary was required to announce an acreage allotment for rice for each year unless a national emergency occurred. Compliance with the acreage allotment was required for price support eligibility. If marketing quotas were in effect, producers were subject to fines approximating the crop value for any acreage harvested over their allotment. Marketing quotas were in effect if the total supply exceeded the normal supply and if marketing quotas were approved by two-thirds of the producers voting in a referendum. The following equations illustrated the legislative formulas for determining allotment levels and whether marketing quotas were to be announced:

1.1) $QNS_t = [QFE_{t-2} + QSE_{t-2} - QFD_{t-2} + QB_{t-2} + QH_{t-2} + QEC_{t-1} + QEG_{t-1} + QER_{t-1}]1.1$

1.2) $QTS_t = [QCP_{t-2} + QCG_{t-2} + QP_{t-2}]$

1.3) $AA_t = \dfrac{QNS_t - QCP_{t-1} - QCG_{t-1}}{[Y_{t-1} + Y_{t-2} + Y_{t-3} + Y_{t-4} + Y_{t-5}]/5}$

1.4) $AA_t \geq 1650$

1.5) $AAA_t = 1.0140 + \underset{(34.38)}{1.0236}AA_t \qquad R^2 = 98.09 \qquad \sigma = 116.87$

If

1.6) $QTS_t > QNS_t$ then marketing quotas were announced, and if

1.7) $QTS_t \leq QNS_t$ then no marketing quotas announced

Where

QNS_t = normal supply of rice, 1,000 hundredweights, rough rice

QTS_t = total supply of rice, 1,000 hundredweights, rough rice

AA_t = derived rice allotment based on legislative formula, 1,000 acres

AAA_t = actual allotment announced by Secretary, 1,000 acres

Y_t = average U.S. rice yield, hundredweights per acre

The allotment level announced by the Secretary differed slightly from the allotment derived by the legislative formula. However, as indicated by equation 1.5, the announced allotment was closely related to the formula allotment.

A central problem over the time period in this analysis was the measurement of the price effect of Government programs (allotments and marketing quotas) restricting acreage during the period 1955-73. J. P. Houck and Mary Ryan demonstrated that this effect could be approximated by the formula:

$$PF'_{t-1} = (R)\ PF_{t-1}$$

where PF_{t-1} is the actual farm price lagged 1 year; PF'_{t-1} is the "effective" farm price; and R is some adjustment factor which embodies the planting restriction [7]. When no marketing quotas apply, R = 1.0 and PF'_{t-1} = PF_{t-1}. As allotments restrict acreage (marketing quotas in effect) R lies between 0 and 1.0. In this study, R is the allotted acreage in the years of restrictions divided by the largest planted acreage when restraints were not in effect by State. The following equations illustrate the calculation of R for Arkansas,

If:

1.8) $QTS_t > QNS_t$ then $RA_t = \frac{AAA_t}{900}$, and if

1.9) $QTS_t \leq QNS_t$ then R = 1

In addition to "effective" farm price, acreage in each State was assumed to be a function of lagged stocks, early season precipitation, selected dummy variables to account for unusual conditions, and trend variables. The estimated acreage and yield equations for the various States are presented below by State.

Acreage

The first component of the recursive supply model for each of the producing States is an acreage equation. The estimated coefficients for the variables affecting acreage are shown in equations 1 to 5 by State. The parameter estimates display theoretically appropriate signs with one exception which will be noted later. The t-value for each parameter estimate is shown in parentheses under each coefficient, and related statistics are presented below each equation.

1. Mississippi

$$AM_t = -44889.5595 + \underset{(12.66)}{9.6262(RM{*}PF)_{t-1}} - \underset{(8.80)}{1413.7534T_t} + \underset{(9.00)}{15035.2198T_t^{\frac{1}{2}}}$$

$$+ \underset{(8.44)}{3.6950T_t^2} - \underset{(3.96)}{1.5264P3M_t} - \underset{(2.95)}{12.2425D57_t} + \underset{(2.26)}{9.2939D68_t} - \underset{(9.86)}{79.2904D74_t}$$

$R^2 = 0.98$ D.W. = 2.10 $\overline{AM} = 58.19$ $\sigma = 4.97$

2. Texas

$$AT_t = 358.3527 + \underset{(2.79)}{7.5046(RT{*}PF)_t} - \underset{(2.13)}{0.0027(QCP{+}QCG)_{t-2}} - \underset{(2.08)}{0.0018(QCP{+}QCG)_{t-1}}$$

$$+ \underset{(2.95)}{95.8790D54_t} - \underset{(2.79)}{65.6265D68_t} + \underset{(2.24)}{0.2814AT_{t-1}}$$

$R^2 = 0.85$ D.W. = 1.92 $\overline{AT} = 490.33$ $\sigma = 30.33$

3. Louisiana

$$AL_t = 517.3760 + \underset{(4.85)}{14.7248(RL{*}PF)_{t-1}} - \underset{(4.99)}{0.0050(QCP{+}QCG)_{t-2}} + \underset{(2.47)}{92.7447D54_t}$$

$$+ \underset{(3.58)}{94.8460D68_t}$$

$R^2 = 0.83$ D.W. = 1.41 $\overline{AL} = 546.78$ $\sigma = 35.58$

4. Arkansas - Missouri

$$AA_t = -6759.7163 + 53.4161(RA*PF)_t - 0.0031(QCP+QCG)_{t-2} + 0.0030(QCP+QCG)_{t-1}$$

(13.99) (3.77) (4.77)

$$+ 165.8570D54_t + 48.6425D68_t - 326.5465D74_t - 100.9528T_t + 1691.5493T_t^{\frac{1}{2}}$$

(6.37) (2.63) (8.59) (2.88) (3.07)

$R^2 = 0.98$ D.W. = 2.16 $\overline{AA} = 492.00$ $\sigma = 23.59$

5. California

$$AC_t = 73.6729 + 20.8254(RC*PF)_{t-1} - 0.0016(QCP+QCG)_{t-2} + 25.4812T_t^{\frac{1}{2}}$$

(7.83) (1.92) (2.28)

$$- 97.2347D50_t + 110.4156D54_t - 45.1254D57_t + 56.3969D68_t - 105.0520D74_t$$

(4.09) (4.75) (2.14) (3.41) (3.42)

$R^2 = 0.94$ D.W. = 1.75 $\overline{AC} = 348.22$ $\sigma = 21.06$

"Effective" farm prices--The adjusted farm price received by farmers for the previous crop was incorporated in the acreage equations for each State. The effective farm price for the previous crop is assumed to reflect accurately the farmers' price expectations for the crop they are planting. An increase in expected price was found to have a significant impact on acreage in all States. Acreage in Arkansas and California is the most responsive in absolute terms to price changes.

Trends--Trends in acreage were found in Mississippi, Arkansas, and California. A combination of linear and nonlinear trends was identified in equations for the former two States. These combinations were positive over time, but not very large. Significant trends in acreage were not found in Texas and Louisiana, and this suggests that these States have had limitations on acreage expansion over time. Restrictions on water usage is a limiting factor for Texas, while availability of suitable land is a major limitation in Louisiana.

Carryover stocks--Observed carryover of rice stocks during the previous summer and expected carryover during the current marketing year (previous crop) were assumed to affect farmers' planting decisions for the current crop. *A priori* expectations were that large stocks would signal lower prices and a need to reduce acreage. This expected relationship held for all cases except Arkansas, where potential carryover for the previous crop $(QCP+QCG)_{t-1}$ had a positive impact on acreage. Carryover stocks from prior crops had no significant impact on acreage in Mississippi.

Precipitation--Average precipitation during planting time was evaluated in all yield equations. However, a significant relationship was identified for only Mississippi where March precipitation ($P3M_t$) had a negative impact on acreage.

Dummy variables--Various forms of acreage equations were evaluated. In selected years, when observed acreage was vastly different from projected acreage because of unusual circumstances, dummy variables were used to improve the fit. Acreage in 1950 was relatively low in California, and variable $D50_t$ reflects this in the California equation. Acreage and production were exceptionally large in 1954. Variable $D54_t$ was used to capture this variation. As a result of surplus production and carryover, acreage was greatly reduced in both 1957 and 1958 through acreage controls. Variable $D57_t$ was used to capture the large negative acreage adjustment. The variable $D68_t$ was incorporated in the equations to reflect the sizable relaxation of acreage restriction for the 1968 and 1969 crops. Farm prices were abnormally high in 1974, and variable $D74_t$ was incorporated to remove some of the impact of prices on acreage.

Yields

The second component of the recursive supply model for each producing State is an equation relating yields to acreage and other exogenous variables. The estimated coefficients are shown in equations 6 to 10 by State. With the exception of a couple of weather variables, the parameter estimates display theoretically appropriate signs.

6. Mississippi

$$YM_t = 51.1230 - \underset{(5.91)}{0.0982AM_t} + \underset{(17.69)}{0.0095T_t^2} - \underset{(3.33)}{0.4337R3M_t} - \underset{(2.21)}{0.5635T7M_t} + \underset{(2.40)}{0.5353P45M_t}$$

$$- \underset{(3.43)}{0.8012P89M_t}$$

$R^2 = 0.96$ D.W. = 1.86 $\overline{YM} = 35.24$ $\sigma = 1.78$

7. Texas

$$YT_t = 146.5108 - \underset{(2.36)}{0.0190AT_t} + \underset{(11.18)}{14.9430TE_t} - \underset{(2.96)}{1.2754T78T_t} - \underset{(1.76)}{0.3952R4T_t}$$

$R^2 = 0.92$ D.W. = 1.67 $\overline{YT} = 31.21$ $\sigma = 2.76$

8. Louisiana

$$YL_t = 40.2923 + 2.5133TE_t + 3.3388T_t - 0.0219T_t^2 - 0.6737T56L_t - 0.6405P34L_t$$

(2.11) (5.09) (4.26) (2.28) (3.34)

$$+ 0.5931P56L_t$$

(3.10)

$R^2 = 0.97$ D.W. = 1.55 $\overline{YL} = 31.21$ $\sigma = 1.35$

9. Arkansas - Missouri

$$YA_t = -138.1811 - 0.0194AA_t + 2.6827TE_t + 20.2815T_t^{\frac{1}{2}} - 0.6463P45A_t$$

(10.43) (2.23) (15.23) (4.02)

$$-0.4765P67A_t - 0.9629P89A_t + 3.2242SC56A_t + 0.7651T67A_t - 0.5476T78A_t$$

(2.48) (5.81) (4.73) (1.85) (1.84)

$R^2 = 0.99$ D.W. = 2.16 $\overline{YA} = 37.78$ $\sigma = 1.01$

10. California

$$YC_t = -103.6158 - 0.0496AC_t + 18.0722T_t^{\frac{1}{2}} - 0.8824R4C_t + 0.4344T6C_t$$

(7.40) (19.18) (2.87) (2.50)

$$- 1.9137P9C_t - 1.2311SC5C_t$$

(3.83) (3.22)

$R^2 = 0.97$ D.W. = 2.20 $\overline{YC} = 46.55$ $\hat{\sigma} = 1.83$

Acreage harvested--Acreage harvested was used in the equations to reflect the land area devoted to rice production in each State. Acreage increases were found to have a significant negative impact on acreage yield in all States except Louisiana. Acreage changes had the greatest impact in Mississippi and California.

Technology and trend--The technology variable, representing new technology developed in the early sixties (TE_t), was significant in yield equations for all Southern States except Mississippi. The impact was positive in all cases and was very large in Texas. This large impact reflects the advent of second-crop rice production in Texas in the sixties as well as other improvements in production techniques. This technology variable accounted for most of the upward trend in average yields in Texas, thus the other trend variables were not included in the final analysis for this State.

Trend variables were included in the final specification for other States. Yield trends were positive for each State. In all cases except Mississippi, the rate of increase declined over time. In Louisiana, the positive linear trend (T_t) was reduced over time through the negative coefficient on the squared term (T_t^2). Trends in Arkansas and California also were increasing at a decreasing rate (($T_t^{\frac{1}{2}}$).

Rainfall--Rainfall during seeding time had a significant impact on yields in Mississippi, Texas, and California, and the estimated parameters agree in sign with *a priori* expectations.

Precipitation--The average number of days of preciptation over 0.1 inch in selected months during the seeding and growing seasons (March to July) had different impacts at different locations. The impact was positive in Mississippi ($P45M_t$) and negative in Arkansas ($P45A_t$ and $P67A_t$). In Louisiana, precipitation in March and April ($P34L_t$) reduced yields, while precipitation during May and June ($P56L_t$) increased yields. The positive parameter estimates for variables $P45M_t$ and $P56L_t$ do not agree with *a priori* expectations since low yields have been observed in years when rainfall was higher than normal during the growing season. Precipitation during harvest (August and September) had the expected effect of reducing yields in all States except Texas and Louisiana.

Temperature--The relationship between yield and average temperature during selected months of the growing season depended on the location and month. In Mississippi, high average temperatures during July ($T7M_t$) had a negative impact on average yield. The same relationship existed in Texas for the July and August temperature ($T78T_t$), in Louisiana for May and June temperature ($T56L_t$), and in Arkansas for July and August temperature ($T78A_t$). In contrast, higher temperatures in June and July were found to be beneficial in Arkansas ($T67A_t$). Likewise, California yields were positively related to higher June temperatures ($T6C_t$).

Sky cover--Percent of sky cover was found to have a significant impact on average yields in Arkansas and California. Increasing the percent of sky cover during May in California ($SC5C_t$) reduced yields as expected. However, the positive response to a May and June sky cover in Arkansas ($SC56A_t$) was contrary to *a priori* expectations.

Supply Identities

It was noted before that the quantity produced (QP_t) in the United States and total supply (QS_t) are treated as exogenous variables in the demand section. In the model, U.S. production is determined from the acreage and yield equations, and is defined as the sum of quantities (acreage x yield per acre) produced in each State (equation 11). Total supply is defined as current production (QP_t) plus stocks in private (QCP_{t-1}) and Government (QCG_{t-1}) ownership that were carried over from the previous marketing year (equation 12).

$$11.\ QP_t = (AM_t*YM_t) + (AT_t*YT_t) + (AL_t*YL_t) + (AA_t*YA_t) + (AC_t*YC_t)$$

$$12.\ QS_t = QP_t + QCP_{t-1} + QCG_{t-1}$$

The quantity of rice imported into the United States is negligible. Therefore, it is ignored as a component of suppy in the model.

Demand Section

The demand section of the model is composed of a set of economic relationships which represent the several domestic and export outlets for U.S. rice. The parameters associated with the demand equations were estimated using three stage least squares (3SLS). Thus, the parameter estimates for this simultaneous system of equations reflect the economic interrelationships that exist among the various outlets for U.S. rice. The parameter estimates are presented below by major outlet. The t-value for each parameter estimated is shown in parentheses under each coefficient. The related statistics, as given in the supply section, are not applicable with three stage least squares estimation.

Feed

Rice millfeed, a mixture of bran, ground hulls, and polish is one of the minor agricultural products used for feed. Thus, this market is influenced by the general price level for feed grains and hay. Since it is a byproduct of rice milling, the total quantity of rice milled is also a significant determinant of quantity. The signs on the coefficients in equation 13 were in accord with expectation. The coefficients were rather large in relation to their standard errors, especially the quantity of rough rice milled.

$$13.\ QFE_t = -\ 117.6124 - \underset{(1.94)}{6.5427PBR_t} + \underset{(73.57)}{.1103QM_t} + \underset{(3.03)}{3.2589PI_t}$$

Seed

The demand for seed in the current marketing year is determined to a large extent by the acreage seeded to rice in the following year. However, an acreage variable was not included in the specifications because it is an unknown when the model is used in a forecasting framework. The adjusted farm price and lagged total carryover were found to influence planted acreage in each State and were included in the estimating equation for seed demand. A time trend was also included to reflect increases in seeding rates per acre that have occurred over time. The higher per acre rates are due primarily to a shift from drilled seeding to aerial seeding.

The latter method involves higher seeding rates. The parameter estimates associated with these variables are shown in equation 14. The signs associated with the coefficients agree with expectations.

14. $$QSE_t = 58.7343 + 83.1568(R*PF)_t - .0220(QCP+QCG)_{t-1} + 38.2032T_t$$

(4.26) (4.91) (6.12)

Food

Food demand for rice consists of direct food use (including white rice, parboiled, precooked, brown, and flavored) and processed food use (including cereals, soups, baby food, package mixes, and other unclassified uses). Economic theory suggests that food demand for rice is influenced by the retail price of rice, price of competing commodities, income, population, changes in tastes and habits, and other factors. Prices of potatoes, corn, and wheat products were evaluated, but did not have any appreciable effect on food rice consumption. Consequently, prices of these substitutes were not included in the final specification. Income and population are the major variables affecting food rice consumption. Income and population are highly correlated. To avoid statistical problems in estimation, a per capita food demand equation was estimated, and the results were multiplied by population. Changes in the retail rice price were found to have a very minor impact on demand. The estimated parameters in equation 15 agree in sign with *a priori* expectations and are significantly different from zero.

15. $$QFD_t = [74.0344 - .1563PR_t + .1702YI_t + 5.4368D59_t]POP_t$$

(1.68) (5.22) (5.12)

Annual estimates of rice food demand are based primarily on mill shipment data. Actual consumption, not available on a periodic basis, lags behind mill shipments. To compensate for this lag and the mill to consumer fluctuation in projecting stocks, a 3-year moving average for rice food demand was used.

Brewers

Rice used by brewers, a relatively small portion of total starch inputs in the brewing industry, is influenced by the rapid growth in beer sales. Only a limited number of brewing firms use brewers rice. Although brewers rice competes with corn grits in this market, the adjustment in brewing recipes has been limited due to final product identity. Thus, demand in this outlet is determined by a ratio of brewers rice price to corn price, economic variables reflecting growth in beer sales (income), lagged brewers use of rice, and population. The estimated equation was formulated on a per capita basis and the parameter estimates are shown in equation 16.

$$16.\quad QB_t = [9.5079 - \underset{(3.32)}{1.2991}(PB/PC)_t + \underset{(2.32)}{.0287}YI_t + \underset{(9.18)}{7.4750}(QB/POP)_{t-1}]POP_t$$

The signs on the coefficients agree with expectations and are significantly different from zero at the 1-percent probability level.

Exports

The quantity of milled rice exported from the United States under commercial arrangement and Government financial programs averaged about the same during the study period. The relative quantities moving under each arrangement vary greatly from year to year and are determined in part by different variables. The U.S. export price (PE) and the Thailand export price (PT) are highly correlated; however, each is affected by Government programs in the respective countries. The ratio of these prices was assumed to influence U.S. exports and was included in both milled rice export demand equations. The quantity exported under Government programs and the quantity produced also influence the demand for commercial exports. The estimated parameters associated with these variables are shown in equation 17. The magnitude of the coefficients and their associated signs are consistent with expectations.

$$17.\quad QEC_t = 9451.6913 - \underset{(3.93)}{9755.8640}(PE/PT)_t - \underset{(5.44)}{.2938}QEG_t + \underset{(13.66)}{.2937}QP_t$$

In contrast to commercial exports, the quantity exported under Government programs is influenced by the quantity of stocks carried over from the previous year. The parameter estimates for variables influencing Government exports are shown in equation 18.

$$18.\quad QEG_t = 19387.7364 - \underset{(6.98)}{26021.1102}(PE/PT)_t + \underset{(7.81}{.2168}QP_t$$

$$+ \underset{(12.58)}{.8872}(QCP+QCG)_{t-1}$$

A change in relative export prices in the United States and Thailand has a much greater impact on Government-financed exports in comparison to commercial exports. The coefficient estimates indicate that the impact is about three times as great.

Rough rice exports have declined over time and are currently a very minor outlet in terms of total rice exports. Farm price and lagged exports were included in the structural equation and the parameter estimates are shown in equation 19. Rough rice is exported mainly for use as seed in importing countries, and price is not a major determining factor in determining quantity.

$$19.\quad QER_t = 66.5024 - \underset{(.54)}{5.3363PF_t} + \underset{(9.69)}{.7833QER_{t-1}}$$

The price coefficient was negative as expected, but the price effect is not significantly different from zero.

Carryover Stocks

U.S. carryover, both private and Government-held stocks, was influenced during 1950-75 by Government programs. The relationship between the support price and actual price received by producers, the relationship between the U.S. export price and a world price indicator, the P.L.-480 program, the export subsidy program, and allotment program all affected carryover stocks. The estimated parameters for variables that influence private and Government-owned stocks are shown in equations 20 and 21, respectively. The estimated parameters agree in sign with *a priori* expectations.

$$20.\quad QCP_t = -336.1814 - \underset{(1.46)}{1432.0274(PF/PG)_t} + \underset{(3.76)}{.1278QCG_t} + \underset{(7.60)}{.0999QS_t}$$

$$21.\quad QCG_t = -8762.6522 - \underset{(6.12)}{12392.3270(PF/PG)_t} + \underset{(6.75)}{29271.4684(PE/PT)_t}$$

$$- \underset{(4.39)}{9576.4981GP1_t} - \underset{(4.56)}{8346.1331GP_t}$$

Hulls

Utilization data for hulls were not available. Accordingly, the equation for hulls (equation 16) was expressed as a technical relationship of quantity of milled rice using a standard ratio of hulls obtained per hundredweight of rough rice. Lagged use of hulls was added to remove auto correlation

22. $QH_t = 1355.9183 + .1362(QFD+QB+QEC+QEG)_t + .3308QH_{t-1}$

(12.57) (6.53)

Identities

The demand section is closed with identities representing the total quantity milled (equation 23) and total quantity demanded (equation 24).

23. $QM_t = QFD_t + QH_t + QFE_t + QB_t + QEC_t + QEG_t$

24. $QD_t = QM_t + QCP_t + QCG_t + QER_t + QSE_t$

The total quantity milled is the sum of all demands for milled rice. Total demand is a sum of quantities milled, carryover stocks, rough rice exports, and seed uses.

Price Relationships

Price relationships were specified to link the various demand components of the model. The relationship between prices at various stages of the marketing process was established using the price equations. The model was formulated such that various domestic prices are directly related to the wholesale price established at the mill level (PW). The domestic price relationships assumed in the model are shown in equations 26-29.

26. $PR_t = - 9.7708 + .8857PW_t + .1400T_t + .6176PR_{t-1}$

(13.60) (3.07) (18.94)

27. $PB_t = 1.5266 + .1814PW_t + .3745PB_{t-1}$

(6.84) (6.08)

28. $PBR_t = - 46.2637 + .7840PW_t + .6561LU_t + .2453PI_t$

(5.57) (3.72) (13.44)

29. $PF_t = - 2.1383 + .4171PW_t + .0445T_t$

(28.67) (4.86)

Changes in the price at the wholesale level (PW) do not generally result in immediate changes in the retail price (PR) and in the price of brewers rice (PB). To account for this lag in price response, a partial adjustment scheme was hypothesized for the retail and brewer price relationships (equations 26 and 27). The distribution lag in price adjustments at the brewers and retail level to changes in the wholesale price is given by the coefficient estimate for the lagged dependent variables.

The price of bran (PBR) is affected by changes in the wholesale price (PW), the number of grain-consuming animal units (LU), and the price index for feed grains and hay (PI). The coefficient estimates were positive as expected and were highly significant (equation 28). The farm price (PF) was assumed to be directly related to the wholesale price (PW) and a trend variable was included to account for gradual upward adjustment and Government support of farm prices that occurred during the study period (equation 29).

The U.S. export price (PE) and the Thailand export price (PT) were hypothesized to be determined by world rice production per capita $(QWR/POPW)_t$, world rice exports (QWE), and world wheat production per capita $(QWW/POPW)_t$. The estimated coefficients associated with each of these variables are shown in equations 30 and 31. There are lags in the adjustment of export prices to changes in world supply conditions; therefore, a partial adjustment scheme was assumed for the export price equations.

30. $$PE_t = 8.6798 - \underset{(1.30)}{.2497}(QWR/POPW)_t - \underset{(.93)}{.7261}QWE_t + \underset{(1.89)}{0.2256}(QWW/POPW)_t + \underset{(9.17)}{.7648}PE_{t-1}$$

31. $$PT_t = 8.9553 - \underset{(2.04)}{.3153}(QWW/POPW)_t - \underset{(.52)}{.3247}QWE_t + \underset{(2.57)}{0.2464}(QWW/POPW)_t + \underset{(9.87)}{.7684}PT_{t-1}$$

The signs of the estimated coefficients agree with expectations. A more significant relationship between world exports and export prices was expected; however, U.S. export prices appear to be more responsive to changes in the volume of rice traded in the world market as was expected.

The U.S. export price (PE) was linked to the domestic wholesale price (PW) in the model through an identity involving the export subsidy established by the U.S. Government (PS). This relationship is expressed in equation 32. This subsidy was discontinued after 1972 so domestic prices currently respond directly to changes in world market conditions.

32. $$PW_t = PE_t + PS_t$$

Relative Performance of the Model

The performance of the model was further evaluated by comparing the predicted values of the endogenous variables with their actual values. The OLS estimates of the structural equation were used for the supply section, and the reduced-form equations were used for the demand section. The reduced-form equations are an expression of each endogenous variable within the model as a function of all the exogenous variables. The reduced-form equations may be estimated by fitting each equation by ordinary least squares regression techniques (unrestricted reduced-form equations) or by solving the structural models simultaneously (derived reduced-form equations). The two methods will yield identical results only if the model is just identified. The demand model was overidentified in this study. The derived reduced-form equations are theoretically more efficient estimators than the unrestricted reduced-form equations. However, they may not track historical data as well. The algebraic determination of the derived reduced-form equations was complicated by the presence of nonlinear variables (ratios and products). The nonlinear variables, however, were linearized according to the procedure suggested by Klein [6].

The actual ratio and product values were replaced by the linearized values in the models during the estimation process. The estimated structural equations may be rewritten by incorporating the linearized values as follows:

14a. $$QSE_t = -295.0979 + 61.536PF_t + 478.1516R_t - .0220QCP_{t-1} - .0220QCG_{t-1} + 38.2032T_t$$

15a. $$QFD_t = -1984.585 - 28.969PR_t + 31.569YI_t + 1009.651D59_t + 84.721POP_t$$

16a. $$QB_t = -3298.2612 - 169.8969PB_t + 708.2784PC_t + 5.3296YI_t + 1388.1075(QB/POP)_{t-1} + 21.8531POP_t$$

17a. $$QEC_t = -2339.7205 - 1054.688PE_t + 1274.7472PT_t - .2938QEG_t + .2937QP_t$$

18a. $$QEG_t = -12062.6433 - 2813.093PE_t + 3400.0410PT_t + .2168QP_t + .8872QCP_{t-1} + .8872QCG_{t-1}$$

20a. $QCP_t = -1976.4518 - 285.2644PF_t + 326.7471PG_t + .1278QCG_t$

$+ .0999QS_t$

21a. $QCG_t = 12421.8701 - 2468.5910PF_t + 2827.5694PG_t + 3164.4831PE_t$

$- 3824.7482PT_t - 9576.4981GP1_t - 8346.1331GP_t$

The reduced-form equations for the demand section of the model are presented in appendix table 9.

The relative performance of the model was evaluated by examining the frequency of underestimation and overestimation errors, the number of errors in the estimation of turning points, and plots of actual and estimated endogenous variables. The supply section is first examined, followed by the demand section.

Supply Section

The frequency of underestimation and overestimation errors was about equal for all equations in the supply system (table 1). The frequency of turning point errors for each dependent variable was determined by comparing the direction of change in observed values with that of estimated values (table 1). The turning point errors ranged from 2 for California acreage (CA) to 6 for Texas yield (YT).

The coefficient of variation (C.V.) associated with each of the estimating equations in the supply model is shown in table 1. The C.V. expresses the standard error of the estimate for each equation as a percent of the mean of the dependent variable. Thus, this statistic allows comparison of the estimating power of equations with small values for the dependent variable with those having large values. For example, Mississippi has small average acreage in comparison to Arkansas, and the acreage equation for Mississippi (equation 1) had a relatively small standard error of the estimate (4.97). In comparison, the standard error of the estimate for the acreage equation for Arkansas (equation 4) was 23.59; however, the equation for Arkansas provides better estimates when judged on the basis of the coefficient of variation.

Actual and estimated dependent variables for the supply section are shown in figures 3 to 14. In most instances, the estimated values approximate the values fairly accurately.

Demand Section

The frequency of turning point errors for an endogenous variable was determined by comparing the actual change with the estimated change (table 2).

Table 1--Underestimation, overestimation, and turning point errors and the coefficient of variation for supply section equations estimated by ordinary least squares, 1950-76

Equation	Dependent variable	Under-estimation error	Over-estimation error	Turning point error	C.V. 1/
Acreage:					
Miss.	AM	12	15	3	8.55
Texas	AT	12	14	7	6.19
La.	AL	14	13	4	6.51
Ark.	AA	14	13	4	4.79
Cal.	AC	15	12	2	6.05
Yield:					
Miss.	YM	15	12	5	5.04
Texas	YT	15	12	6	7.45
La.	YL	12	15	5	4.31
Ark.	YA	12	15	4	2.67
Cal.	YC	15	12	4	3.94

1/ Coefficient of variation is the standard error of the estimate for each equation expressed as a percent of the mean of the dependent variable.

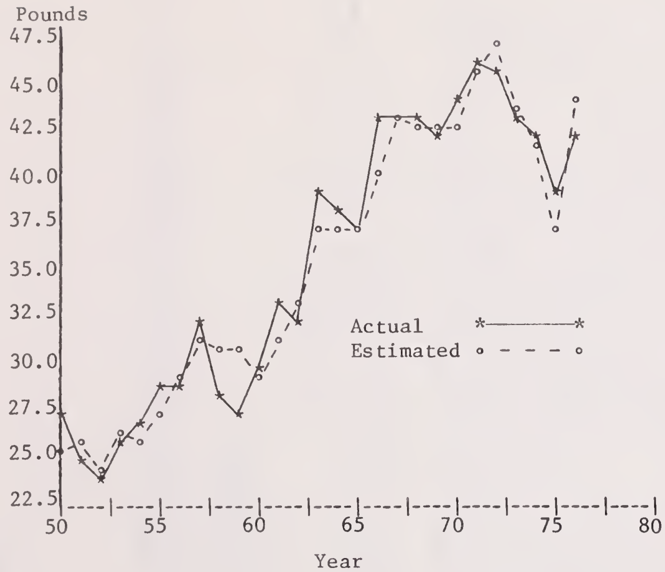

Figure 3. Mississippi: Yield per harvested acre, actual and estimated from equation, 1950-76

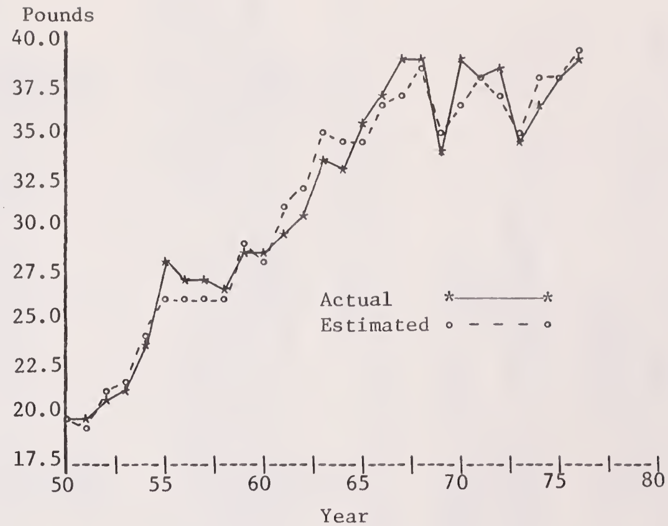

Figure 4. Louisiana: Yield per harvested acre, actual and estimated from equation, 1950-76

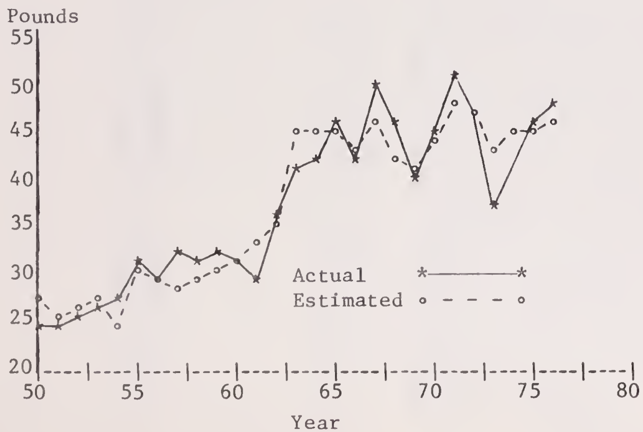

Figure 5. Texas: Yield per harvested acre, actual and estimated from equation, 1950-76

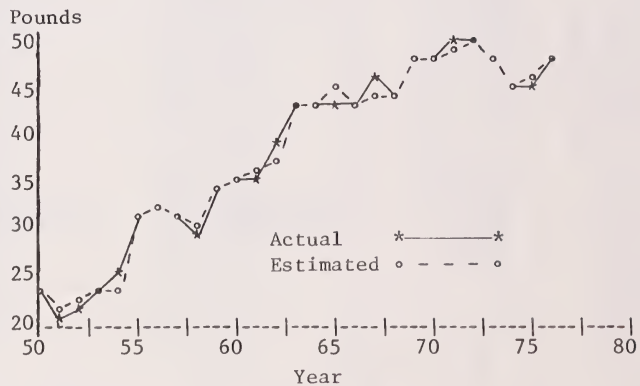

Figure 6. Arkansas: Yield per harvested acre, actual and estimated from equation, 1950-76

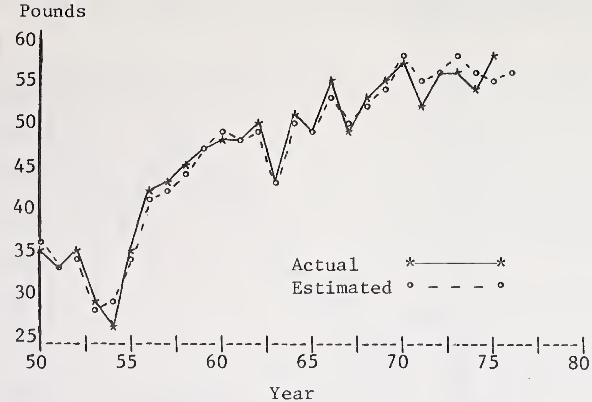

Figure 7. California: Yield per harvested acre, actual and estimated from equation, 1950-76

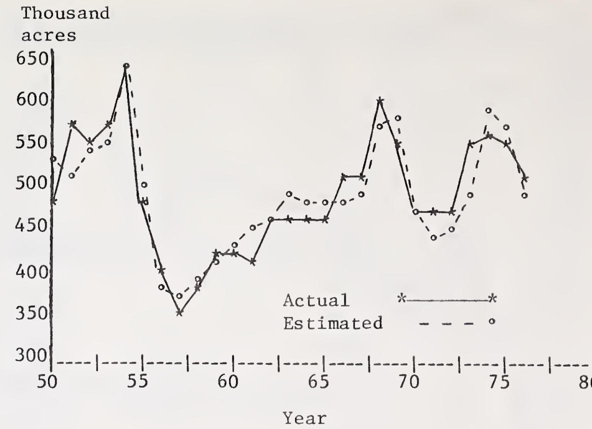

Figure 8. Texas: Harvested acres, actual and estimated from equation, 1950-76

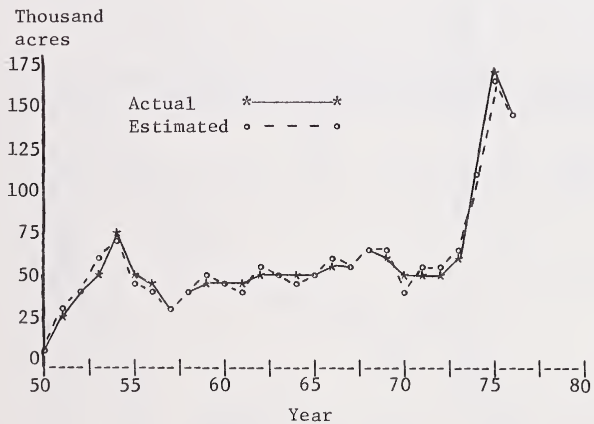

Figure 9. Mississippi: Harvested acres, actual and estimated from equation, 1950-76

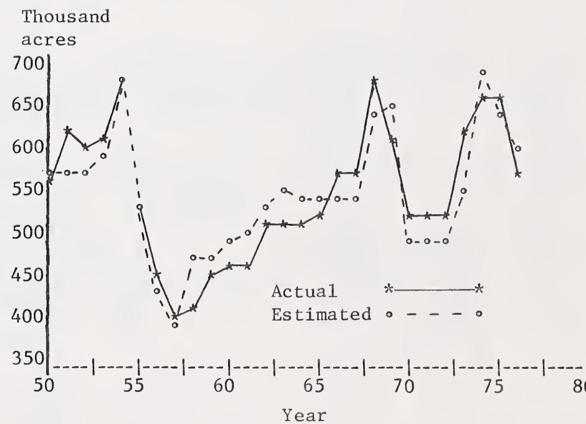

Figure 10. Louisiana: Harvested acres, actual and estimated from equation, 1950-76

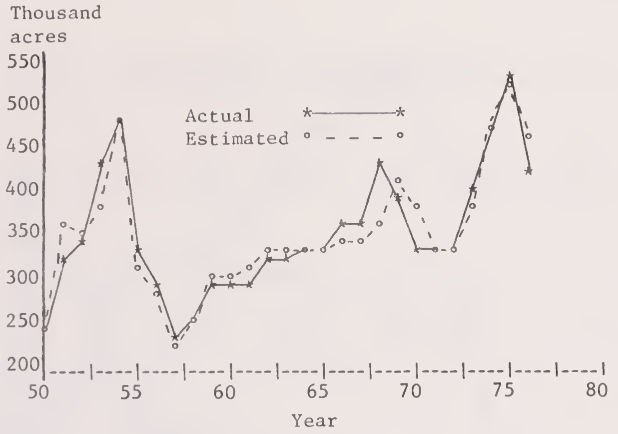

Figure 11. California: Harvested acres, actual and estimated from equation, 1950-76

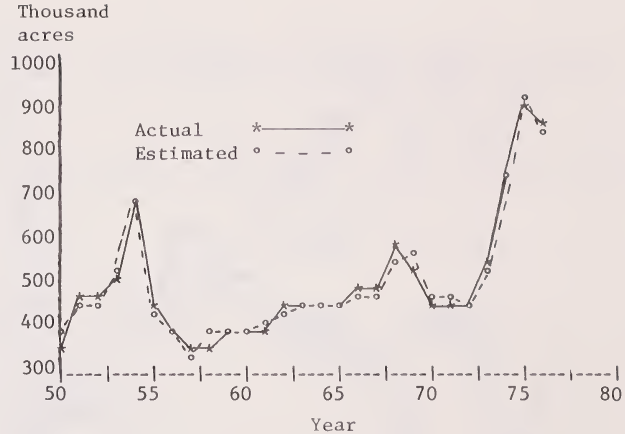

Figure 12. Arkansas: Harvested acres, actual and estimated from equation, 1950-76

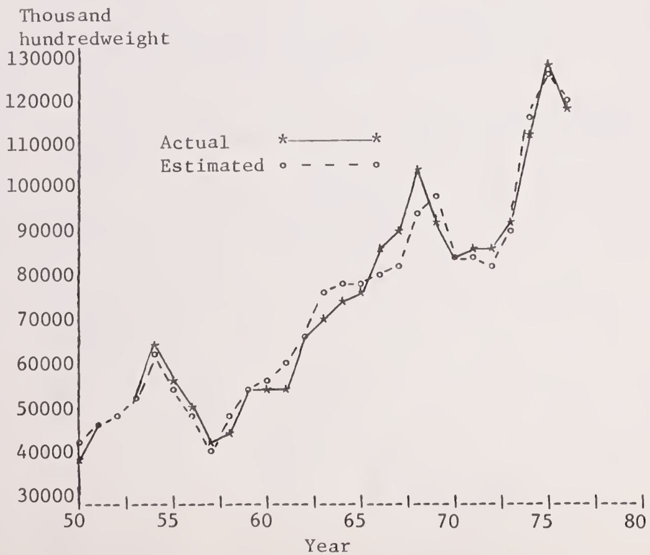

Figure 13. United States: Rice production, actual and estimated from identity equation, 1950-76

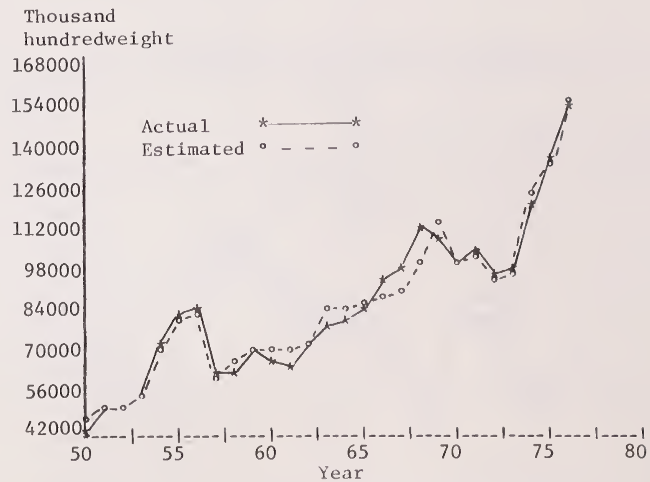

Figure 14. United States: Rice supply, actual and estimated from identity equation, 1950-76

Table 2--Errors due to underestimation, overestimation, and turning point for demand endogenous variables using unrestricted and derived reduced-form equations, 1950-75

Endogenous variable	Underestimation error		Overestimation error		Turning point error	
	Unrestricted	Derived	Unrestricted	Derived	Unrestricted	Derived
QFE	13	15	12	11	1	6
QSE	12	8	13	18	5	6
QFD 1/	13	16	12	10	3	5
QB 1/	12	11	13	15	3	6
QEC	12	15	13	11	4	6
QEG	12	12	13	14	3	6
QER	15	13	10	13	8	14
QCP	14	15	11	11	4	11
QCG	11	12	14	14	8	10
QH	15	10	10	16	3	7
QM	13	14	12	12	1	8
QD	12	14	13	12	0	5
PW	13	10	12	16	2	13
PR	14	10	11	16	0	4
PBR	12	14	13	12	4	9
PB	11	12	14	14	3	10
PF	14	9	11	17	4	11
PE	14	10	11	16	1	13
PT	14	8	11	18	2	9

1/ With unrestricted reduced-form, the endogenous variable is on a per capita basis.

The turning point errors ranged from 0 on both QD and PR to 8 on QER and QCG using the unrestricted reduced-form coefficients. The turning point errors were greater with the derived reduced-form coefficients (4 for PR to 14 for QER).

The frequency of underestimation and overestimation errors is about equal with the unrestricted reduced-form equations. The worst distribution was for QER and QH with 15 underestimation errors to 10 overestimation errors. The derived reduced-form equations give a less equal distribution. The worst distributions were with QSE and PT at 8 underestimation errors to 18 overestimation errors.

The relative performance of the model may be further examined by comparing visually the actual data plotted against the estimated values calculated with the unrestricted reduced-form equations. This information is summarized in figures 15 to 33. In most instances, the estimated values over time approximate the actual values. The export and carryover variables have the largest variation between actual and estimated. The plots from the derived reduced-form equations are not presented.

Both methods of calculating the reduced-form equations indicate that the estimates for QER, QCP, and QCG during the study period were the least accurate for the model.

Elasticities

Production and demand elasticities calculated with the structural model for 1975 are presented in tables 3 and 4. Elasticities were computed at the price level in the market that the structural equation represents.

Table 3--Estimated rice supply elasticities for 1975

State	$E_{A/P}$	$E_{Y/A}$	$E_{Q/P}$ 1/
Mississippi	0.78	-0.43	0.44
Texas	.19	-.23	.15
Louisiana	.31	-.00	.31
Arkansas	.82	-.39	.50
California	.55	-.45	.30
United States 2/	.52	-.28	.35

1/ $E_{Q/P} = E_{Q/P}(1+E_{Y/A})$

2/ Weighted acreage based on State acreage.

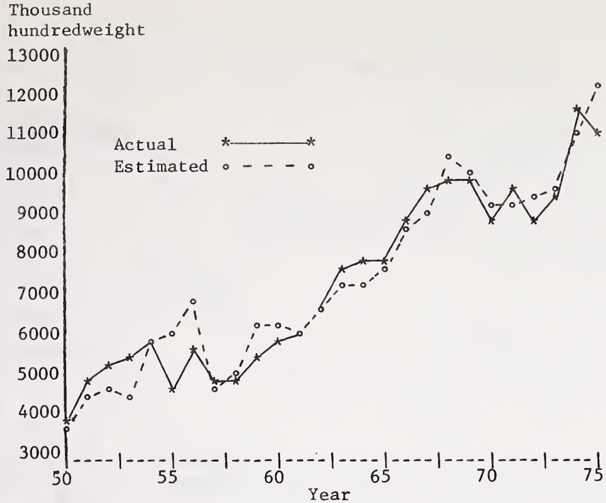

Figure 15. Rice demand for feed, actual and estimated from reduced-form equation, 1950-75

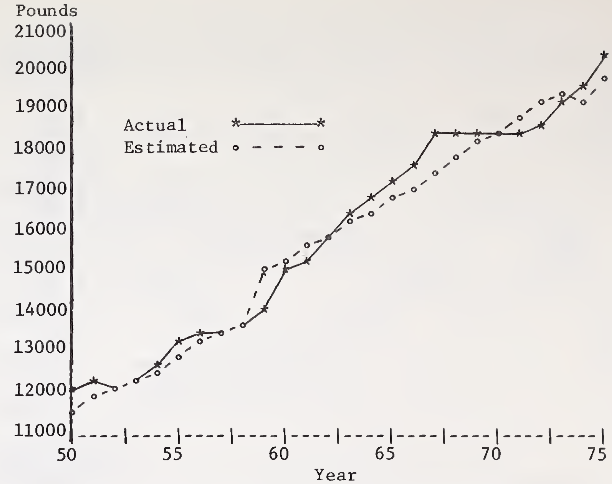

Figure 16. Rice demand for food, actual and estimated from reduced-form equation, 1950-75

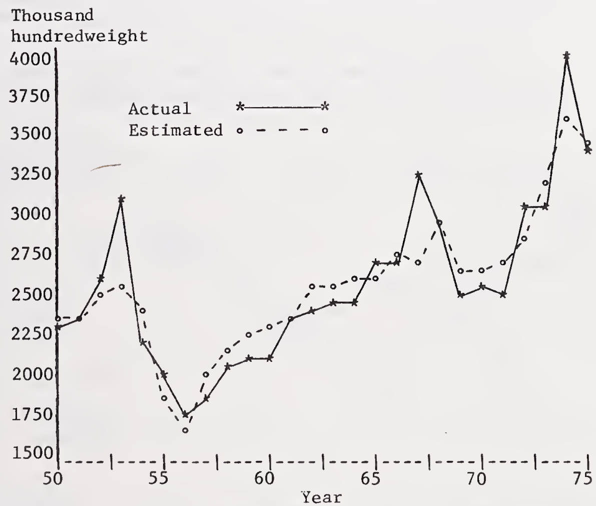

Figure 17. Rice demand for seed, actual and estimated from reduced-form equation, 1950-75

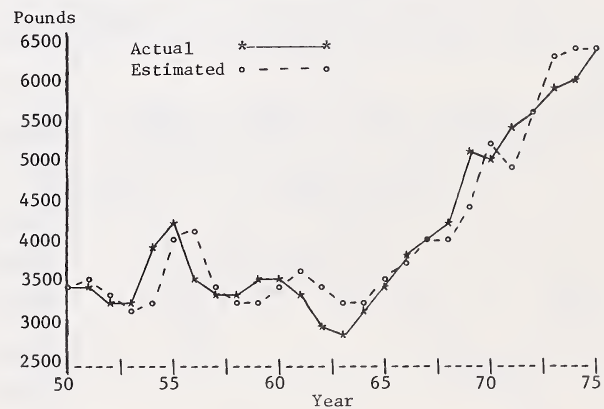

Figure 18. Rice demand for beer, actual and estimated from reduced-form equation 1950-75

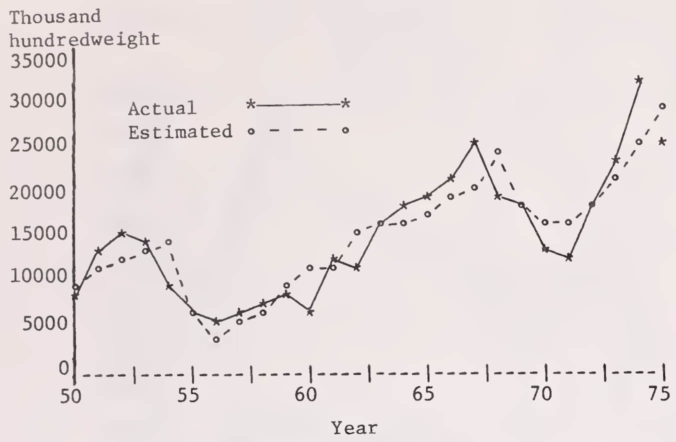

Figure 19. Commercial milled rice exports, actual and estimated from reduced-form equation, 1950-75

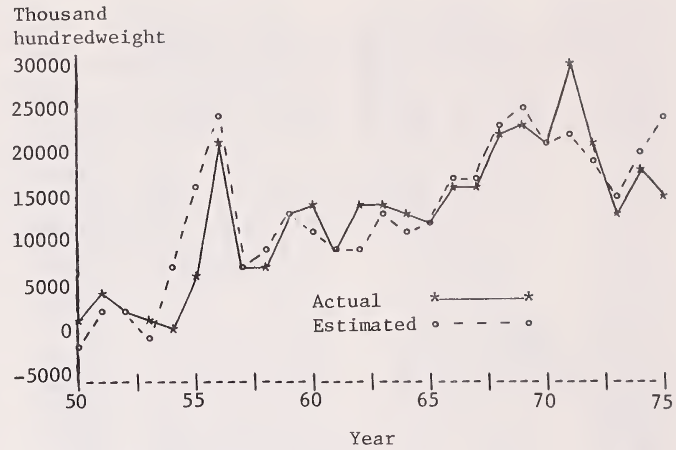

Figure 20. Government milled rice exports, actual and estimated from reduced-from equation, 1950-75

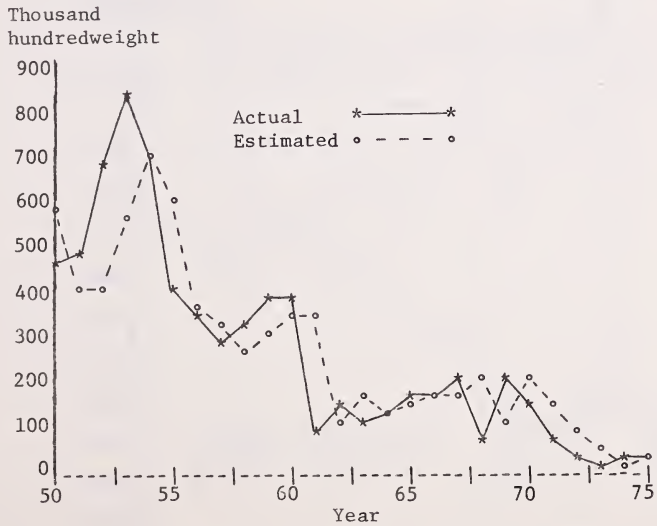

Figure 21. Rough rice exports, actual and estimated from reduced-form equation, 1950-75

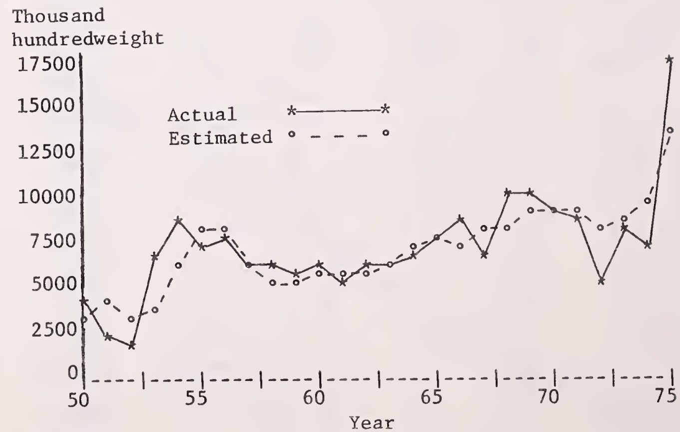

Figure 22. Rice in private carryover, actual and estimated from reduced-form equation, 1950-75

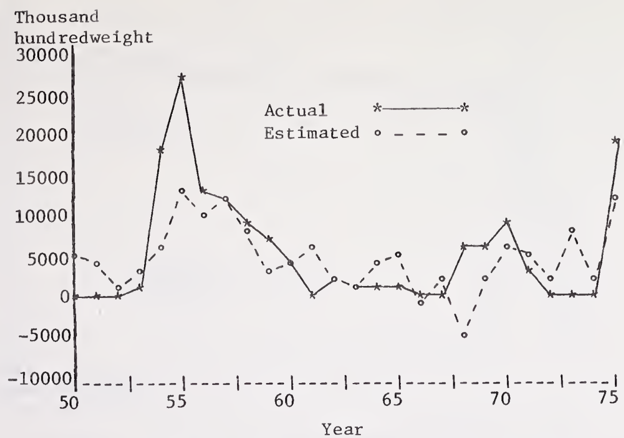

Figure 23. Rice in Government carryover, actual and estimated from reduced-form equation, 1950-75

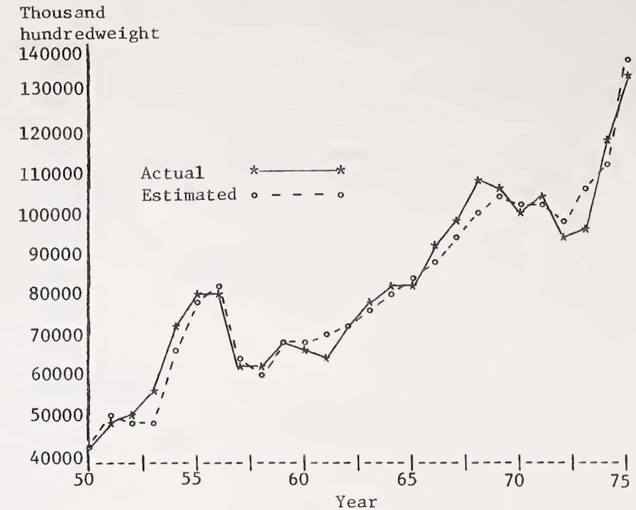

Figure 24. Total utilization of U.S. rice, actual and estimated from reduced-form equation, 1950-75

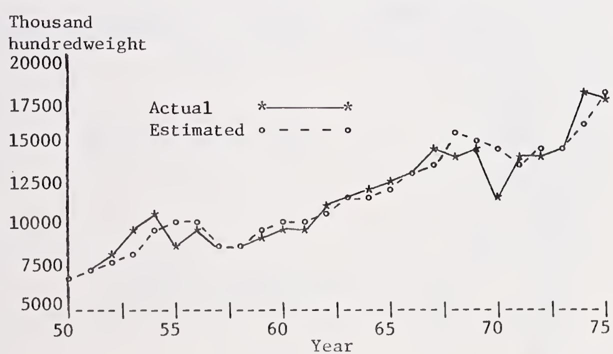

Figure 25. Rice hulls available, actual and estimated from reduced-form equation, 1950-75

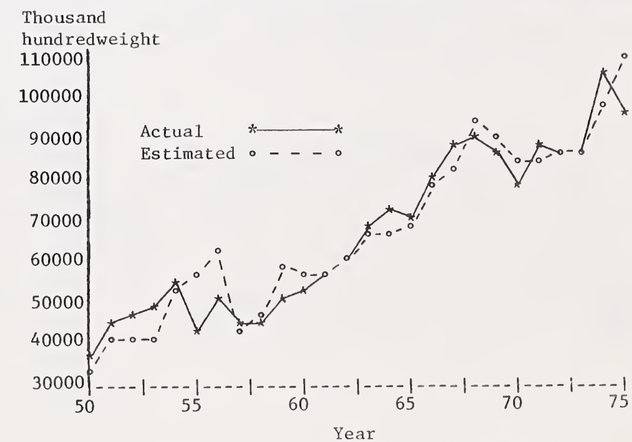

Figure 26. Rough rice milled, actual and estimated from reduced-form equation, 1950-75

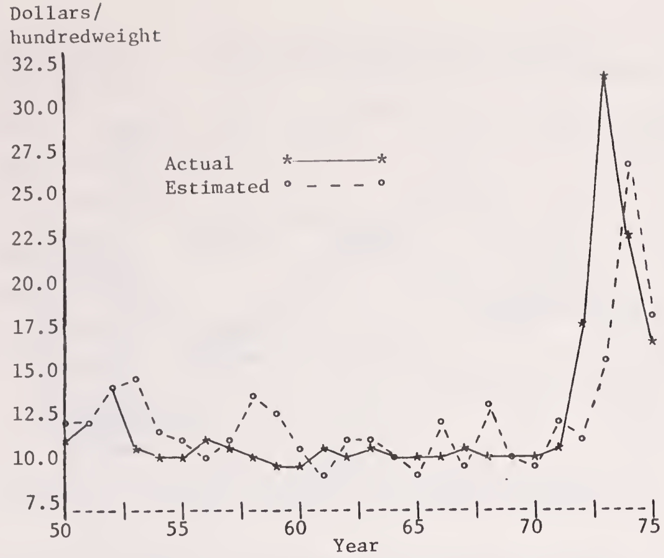

Figure 27. U.S. mill price of long grain rice, actual and estimated from reduced-form equation, 1950-75

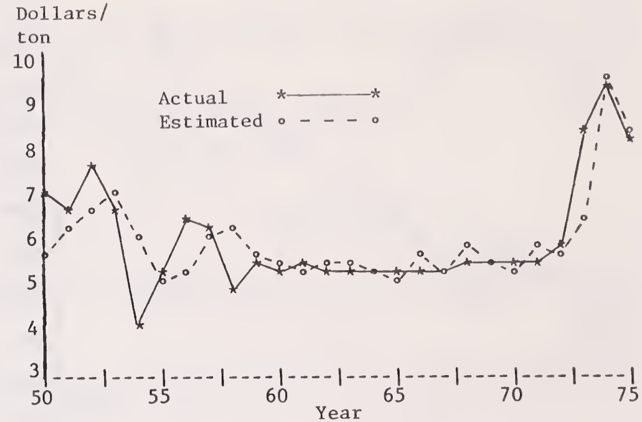

Figure 28. Mill price of bran, actual and estimated from reduced-form equation, 1950-75

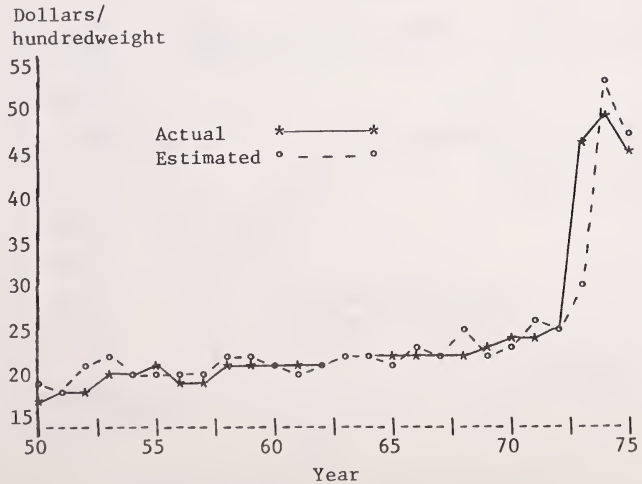

Figure 29. Retail price of long grain rice, actual and estimated from reduced-form equation, 1950-75

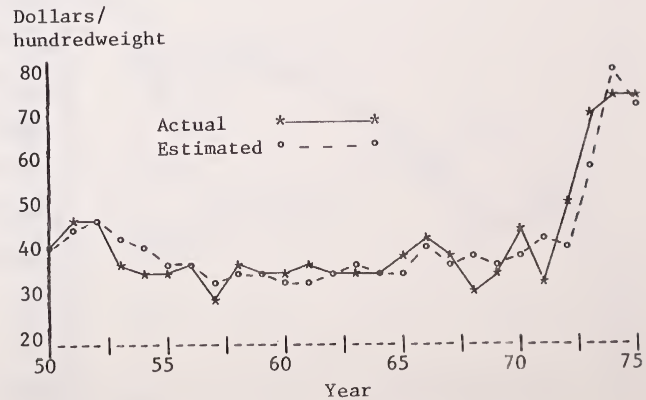

Figure 30. Mill price of brewers rice, actual and estimated from reduced-form equation, 1950-75

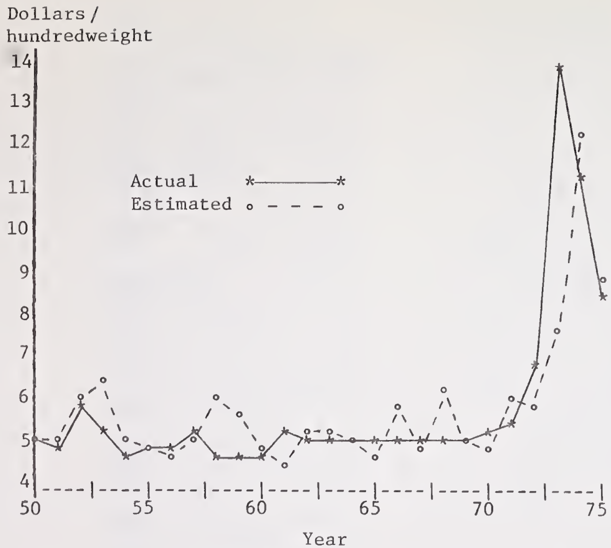

Figure 31. U.S. farm price of rice, actual and estimated from reduced-form equation, 1950-75

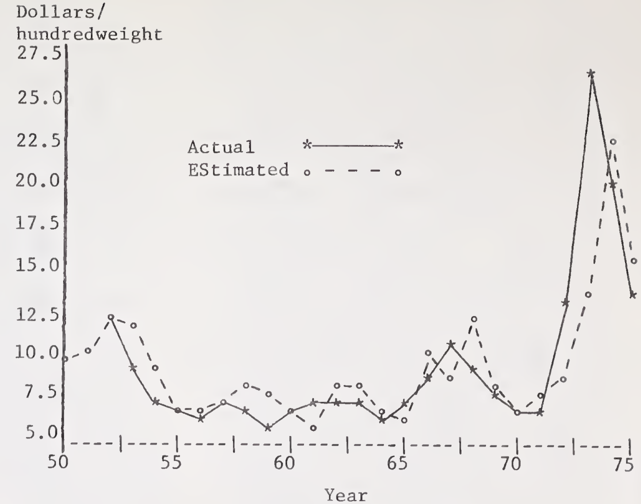

Figure 32. Thailand export price, actual and estimated from reduced-form equation, 1950-75

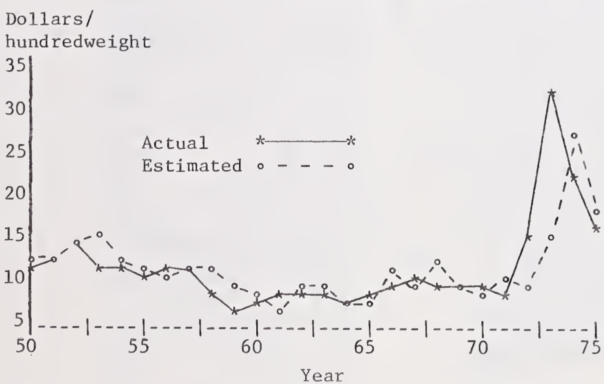

Figure 33. U.S. export price, actual and estimated from reduced-form equation, 1950-75

Table 4--Estimated demand elasticities, 1975

Endogenous variable	PR_t	PBR_t	PB_t	PF_t	PE_t	PT_t	YI_t	PC_t	PI_t	QEG_t	PG_t	QP_t
QFE_t	--	-0.04	--	--	--	--	--	--	0.07	--	--	--
QSE_t	--	--	--	-0.20	--	--	--	--	--	--	--	--
QFD/POP_t	-0.07	--	--	--	--	--	0.23	--	--	--	--	--
QB/POP_t	--	--	-0.14	--	--	--	0.12	0.14	--	--	--	--
QEC_t	--	--	--	--	-0.46	0.46	--	--	--	-0.17	--	1.50
QEG_t	--	--	--	--	-2.11	2.11	--	--	--	--	--	1.88
QER_t	--	--	--	-4.45	--	--	--	--	--	--	--	--
QCP_t	--	--	--	-0.08	--	--	--	--	--	--	0.08	--
QCG_t	--	--	--	-0.63	1.83	-1.83	--	--	--	--	0.63	--
$QWR/POPW_t$	--	--	--	--	0.74	0.51	--	--	--	--	--	--
QWE_t	--	--	--	--	-3.05	-5.72	--	--	--	--	--	--
$QWW/POPW_t$	--	--	--	--	0.83	0.63	--	--	--	--	--	--

-- = Not available.

Area

The elasticity of harvested acreage with respect to lagged farm price ranged from a low of 0.32 in Louisiana to a high of 0.82 in Arkansas. Land and water restrictions are not as limiting a factor in the areas with higher elasticities. Water limitations on the Gulf Coast prevent much upward adjustment in acreage. Using each State's share of acreage as weights, the estimated elasticity of U.S. acreage with respect to lagged farm price was 0.52 for 1975. That is, a 0.52-percent change in acreage was associated with a 1-percent change in lagged farm price in the same direction. John Kincannon (4), using equations based on 1923-40 and 1948-54 data, estimated elasticity of U.S. rice acreage with respect to lagged farm price, deflated by the index of prices paid, at 0.33 for 1954. He found also that yield during the same period was not appreciably affected by lagged, deflated farm price. The research reported here also indicates no farm price-yield relationship.

Yield

Although yield is not directly affected by price changes, the acreage changes in response to price changes do affect yields. The elasticity of average yield with respect to harvested acreage ranged from 0.00 in Louisiana to -0.45 in Mississippi and California. Again, using State shares of acreage as weights, the estimated elasticity for U.S. average yield with respect to acreage harvested is -0.28.

Production

The elasticity of production with respect to lagged farm price is a combination of the direct effect of acreage changes in response to price changes and yield changes in response to acreage changes. The estimated production elasticities with respect to lagged farm price for 1975 ranged from 0.15 in Texas to 0.50 in Arkansas. The weighted average elasticity for the United States was 0.35. That is, a 1-percent change in price will result in a 0.35-percent average change in production in the same direction.

Domestic Feed Demand

The elasticity of domestic rice feed demand with respect to the price of rice bran was estimated to be -0.04 in 1975. That is, a 0.04-percent change in rice mill feed use was associated with a 1-percent change in the opposite direction of the price of rice bran. Rice mill feed, a relatively small portion of the total feed market and commanding very few alternative uses, would be expected to have a low response to price change. No estimates of elasticity by other researchers were found for this outlet. The cross-elasticity between rice mill feed use and the index of feed grain prices at 0.07 indicates very little effect on rice mill feed use relative to a change in feed grain prices and the very minor role rice mill feeds play in the total feed picture.

Domestic Food Demand

The elasticity of per capita domestic food demand with respect to the retail rice price was -0.07 for 1975. That is, a 0.07-percent change in per capita food demand of rice was associated with a 1-percent change in the opposite direction in the retail price. With this condition, changes in the retail rice price have little effect on direct food use of rice.

Several researchers have estimated the elasticity of total U.S. domestic demand with respect to farm price for various time periods as: -0.04 (G.E. Brandow (2) in 1955-57); -0.15 (Grant and Moore (3) in 1966); -0.21 (Kincannon (4) in 1954); and -0.56 (G. L. Mehren and N. Thuroczy (5) in 1952). All these estimates of demand elasticity are relatively low (inelastic) and indicate a downward trend over time.

The income elasticity of per capita domestic demand for rice as a food was estimated to be 0.23 in 1975. That is, a 0.23-percent change in per capita food demand for rice was associated with a 1-percent change in the same direction in the index of per capita income. This compares with estimates of elasticity of total domestic use with respect to income of 0.99 for 1952 by Mehren and Thuroczy (5), 0.46 for 1954 by Kincannon (4), and 0.61 for 1966 by Grant and Moore (3). With the income elasticity declining over time, the impact of rising incomes on per capita direct food use of rice is of diminishing magnitude.

To determine the importance of potatoes and corn products as a substitute for rice, the retail price of potatoes and farm price of corn were included in early runs of the food demand equation. The standard errors of these coefficients were greater than the coefficients indicating that the substitutability of potatoes and corn for rice was not statistically significant.

Domestic Brewer Demand

In preliminary runs of the model, the coefficient for brewers rice price was not statistically significant and carried the wrong sign in the demand equation for brewers rice. Prices for brewers rice and corn tended to move together creating estimation problems when both are included as separate variables in the equation. A ratio between brewers price and corn price was used. Using this ratio assumes that a 10-percent increase in corn price has the same effect as a 10-percent decrease in brewers price. Thus, the elasticity of demand for brewers rice with respect to brewers price at -0.14 is the same, except for the sign, as for the cross-elasticity with respect to corn price. The income elasticity at 0.12 is slightly less than that for direct food demand. No estimates of these elasticities by other researchers are available.

U.S. Export Demand

U.S. exports were grouped into three categories for this study, commercial milled rice, Government milled rice, and rough rice. Equations were estimated for each category.

The U.S. milled rice commercial export elasticity with respect to the U.S. export price at -0.46 is considerably smaller than the U.S. milled rice Government export elasticity with respect to the same price (-2.11). A priori expectations point to Government exports being more responsive to price changes than commercial exports.

The cross-elasticity of U.S. commercial milled exports to U.S. Government milled exports was -0.17 in 1975. The degree of substitution of P.L.-480 rice for commercial export sales is relatively low. Differentiated markets, quality of product demanded, and credit terms limit substitution between these markets.

Rough rice export elasticity with respect to U.S. farm price at -4.45 appears high relative to the milled rice export elasticities. The farm price variable in the rough rice export equation had the right sign, but did not appear to have a strong statistical significance. Thus, reliance upon this elasticity should be viewed with caution.

The elasticity of demand for world rice exports with respect to the U.S. export price was at -3.05 in 1975. However, this coefficient must be viewed with caution since the t-value is relatively low. Grant and Moore (3) estimated the world export elasticity with respect to the U.S. average export value at -1.56 and the partial elasticity of U.S. exports to the same price at -8.05 in 1966. The established 1975 elasticity for total world exports is greater than that for U.S. commercial exports. In a purely competitive market, the elasticity for the United States should be greater than that for the total world export demand. In the real world, world rice markets are not purely competitive. The U.S. commercial rice exports are moving into differentiated markets with a differentiated product. P.L.-480 rice exports compete more directly with low quality rice exported from other countries. Thus, the elasticity for U.S. Government exports with respect to U.S. export price is nearer to the total world rice export demand elasticity than that for U.S. commercial exports.

U.S. Carryover Demand

U.S. carryover was grouped into two categories for this analysis: that in private hands and that held by the Government. During 1950-75, the private sector of the U.S. rice industry carried over enough rice to meet market and pipeline demands. Any excess was channeled into Commodity Credit Corporation (CCC) stocks. For this reason, the elasticity of demand for private carryover with respect to U.S. farm price of rice would be expected to be much lower than the elasticity of demand for Government carryover with respect to the same price series. They were -0.03 for private carryover and -0.63 for Government carryover.

World Demand

The elasticity of per capita world rice demand with respect to the U.S. export price was -0.74 in 1975 and, with respect to the Thailand export price, was at -0.51 in 1975. Mehren and Thuroczy (5) estimated the elasticity of world production (a rough estimate of consumption) with respect to the price of rice in London at -0.225 for 1938. Their estimate was based on 1922-38 data. Grant and Moore (3), using equations estimated from 1934-66 data minus the two periods 1941-45 and 1954-58, estimated the elasticity of per capita world demand with respect to the U.S. export value at -0.61 for 1966. World War II interrupted world rice production, trade, and demand. Although the conflict ended in 1945, the impact lasted much longer. For example, the low elasticity in 1938 had increased nearly threefold by 1966, but little change has occurred since then.

APPLICATION OF THE MODEL

Estimates for the period 1950-75 were made using the mean values for exogenous variables, and estimates for the 1978/79 crop year were made using the actual values for exogenous variables and the derived reduced-form equations. The supply section is first discussed, followed by the demand section.

Supply Section

Estimated 1977 rice production is 98.8 million hundredweights, assuming actual values for the exogenous variables (table 5). This is from 2,047,000 acres harvested, yielding an average of 48.28 hundredweights per acre. The estimated yield is slightly below the overall trend level. However, historically, as acreage increased, yields declined. The supply model reflects the historical relationship between yield and area. Lagged endogenous variables, PF_{t-1} and $(QCP+QCG)_{t-2}$, primarily shift production through their effect on area. Both are relavtively inelastic. A \$1.00 per hundredweight change in the lagged farm price affects U.S. production by about 3.2 million hundredweights.

The change in Government policy, from a rigid supply control through acreage allotments to a relaxed supply management through target price and set aside coupled with a reserve program, is shifting producer response. During 1955-73, Government response to large increases in carryover was to decrease allotments and move the surpluses through P.L.-480 or other programs. However, under the current policy, carryover controlled by the Governent is isolated from the market unless rice prices are 155 percent above

Table 5--Actual and estimated values for endogenous supply variables, using the actual equations

Variable	Average, 1950-76		1977		
	Actual	Estimated 1/	Actual	Estimated	Adjusted 2/
			Hundredweights		
YM	35.24	35.18	40.00	41.75	41.75
YC	46.55	46.56	58.10	58.18	56.64
YT	37.04	37.03	46.70	48.22	46.60
YL	31.21	31.31	36.70	35.53	35.53
YA	37.78	37.77	42.18	52.28	52.18
			1,000 acres		
AM	58.19	58.01	111.00	152.50	152.50
AC	348.22	348.21	308.00	384.50	415.40
AT	490.33	490.34	501.00	381.50	466.60
AL	546.78	547.06	475.00	436.30	532.30
AA	492.00	492.49	854.00	692.40	697.30
			1,000 hundredweights		
QP	72,849.33	72,137.29	99,223.00	98,834.00	106,937.00
QS	84,992.89	84,280.84	139,723.00	139,334.00	147,437.00

1/ The 1950-76 means for each exogenous variable were used to obtain the estimated average.
2/ Government-owned stocks were removed from the lagged carryover.

the loan level. This isolation tends to dampen the negative effect on production of a buildup on Government-held carryover.

The rice industry started the 1976/77 marketing season with nearly 37 million hundredweights in stocks. The Government held over half of this total. Lowering stocks to the level held by the private sector increased the estimated production for 1977 by 8.1 million hundredweights (table 5).

Demand Section

Estimated demand for the 1977/78 marketing season totals 143.2 million hundredweights, assuming production at 99.2 million hundredweights (table 6). Of this total, 11.8 million hundredweights is in carryover stocks, 11.5 million private and 0.3 million Government. Domestic use plus exports total 131.4 million hundredweights, 18.3 million over the actual use in 1977/78.

The change in Government policy discussed earlier also affects exports. With the program in effect during 1955-75, surplus production was moved by the Government primarily into export channels. The shift to a reserve policy resulted in part of this excess being isolated from the market and held in reserve until prices rose above certain levels. The model developed in this study is influenced largely by the 1955-75 policy. As a result, it shows a large portion of the 1977/78 supply exported under Government programs, rather than through private transactions. The model estimates are closer to the actual 1977/78 data when the lagged Government carryover is reduced to the zero level (table 6).

Table 6--Actual and estimated values for endogenous demand variables, using the derived reduced-form equations

Variable	Average, 1950-75		1977		
	Actual	Estimated	Actual	Estimated	Adjusted
			1,000 hundredweights		
QFE	7,268	7,335	11,723	14,233	12,505
QSE	2,563	2,554	3,800	2,790	3,211
QFD	15,848	15,739	21,156	21,116	21,107
QB	4,045	4,057	7,100	7,208	7,196
QEC	14,608	14,651	34,843	13,994	18,835
QEG	12,743	13,310	13,228	51,847	34,767
QER	261	261	2,800	22	21
QCP	6,996	6,867	15,000	11,469	11,445
QCG	5,481	4,637	10,000	337	491
QH	11,442	11,515	18,404	20,182	18,512
QM	65,973	66,607	106,454	128,581	112,925
QD	81,237	80,926	138,054	143,199	128,094
			Dollars per hundredweight		
PW	12.22	12.26	22.72	18.59	18.95
PR	24.04	24.04	43.00	42.79	43.11
PB	5.92	5.92	7.25	7.49	7.56
PF	5.75	5.76	10.78	9.04	9.19
PE	11.18	11.18	22.72	18.59	18.95
PT	9.25	9.26	16.09	17.28	17.44
			Dollars per ton		
PBR	40.95	40.96	--	64.41	64.69

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Appendix table 1--Acreage and yield data used in supply section of model

Crop year	Average yield					Acreage harvested				
	Miss. (YM_t)	Tex. (YT_t)	La. (YL_t)	Ark. (YA_t)	Cal. (YC_t)	Miss. (AM_t)	Tex. (AT_t)	La. (AL_t)	Ark. 1/ (AA_t)	Cal. (AC_t)
	Hundredweight per acre					1,000 acres				
1950	27.00	24.00	19.50	22.52	34.75	7	482	563	347	238
1951	24.50	23.75	19.50	20.03	33.00	26	569	619	458	324
1952	23.25	25.00	20.25	20.52	34.75	40	552	600	468	337
1953	25.50	26.25	20.75	23.02	29.00	51	574	612	497	425
1954	26.25	26.75	23.50	25.02	25.50	77	637	679	680	477
1955	28.50	30.50	28.00	31.21	34.50	52	480	526	439	329
1956	28.50	29.00	27.00	32.01	42.00	44	403	450	386	286
1957	32.00	32.00	26.75	31.01	43.00	31	347	400	336	226
1958	28.00	31.00	26.50	29.49	44.50	39	379	408	340	249
1959	27.00	31.50	28.50	34.01	46.50	44	417	453	387	285
1960	29.50	30.75	28.50	35.22	47.75	44	417	458	388	288
1961	33.00	29.00	29.25	34.97	48.00	44	409	458	388	290
1962	32.00	35.50	30.50	38.50	49.50	49	462	508	431	323
1963	39.00	41.25	33.25	42.97	43.25	49	459	508	431	324
1964	38.00	41.50	33.00	42.96	50.50	49	462	513	435	327
1965	37.00	46.00	35.50	43.09	49.00	50	462	515	438	327
1966	43.00	42.00	37.00	43.03	55.00	55	505	565	482	360
1967	43.00	50.00	39.00	45.52	49.00	55	508	565	482	360
1968	43.00	46.00	39.00	43.55	53.25	67	597	679	578	432
1969	42.00	39.50	34.00	47.52	55.25	60	548	611	520	389
1970	44.00	44.50	39.00	47.93	57.00	51	467	523	443	331
1971	46.00	51.00	38.00	50.46	52.00	51	468	522	446	331
1972	45.59	47.27	38.25	49.68	56.14	51	468	522	446	331
1973	43.06	37.40	34.51	47.68	56.16	62	549	620	538	401
1974	41.80	44.94	36.50	45.23	53.80	108	562	660	739	467
1975	39.00	45.60	38.10	45.35	58.00	171	548	658	900	525
1976	42.00	48.10	39.10	47.56	55.70	144	508	568	861	420

1/ Missouri data included in Arkansas.

Appendix table 2--Production and stock data used in supply section of model

Crop year	Production						Ending stocks	
	Miss. (YM_t*AM_t)	Tex. (YT_t*AT_t)	La. (YL_t*AL_t)	Ark. 1/ (YA_t*AA_t)	Cal. (YC_t*AC_t)	Total (QP_t)	1-year lag $(QCG+QCP)_{t-1}$	2-year lag $(QCG+QCP)_{t-2}$
	1,000 hundredweight							
1950	189.0	11,568.0	10,978.5	7,815.0	8,270.5	38,821.0	3,469	2,505
1951	637.0	13,513.8	12,070.5	9,176.0	10,692.0	46,089.3	4,519	3,469
1952	930.0	13,800.0	12,150.0	9,602.0	11,710.8	48,193.8	2,040	4,519
1953	1,300.5	15,067.5	12,699.0	11,442.0	12,325.0	52,834.0	1,515	2,040
1954	2,021.2	17,039.8	15,956.5	17,012.0	12,163.5	64,193.0	7,546	1,515
1955	1,482.0	14,640.0	14,728.0	13,702.0	11,350.0	55,902.5	26,700	7,546
1956	1,254,9	11,687.0	12,150.0	12,356.0	12,012.0	49,459.0	34,618	26,700
1957	992.0	11,104.0	10,700.0	10,421.0	9,718.0	42,935.0	19,956	34,618
1958	1,092.0	11,749.0	10,812.0	10,027.0	11,080.5	44,760.5	18,169	19,956
1959	1,188.0	13,135.5	12,910.5	13,161.0	13,252.5	53,647.5	15,669	18,169
1960	1,298.0	12,822.8	13,053.0	13,665.0	13,752.0	54,590.8	12,144	15,669
1961	1,452.0	11,861.0	13,396.5	13,569.0	13,920.0	54,198.5	10,080	12,144
1962	1,568.0	16,401.0	15,494.0	16,593.0	15,988.5	66,044.5	5,329	10,080
1963	1,911.0	18,933.8	16,891.0	18,520.0	14,013.0	70,268.8	7,730	5,329
1964	1,862.0	19,173.0	16,929.0	18,688.0	16,513.5	73,165.5	7,539	7,730
1965	1,850.0	21,252.0	18,282.5	18,874.0	16,023.0	76,281.5	7,677	7,539
1966	2,365.0	21,210.0	20,905.0	20,740.0	19,800.0	85,020.0	8,239	7,677
1967	2,365.0	25,400.0	22,035.0	21,939.0	17,640.0	89,379.0	8,511	8,239
1968	2,881.0	27,462.0	26,481.0	25,170.0	23,004.0	104,998.0	6,784	8,511
1969	2,520.0	21,646.0	20,774.0	24,711.0	21,492.3	91,143.3	16,210	6,784
1970	2,244.0	20,781.5	20,397.0	21,231.0	18,867.0	83,520.5	16,446	16,210
1971	2,346.0	23,868.0	19,836.0	22,506.0	17,212.0	85,768.0	18,634	16,446
1972	2,325.1	22,122.4	19,966.5	22,157.0	18,582.3	85,153.3	11,434	18,634
1973	2,669.7	20,532.6	21,396.2	25,650.0	22,520.2	92,768.7	5,139	11,434
1974	4,514.4	25,256.3	24,090.0	33,423.0	25,124.6	112,408.3	7,842	5,139
1975	6,669.0	24,988.8	25,069.8	40,811.0	30,450.0	127,988.6	7,057	7,842
1976	6,048.0	24,434.8	22,208.8	40,950.0	23,394.0	117,035.6	36,880	7,057

1/ Missouri data included in Arkansas.

Appendix table 3--Price trend and technology data used in supply section of model

Crop year	Effective farm prices					Trend variables			Technology (TE)
	Miss. ($RM*PF_{t-1}$)	Tex. ($RT*PF_{t-1}$)	La. ($RL*PF_{t-1}$)	Ark. ($RA*PF_{t-1}$)	Cal. ($RC*PF_{t-1}$)	Time (T_t)	Time ($T_t^{\frac{1}{2}}$)	Time (T_t^2)	
	Dollars per hundredweight								
1950	4.1000	4.1000	4.1000	4.1000	4.1000	50	7.07107	2500	0.0
1951	5.0900	5.0900	5.0900	5.0900	5.0900	51	7.14143	2601	0.0
1952	4.8200	4.8200	4.8200	4.8200	4.8200	52	7.21110	2704	0.0
1953	5.8700	5.8700	5.8700	5.8700	5.8700	53	7.28011	2809	0.0
1954	5.1900	5.1900	5.1900	5.1900	5.1900	54	7.34847	2916	0.0
1955	1.4699	3.5297	3.7287	2.3916	3.0467	55	7.41620	3025	0.0
1956	1.3220	3.1865	3.3649	2.1592	2.7486	56	7.48331	3136	0.0
1957	1.3358	3.2197	3.3999	2.1816	2.7771	57	7.54983	3249	0.0
1958	1.4045	3.3853	3.5747	2.2938	2.9200	58	7.61577	3364	0.0
1959	1.2863	3.1004	3.2739	2.1008	2.6743	59	7.68115	3481	0.0
1960	1.2616	3.0408	3 2110	2.0604	2.6229	60	7.74597	3600	0.0
1961	1.2506	3.0143	3.1830	2.0424	2.6000	61	7.81025	3721	0.0
1962	1.5330	3.7521	3.9591	2.5357	3.2309	62	7.87401	3844	0.5
1963	1.5032	3.6791	3.8821	2.4864	3.1680	63	7.93725	3969	1.0
1964	1.4942	3.6572	3.8590	2.4716	3.1491	64	8.00000	4096	1.0
1965	1.4614	3.5769	3.7742	2.4173	3.0800	65	8.06226	4225	1.0
1966	1.6145	3.9548	4.1749	2.6786	3.4087	66	8.12404	4356	1.0
1967	1.6211	3.9709	4.1918	2.6895	3.4226	67	8.18535	4489	1.0
1968	1.9764	4.7827	5.0505	3.2415	4.1180	68	8.24621	4624	1.0
1969	1.7836	4.3328	4.5729	2.9333	3.7333	69	8.30662	4761	1.0
1970	1.5053	3.6445	3.8492	2.4640	3.1397	70	8.36660	4900	1.0
1971	1.5722	3.8065	4.0203	2.5735	3.2793	71	8.42615	5041	1.0
1972	1.6239	3.9316	4.1525	2.6581	3.3871	72	8.48528	5184	1.0
1973	2.4795	6.0010	6.3335	4.0530	5.1661	73	8.54400	5329	1.0
1974	13.8000	13.8000	13.8000	13.8000	13.8000	74	8.60233	5476	1.0
1975	11.2000	11.2000	11.2000	11.2000	11.2000	75	8.66025	5626	1.0
1976	8.3400	8.3400	8.3400	8.3400	8.3400	76	8.71780	5776	1.0

Appendix table 4--Precipitation data used in supply section of model

Crop year	Average days of precipitation over 0.1 inch during									
	Mar. Miss. ($P3M_t$)	Apr.-May Miss. ($P45M_t$)	Aug.-Sept. Miss. ($P89M_t$)	Mar. Tex. ($P3T_t$)	Mar.-Apr. La. ($P34L_t$)	May-June La. ($P56L_t$)	Apr.-May Ark. ($P45A_t$)	June-July Ark. ($P67A_t$)	Aug.-Sept. Ark. ($P89A_t$)	Sept. Cal. ($P9C_t$)
	Days per month									
1950	7.0	4.50	6.25	7.0	6.50	7.75	6.50	4.25	8.75	1.5
1951	8.5	5.25	3.00	4.5	5.25	3.50	4.75	7.50	5.00	1.0
1952	7.5	5.50	2.75	3.5	6.50	6.00	5.75	2.50	3.25	0.0
1953	10.5	8.75	3.00	1.5	3.75	6.25	10.25	2.75	2.50	0.0
1954	4.5	8.00	1.50	3.0	4.50	4.00	5.75	2.75	2.50	0.0
1955	4.0	6.50	2.50	1.0	3.25	5.50	6.25	4.50	3.25	2.0
1956	8.0	5.00	2.50	3.5	5.25	7.00	4.50	4.75	2.00	1.0
1957	9.0	9.50	6.75	8.5	7.00	7.25	12.00	6.00	5.75	2.5
1958	7.0	8.50	6.50	5.0	5.25	5.75	7.75	7.00	5.75	0.5
1959	8.0	6.00	6.25	3.5	5.25	8.25	4.75	6.75	6.00	1.0
1960	9.5	5.25	7.50	2.5	4.00	2.50	5.25	4.75	4.25	0.0
1961	14.0	4.50	5.00	3.0	5.50	7.25	7.00	6.00	5.50	1.5
1962	5.5	4.75	5.25	2.5	4.75	5.75	3.25	8.00	5.75	0.0
1963	8.5	4.50	2.75	2.5	1.25	5.00	5.50	5.25	3.25	0.5
1964	10.0	5.50	3.50	3.5	3.75	5.00	6.75	3.50	4.75	0.5
1965	7.0	5.75	5.00	3.5	3.50	4.25	4.50	5.00	5.25	0.0
1966	1.5	6.00	4.00	2.5	4.75	7.00	6.75	3.50	6.00	0.0
1967	4.0	6.00	4.25	2.0	3.00	6.25	9.00	5.75	5.25	0.0
1968	5.5	10.25	5.00	6.0	4.00	8.75	9.75	5.00	4.75	0.0
1969	6.0	4.75	2.00	7.0	7.25	5.00	5.00	6.25	3.50	0.0
1970	12.5	6.50	5.75	8.5	6.25	6.00	5.00	6.25	5.25	0.0
1971	7.5	4.50	4.00	3.5	3.00	5.25	6.50	6.25	4.50	0.5
1972	9.0	4.25	4.00	2.5	4.50	5.00	3.00	4.75	6.75	2.5
1973	11.5	7.50	3.75	7.0	9.25	5.50	9.75	6.75	5.00	1.0
1974	6.5	4.25	6.50	4.0	4.25	6.00	6.25	5.50	9.00	0.0
1975	8.5	9.75	6.00	4.0	6.75	8.75	7.00	6.00	5.25	0.0
1976	10.5	6.25	3.00	10.0	4.75	5.75	7.00	6.00	4.25	2.0

Appendix table 5--Rainfall and sky cover data used in supply section of model

Crop year	Average monthly rainfall					Percent sky cover		
	Mar. Miss. ($R3M_t$)	Mar. Tex. ($R3T_t$)	Apr. Tex. ($R4T_t$)	May Tex. ($R5T_t$)	Sept. Cal. ($R4C_t$)	May Tex. ($SC5T_t$)	May-June Ark. ($SC56A_t$)	May Cal. ($SC5C_t$)
	Inches					Percent		
1950	4.595	1.625	9.820	4.040	1.135	7.7	6.65	2.1
1951	4.895	3.975	0.475	2.225	1.000	5.8	5.65	3.4
1952	4.580	1.845	5.445	4.025	1.575	5.4	3.60	2.9
1953	6.390	0.670	2.750	8.890	2.765	6.0	4.65	5.1
1954	1.835	1.710	4.110	3.935	2.955	4.9	5.00	3.5
1955	7.030	0.395	2.700	4.915	3.050	6.3	6.50	3.0
1956	3.980	2.735	2.470	2.930	1.605	5.3	5.15	4.1
1957	4.650	6.720	9.550	1.865	1.535	6.4	6.45	5.3
1958	5.975	1.235	3.065	2.265	4.165	6.6	5.45	3.4
1959	4.475	1.285	8.200	5.500	1.075	6.4	6.25	3.1
1960	4.730	0.885	2.665	0.620	1.640	5.8	5.35	4.3
1961	11.130	1.165	3.790	2.310	0.725	6.1	6.05	4.2
1962	2.535	1.140	4.350	1.550	0.385	4.8	5.70	4.2
1963	4.415	0.595	1.050	1.045	4.655	6.7	5.50	5.8
1964	6.025	2.900	1.695	3.270	0.305	6.9	5.25	3.7
1965	5.755	2.210	1.385	3.510	3.065	8.4	5.85	3.2
1966	0.510	1.635	5.990	9.725	0.640	7.9	5.25	3.4
1967	2.170	1.215	4.625	5.730	4.375	6.1	5.65	2.8
1968	4.650	2.865	5.805	10.010	0.325	6.3	6.40	3.6
1969	4.465	3.180	5.300	5.490	2.125	6.3	5.30	1.8
1970	7.370	4.635	2.370	10,385	0.215	6.6	5.20	4.0
1971	4.670	1.795	1.370	2.880	0.415	6.8	5.00	5.3
1972	4.850	2.755	5.715	6.510	1.390	5.2	4.85	3.2
1973	14.870	5.600	8.690	4.325	0.030	5.4	5.65	3.3
1974	4.770	4.060	2.480	6.665	1.290	6.4	6.00	1.9
1975	10.765	2.945	5.055	7.900	0.995	6.8	5.80	2.1
1976	7.100	3.930	3.180	4.370	1.880	5.9	5.95	2.5

Appendix table 6--Temperature data and dummy variables used in supply section of model

Crop year	Average daily temperature: July Miss. ($T7M_t$)	July-Aug. Tex. ($T78T_t$)	May-June La. ($T56L_t$)	June-July Ark. ($T67A_t$)	July-Aug. Ark. ($T78A_t$)	June Cal. ($T6C_t$)	Dummy variables: ($D50_t$)	($D54_t$)	($D57_t$)	($D68_t$)	($D71_t$)	($D74_t$)
	Degrees											
1950	78.90	83.375	78.275	79.025	78.725	69.85	1	0	0	0	0	0
1951	81.95	86.750	73.300	79.700	82.075	71.45	0	0	0	0	0	0
1952	84.10	84.900	78.025	84.975	83.850	66.30	0	0	0	0	0	0
1953	81.90	83.975	81.200	83.400	81.850	67.70	0	0	0	0	0	0
1954	85.20	85.625	76.450	84.650	87.275	69.90	0	1	0	0	0	0
1955	82.05	83.475	77.775	79.425	82.825	70.30	0	0	0	0	0	0
1956	82.75	85.075	78.275	80.675	83.425	72.65	0	0	0	0	0	0
1957	81.25	84.725	78.475	81.025	81.350	75.70	0	0	1	0	0	0
1958	80.50	85.150	79.750	80.250	81.650	71.65	0	0	1	0	0	0
1959	80.75	82.425	78.625	79.100	81.225	75.40	0	0	0	0	0	0
1960	82.70	83.225	77.275	79.875	81.950	77.70	0	0	0	0	0	0
1961	79.20	81.825	76.375	78.200	79.650	76.90	0	0	0	0	0	0
1962	83.35	85.450	77.575	79.800	82.175	72.70	0	0	0	0	0	0
1963	80.25	84.000	78.400	82.025	82.650	71.50	0	0	0	0	0	0
1964	81.50	84.050	77.375	82.725	82.475	70.60	0	0	0	0	0	0
1965	81.85	83.675	77.575	81.025	82.525	68.75	0	0	0	0	0	0
1966	83.60	83.750	77.100	81.025	80.750	73.65	0	0	0	0	0	0
1967	78.55	81.425	77.550	78.425	76.925	70.65	0	0	0	0	0	0
1968	80.45	82.750	77.150	79.050	80.250	75.05	0	0	0	1	0	0
1969	83.45	84.725	76.650	81.450	81.925	70.65	0	0	0	1	0	0
1970	80.95	84.500	76.500	79.250	80.475	73.10	0	0	0	0	0	0
1971	81.15	81.600	77.350	80.625	79.625	71.35	0	0	0	0	1	0
1972	80.10	81.175	77.400	79.875	80.750	74.05	0	0	0	0	0	0
1973	82.75	81.700	76.475	80.150	80.875	75.70	0	0	0	0	0	0
1974	82.10	82.275	77.300	78.750	80.825	71.85	0	0	0	0	0	1
1975	82.15	81.400	77.575	79.600	80.500	72.50	0	0	0	0	0	0
1976	80.95	81.975	74.950	78.100	80.000	72.50	0	0	0	0	0	0

Appendix table 7--Data used in the demand section of the model

T	PI	QCP_{T-1}	QCG_{T-1}	D59	QP	QER_{T-1}	QS	QP1	GP	QH_{T-1}	PR_{T-1}	R	YI	POP	PC	$(QB/POP)_{T-1}$	PG	PS	LU	PB_{T-1}	QWP/POP	QWE	QWW/POP	PE_{T-1}	P_{T-1}
1950	111	3010	459	0	38820	696	42833	1	0	7173	18	1.00	33.00	152.30	1.52	2.19	4.56	.00	76.60	4.85	67.40	4.10	67.40	10.25	8.37
1951	130	4124	395	0	46089	469	50997	1	0	6290	17	1.00	36.40	154.90	1.66	2.21	5.00	.00	76.30	6.95	68.40	5.00	67.90	11.10	9.49
1952	134	1813	227	0	48193	471	50476	1	0	6907	18	1.00	38.20	157.60	1.52	2.19	5.04	.00	72.70	6.65	71.80	5.10	79.60	12.00	10.23
1953	118	1507	8	0	52834	672	54639	1	0	8089	18	1.00	39.70	160.20	1.48	2.01	4.84	.00	72.00	7.50	76.50	4.40	77.60	14.00	11.87
1954	117	6346	1200	0	64193	847	71784	1	0	9447	20	1.00	39.30	163.00	1.43	1.98	4.92	.00	73.70	6.60	73.10	4.60	72.90	10.50	8.78
1955	105	8255	18445	0	55902	706	82737	1	0	10624	20	.66	41.40	166.00	1.35	2.38	4.66	.00	74.50	3.90	77.50	5.50	75.90	11.10	6.90
1956	105	7244	27374	0	49459	401	84345	1	0	8312	21	.57	43.60	168.90	1.29	2.52	4.57	.00	72.90	5.15	79.70	6.60	81.70	9.90	6.40
1957	95	7401	12555	0	42935	346	63055	1	0	9696	19	.51	45.20	172.00	1.11	2.10	4.72	.00	71.40	6.40	76.70	6.30	78.30	10.85	6.22
1958	89	6157	12012	0	44760	280	63045	0	1	8430	19	.51	45.70	174.80	1.12	1.95	4.48	2.08	73.90	6.20	82.50	6.60	88.10	10.50	6.87
1959	90	6214	9455	1	53647	327	69866	0	1	8424	21	.57	47.80	177.80	1.05	1.88	4.38	3.22	73.20	4.75	77.90	6.70	82.90	8.07	6.47
1960	87	5277	6867	1	54591	385	66938	0	1	9236	21	.57	49.00	180.70	1.00	1.96	4.42	2.90	73.80	5.30	77.50	6.40	80.00	6.28	5.53
1961	87	5948	4132	1	54198	379	64552	0	1	9392	21	.57	50.10	183.70	1.10	1.93	4.71	2.64	74.80	5.20	78.30	6.50	74.20	6.80	6.43
1962	89	5015	314	1	66045	79	71401	0	1	9605	21	.63	52.40	186.50	1.12	1.82	4.71	2.21	76.70	5.35	77.80	7.10	82.20	7.81	7.04
1963	95	5870	1860	1	70269	143	78012	0	1	10833	21	.63	54.20	189.20	1.11	1.56	4.71	2.53	76.00	5.10	79.80	8.00	86.40	7.94	6.93
1964	96	6104	1435	1	73166	105	81043	0	1	11610	22	.64	57.20	191.90	1.17	1.46	4.71	2.69	74.30	5.10	83.20	8.00	85.00	7.97	6.91
1965	100	6633	1044	1	76281	126	84440	0	1	12125	22	.64	61.20	194.30	1.16	1.61	4.50	1.84	74.40	5.10	79.10	7.60	80.20	7.46	6.23
1966	104	7618	621	1	85020	169	93265	0	1	12451	22	.70	65.90	196.60	1.24	1.75	4.50	.86	77.20	5.10	78.10	7.40	92.00	8.31	7.09
1967	100	8279	232	1	89379	160	97895	0	1	12952	22	.70	69.90	198.70	1.03	1.95	4.55	.00	77.10	5.10	83.20	6.90	86.90	9.04	8.61
1968	91	6698	86	1	104142	206	110934	0	1	14516	22	.84	75.60	200.70	1.08	1.99	4.60	.64	78.40	5.28	82.90	6.80	94.30	10.25	10.48
1969	96	9886	6325	1	91904	67	108273	0	1	13966	22	.76	81.50	202.70	1.16	2.10	4.72	.93	78.60	5.30	84.40	7.50	87.30	9.36	8.81
1970	101	10029	6417	1	83805	193	101315	0	1	14395	23	.65	86.70	204.90	1.33	2.51	4.86	1.21	80.00	5.30	85.90	7.90	87.30	9.07	7.67
1971	106	9167	9467	1	85768	140	105205	0	1	11736	24	.65	91.90	207.10	1.08	2.44	5.07	2.35	80.20	5.30	84.90	8.10	94.50	8.89	6.33
1972	105	8687	2747	1	85439	62	97254	0	1	14196	24	.65	100.00	208.80	1.57	2.61	5.27	1.91	79.40	5.48	80.40	8.20	91.40	7.90	6.39
1973	162	4991	148	1	92765	16	98021	0	0	14224	25	.77	110.80	210.40	2.55	2.67	6.07	.00	78.50	5.80	84.70	7.70	96.20	15.34	12.97
1974	242	7842	0	1	112394	6	120259	0	0	14511	46	1.00	120.60	211.90	3.03	2.79	7.54	.00	69.80	8.43	84.80	7.60	91.40	31.50	26.25
1975	230	7053	4	1	127624	10	134712	0	0	18141	49	1.00	129.60	213.60	2.55	2.84	8.52	.00	73.30	9.43	88.50	7.40	88.00	22.25	19.92

Appendix table 8--Data for the endogenous variables, demand section

T	QFE	QSE	QFD	QB	QEC	QEG	QER	QCP	QCG	QH	QM	QD	PW	PR	PBR	PB	PF	PE	PT
1950	3892	2295	12010	3367	8139	897	469	4124	395	6290	35400	42221	11.10	17.00	39.15	6.95	5.09	11.10	9.49
1951	4746	2340	12130	3395	13350	3583	471	1813	227	6907	43200	48812	12.00	18.00	45.75	6.65	4.82	12.00	10.23
1952	5188	2575	11951	3165	14657	2065	672	1507	8	8089	45700	49983	14.00	18.00	46.00	7.50	5.87	14.00	11.87
1953	5342	3103	12237	3170	13926	1272	847	6346	1200	9447	48500	56470	10.50	20.00	35.35	6.60	5.19	10.50	8.78
1954	5892	2222	12657	3882	8928	463	706	8255	18445	10624	53600	72255	10.10	20.00	34.80	3.90	4.57	11.10	6.90
1955	4620	1988	13293	4176	6157	5899	401	7244	27374	8312	42200	79587	9.90	21.00	34.80	5.15	4.81	9.90	6.40
1956	5536	1735	13417	3549	4638	20999	346	7401	12555	9696	50400	80081	10.85	19.00	35.50	6.40	4.86	10.85	6.22
1957	4804	1849	13311	3348	6063	6691	280	6157	12012	8430	43700	62843	10.50	19.00	28.90	6.20	5.11	10.50	6.87
1958	4840	2071	13608	3278	6867	6661	327	6214	9455	8424	43700	61236	10.15	21.00	35.05	4.75	4.68	8.07	6.47
1959	5446	2092	13910	3488	7726	12601	385	5277	6867	9236	49500	67634	9.50	21.00	33.60	5.30	4.59	6.28	5.53
1960	5726	2119	14923	3482	6459	14184	379	5948	4132	9392	52000	65936	9.70	21.00	33.60	5.20	4.55	6.80	6.43
1961	6094	2350	15182	3338	11701	9134	79	5015	314	9605	55400	63767	10.45	21.00	35.60	5.35	5.14	7.81	7.04
1962	6678	2383	15863	2911	11424	13766	143	5870	1860	10833	60800	71163	10.15	21.00	34.05	5.10	5.04	7.94	6.93
1963	7508	2458	16315	2767	16232	13788	105	6104	1435	11610	68300	78165	10.50	22.00	33.00	5.10	5.01	7.97	6.91
1964	7808	2464	16851	3095	17934	12555	126	6633	1044	12125	71000	81276	10.15	22.00	33.95	5.10	4.90	7.46	6.23
1965	7766	2702	17276	3391	19487	11648	169	7618	621	12451	70600	82755	10.15	22.00	37.70	5.10	4.93	8.31	7.09
1966	8876	2688	17507	3828	21471	15961	160	8279	232	12952	80200	91882	9.90	22.00	42.10	5.10	4.95	9.04	8.61
1967	9520	3235	18449	3952	25133	16082	206	6698	86	14516	88100	97612	10.25	22.00	38.25	5.28	4.97	10.25	10.48
1968	9880	2932	18302	4215	18708	22292	67	9886	6325	13966	89100	107998	10.00	22.00	29.85	5.30	5.00	9.36	8.81
1969	9800	2510	18379	5089	17863	22957	193	10029	6417	14395	86500	106247	10.00	23.00	33.10	5.30	4.95	9.07	7.67
1970	8720	2531	18335	5000	13052	21044	140	9167	9467	11736	77300	99271	10.10	24.00	43.20	5.30	5.17	8.89	6.33
1971	9580	2500	18433	5407	11624	29979	62	8687	2747	14196	87900	103379	10.25	24.00	31.95	5.48	5.34	7.90	6.39
1972	8840	3032	18558	5585	18324	21100	16	4991	148	14224	85400	94547	17.25	25.00	50.90	5.80	6.73	15.34	12.97
1973	9340	3069	19225	5875	22934	12911	6	7842	1	14511	85400	95277	31.50	46.00	70.50	8.43	13.80	31.50	26.25
1974	11520	4003	19562	6015	31949	18065	10	7053	4	18141	105600	117358	22.25	49.00	74.10	9.43	11.20	22.25	19.92
1975	11000	3400	20356	6391	25067	14716	10	17737	19143	17378	95800	134411	16.40	45.00	74.02	8.13	8.34	16.40	13.74

Appendix table 9--Derived reduced-form equations, demand section

Endogenous variable	X°	PI	R	QCP_{T-1}	QCG_{T-1}	T	YI	059	POP	PC	$(QB/POP)_{T-1}$	QP	QER_{T-1}	PG
QFE	-1092.4105	1.8590	.0000	.0883	.0883	-.5725	5.2016	142.2430	14.9938	100.0391	194.9863	.0629	.0000	.0000
QSE	-203.8019	.0000	478.5009	-.0220	-.0220	40.9379	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
QFO	-1924.7353	.0000	.0000	.0000	.0000	-4.0643	31.6126	1009.8204	84.7226	.0000	.0000	.0000	.0000	.0000
QB	-3806.6924	.0000	.0000	.0000	.0000	.0000	5.3148	.0000	21.7222	710.2037	1384.2593	.0000	.0000	.0000
QEC	1693.4745	.0000	.0000	-.2607	-.2607	.0000	.0000	.0000	.0000	.0000	.0000	.2300	.0000	.0000
QEG	-6032.2741	.0000	.0000	.8872	.8872	.0000	.0000	.0000	.0000	.0000	.0000	.2168	.0000	.0000
QER	58.5938	.0000	.0000	.0000	.0000	-.2375	.0000	.0000	.0000	.0000	.0000	.0000	.7833	.0000
QCP	-2145.2864	.0000	.0000	.0000	.0000	-26.7121	.0000	.0000	.0000	.0000	.0000	.0000	.0000	687.5170
QCG	1983.5256	.0000	.0000	.0000	.0000	-109.7648	.0000	.0000	.0000	.0000	.0000	.0000	.0000	2825.1307
QH	-15.6467	.0000	.0000	.0853	.0853	-.5536	5.0295	137.5375	14.4978	96.7297	188.5361	.0609	.0000	.0000
QM	-11178.2844	1.8590	.0000	.8001	.8001	-5.1904	47.1585	1289.6009	135.9364	906.9725	1767.7817	.5706	.0000	.0000
QD	-11485.2533	1.8590	478.5009	.7781	.7781	-100.9669	47.1585	1289.6009	135.9364	906.9725	1767.7817	.5706	.7833	3512.6477
PW	8.6798	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
PR	-2.0831	.0000	.0000	.0000	.0000	.1400	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
PBR	-39.4587	.2453	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
PB	3.1011	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
PF	1.4820	.0000	.0000	.0000	.0000	.0445	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
PE	8.6798	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
PT	8.9553	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0C00	.0000	.0000	.0000	.0000	.0000

Continued--

Appendix table 9--Derived reduced-form equations, demand section--Continued

Endogenous variable	QS	GP1	GP	QH_{T-1}	PS	PR_{T-1}	LU	PB_{T-1}	QWP/POPW	QWE	QWW/POPW	PE_{T-1}	PT_{T-1}
QFE	.0000	23.9305	.0000	.0410	-13.7444	-2.5255	-4.8248	-8.9953	-52.7480	152.9737	27782.3264	-338.0673	397.5398
QSE	.0000	.0000	.0000	.0000	25.6320	.0000	.0000	.0000	-6.4003	-18.6114	5782.0753	19.6034	.0000
QFD	.0000	.0000	.0000	.0000	-25/7126	-17.9294	.000	.0000	6.4204	18.6699	-5800.2514	-19.6650	.0000
QB	.0000	169.8889	.0000	.0000	-30.9324	.0000	.0000	-63.8599	7.7238	22.4600	-6977.7402	-23.6571	.0000
QEC	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	-29.9264	76.1711	16450.8971	-174.4850	211.7647
QEG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	-368.9098	938.9800	202794.1724	-2150.9186	2610.4751
QER	.0000	.0000	.0000	.0000	-2.2258	.0000	.0000	.0000	.5558	1.6161	-502.0900	-1.7023	.0000
QCP	.0999	-1223.8765	-1066.6358	.0000	-250.3735	.0000	.0000	.0000	115.5541	46.8048	-85633.7833	117.7386	-375.2918
QCG	.0000	-9576.4981	-8346.1331	.0000	-1028.8295	.0000	.0000	.0000	671.8899	-309.2371	-460209.3425	1632.7461	-2936.5557
QH	.0000	23.1389	.0000	.3308	-7.7150	-2.4420	.0000	-8.6977	-52.3950	143.8655	28120.8160	-322.6204	384.3891
QM	.0000	216.9583	.0000	.3718	-78.1044	-22.8969	-4.8248	-81.5529	-489.8350	1353.1202	262370.2203	-3029.4134	3604.1687
QD	.0999	-10583.4163	-9412.7689	.3718	-1333.9012	-22.8969	-4.8248	-81.5529	291.7646	1073.6927	-278192.9202	-1261.0276	292.3212
PW	.0000	.0000	.0000	.0000	1.0000	.0000	.0000	.0000	-.2497	-.7261	225.5803	.7648	.0000
PR	.0000	.0000	.0000	.0000	.8857	.6176	.0000	.0000	-.2212	-.6431	199.7965	.6774	.0000
PBR	.0000	.0000	.0000	.0000	.7840	.0000	.6561	.0000	-.1958	-.5693	176.8550	.5996	.0000
PB	.0000	.0000	.0000	.0000	.1814	.0000	.0000	.3745	-.0453	-.1317	40.9203	.1387	.0000
PF	.0000	.0000	.0000	.0000	.4171	.0000	.0000	.0000	-.1041	-.3029	94.0895	.3190	.0000
PE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	-.2497	-.7261	225.5803	.7648	.0000
PT	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	-.3153	-.3247	246.4363	.0000	.7684

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