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POTENTIAL EFFECT OF DECOUPLING ON THE U.S. RICE INDUSTRY

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ABSTRACT

The potential impact of decoupling on the U.S. rice industry is considered using an economic model based on data for the period 1972-87. Supply and demand equations are fitted based on a recursive system of OLS regression equation and a SURE model. Supply equations for California, Texas, and all other producing areas are estimated. Short-run elasticities of supply and demand for this study are compared with those obtained from other studies considering earlier time periods. The substantial difficulties of introducing decoupling for rice either unilaterally or multilaterally are discussed.

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Introduction

"Decoupling" is a policy proposal for agriculture designed to separate decisions on the production of individual crops from past acreages produced. Transitional income support is to be provided by the government in a period of years while a shift toward a market economy is achieved. Such a scheme was first proposed by Senators Rudy Boschwitz of Minnesota and David Boren of Oklahoma through debate over the Food Security Act of 1985. The U.S. Government also proposed worldwide decoupling at the Uruguay Round of the GATT negotiations in 1987. Under the decoupling program, it is expected that there would be no acreage restrictions, a producer would sell his crop at the market price, and there would be price supports and government intervention only at a very low level to avert price collapse. In return for giving up target prices, the producer would receive transition payments, whether he planted or did not plant a crop. The transition payments would be scaled down annually over a period of years.

Objective:

The overall objective of this study is to assess the potential impacts of instituting a policy of decoupling on supply and demand for U.S. rice. If decoupling were in effect, it would change the decision rules and policy regime. To analyze a policy change, as Lucas suggests, an economist can not use an empirical model based merely on the present regime but should build a model that will allow inferences to be drawn about how economic agents will behave as their environment changes. Nevertheless, this study first estimates supply and demand relationships of U.S. rice and then considers alternative analyses of what might happen if decoupling were introduced in the U.S. rice industry. Specifically, this study seeks to:

1. Identify factors affecting supply and demand for U.S. rice.

2. Assess changes in rice production to be brought about by a change in income support policy.

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3. Estimate changes in domestic rice consumption and exports in response to changes in the market price of rice that would occur under the decoupling.

4. Examine the feasibility of introducing decoupling in the U.S. rice program.

For this study, it is assumed that: (1) the size of transition payments will not be determined simply by current production, prices, or acres planted; (2) there will, however, be an upper limit on the amount of payments per person related to past acreage or actual production; and (3) given these payments, decisions by individual farmers about what and how much to plant will be guided by market prices and costs of production rather than past acreage history.

Organization of the Report

As a basis for understanding the recent performance of the rice sector in the United States, an economic model is developed specifying supply and demand functions for rice. This model draws on the experience and results obtained by others (Brorsen, et. al.; Grant and Leath; Grant, Beach and Lin; Houck and Ryan; Kincannon; Nakagawa). It concentrates on a much more recent time period, 1972-87 and examines regional differences in supply explicitly in the model. Data sources are considered and the models fitted by OLS and SURE procedures. The statistical results are reviewed and compared with results obtained by other research workers. Elasticities are calculated and reviewed.

The results from the statistical model are projected forward to consider what might happen: (1) if the United States unilaterally proceeded with decoupling; (2) if multilateral decoupling occurred over time; and (3) if multilateral decoupling occurred and some kind of crop disaster developed as well. An overview of the likelihood of decoupling for a commodity like rice concludes the report.

MODEL SPECIFICATION OF SUPPLY AND DEMAND FUNCTIONS FOR U.S. RICE

To examine the effects of possible changes in the rice industry, an economic model, based on theory and knowledge of economic and institutional characteristics of the industry, is developed. A statistical model for the supply and demand sections of the economic model is estimated, and the statistical model is interpreted and applied to current conditions. The results are used to assess the probable impacts of alternative public policies on the U.S. rice industry in the following section.

The Economic Model

The supply section of the model is considered to be predetermined because supplies available during a particular marketing year are known and fixed at the beginning of the marketing year. In the supply section, three recursive systems of equations are constructed separately for California, Texas, and the remaining southern states (Arkansas, Louisiana, Mississippi, and Missouri). The demand section includes relationships for domestic use, exports, and ending stocks.

The economic model specified for U.S. rice in this study is presented below.

The Economic Model

Supply Section

1. $AHCA_t = f\ (PFECA,\ COPCA_{t-1},\ AHCA_{t-1},\ QESW_{t-1})$
2. $AHTX_t = f\ (PFETX,\ COPTX_{t-1},\ AHTX_{t-1},\ QESW_{t-1})$
3. $AHRS_t = f\ (PFERS,\ COPRS_{t-1},\ AHRS_{t-1},\ QESW_{t-1})$
4. $YCA_t = f\ (AHCA_t,\ COPCA_t)$
5. $YTX_t = f\ (AHTX_t,\ COPTX_t)$
6. $YRS_t = f\ (AHRS_t,\ COPRS_t)$
7. $QP_t = (YCA_t \times AHCA_t) + (YTX_t \times AHTX_t) + (YRS_t \times AHRS_t)$
8. $QS_t = QP_t + QES_{t-1}$

Demand Section

9. $QDOM_t = f\ (PF_t,\ PC_t,\ PW_t,\ YPC_{t-1}) \times POP_t$
10. $QEXP_t = f\ ((PUS/PT)_t,\ QS_t,\ QGEXP_t,\ QESW_t)$
11. $QES_t = f\ ((PF/PG)_t,\ (PUS/PT)_t,\ QS_t)$
12. $QD_t = QDOM_t + QEXP_t + (QES_t - QES_{t-1})$

In these relations, equations 7, 8, and 12 are identities.

Model Variables

Supply Section -- Endogenous Variables

$AHCA_t$ = 1,000 acres of rice harvested, California
$AHTX_t$ = 1,000 acres of rice harvested, Texas
$AHRS_t$ = 1,000 acres of rice harvested, the rest (Arkansas, Louisiana, Mississippi, and Missouri)
YCA_t = Average yield, California, hundredweights per acre harvested
YTX_t = Average yield, Texas, hundredweights per acre harvested
YRS_t = Average yield, the rest (Arkansas, Louisiana, Mississippi, and Missouri), hundredweights per acre harvested
QP_t = U.S. rice production, 1,000 hundredweights, rough rice
QS_t = Total U.S. rice supply, 1,000 hundredweights, rough rice

Model Variables (Continued)

Supply Section -- Exogenous Variables

$COPCA_t$ = Variable costs of production, California, dollars per acre
$COPTX_t$ = Variable costs of production, Texas, dollars per acre
$COPRS_t$ = Variable costs of production, the rest (Arkansas, Louisiana, Mississippi, and Missouri), dollars per acre
$PFECA_t$ = Expected farm price of rice (farm price lagged one year, the loan rate of the crop year; or the target price, whichever is the greatest), California, dollars per hundredweight, rough rice
$PFETX_t$ = Expected farm price of rice, Texas, dollars per hundredweight, rough rice
$PFERS_t$ = Expected farm price of rice, the rest (Arkansas, Louisiana, Mississippi, and Missouri) dollars per hundredweight, rough rice
QES_t = Ending stocks of rice, 1,000 hundredweights, rough rice
$QESW_t$ = World ending stocks of rice, 1,000 hundredweights, rough rice

Demand Section -- Endogenous Variables

$QDOM_t$ = Quantity of domestic rice use, 1,000 hundredweights, rough rice
$QEXP_t$ = Quantity of rice exported, 1,000 hundredweights, rough rice equivalent QES_t = Ending stocks of rice, 1,000 hundredweights, rough rice
QD_t = Total U.S. rice demand, 1,000 hundredweights, rough equivalent

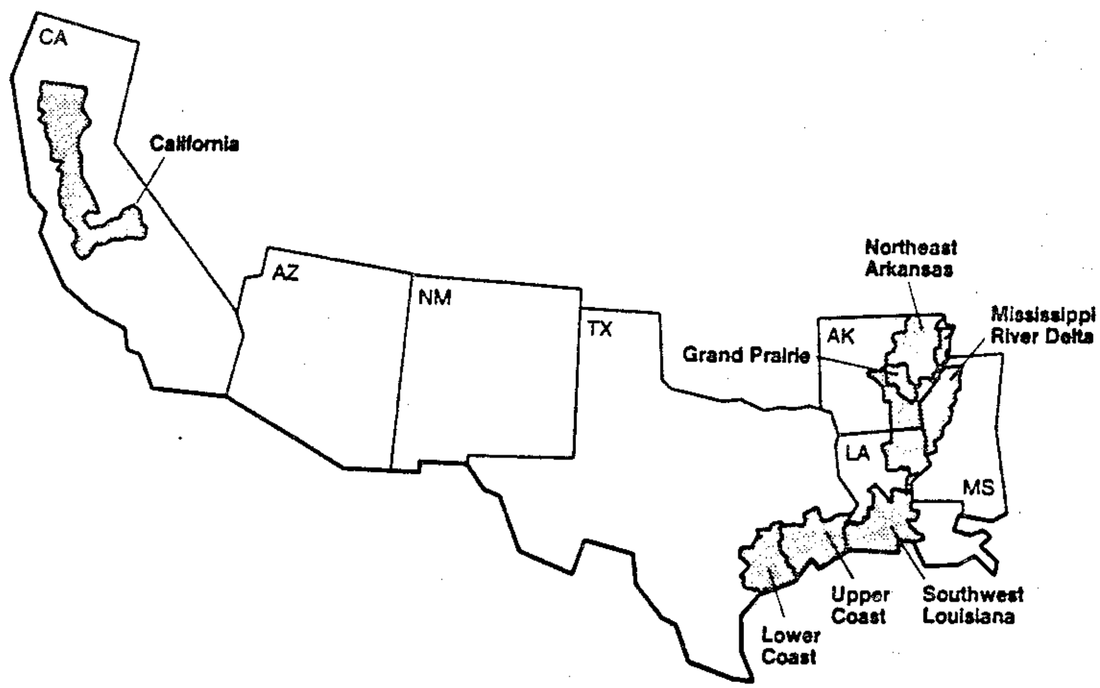
Demand Section -- Exogenous Variables

PC_t = Average price received by farmers for corn, dollars per bushel
PF_t = U.S. farm price of rice, dollars per hundredweight, rough rice
PG_t = Loan rate for rice, dollars per hundredweight, rough rice
POP_t = U.S. midyear population, 100,000
PT_t = Thailand export price, 100 percent 2nd grade, f.o.b. Bangkok, dollars per hundredweights, milled rice
PUS_t = U.S. export price, U.S. No.2 long grain, f.o.b. mill, Houston dollars per hundredweight
PW_t = Average price received by farmers for wheat, dollars per bushel
$QESW_t$ = World ending stocks of rice, 1,000 hundredweights, rough rice
$QGEXP_t$ = Quantity of government-assisted rice exports, 1,000 hundredweights, rough rice
QS_t = Total U.S. rice supply, 1,000 hundredweights, rough rice
YPC_t = Per capita U.S. disposable personal income, dollar

Supply Section

The supply section of the model is composed of three independent recursive submodels that contain harvested acreage and yield equations for each of two major rice producing states and one region; California, Texas, and the remaining southern states (Arkansas, Mississippi, Missouri, and Louisiana). (Figure 1.)

FIGURE 1. MAJOR U.S. RICE AREAS



Source: Dismukes, Robert. U.S. Rice Farms: A Regional Comparison, ERS Staff Report AGES880119, ERS, USDA, February 1988.

Farm structure and operating characteristics of rice farms in California and Texas separate production in these two states from the other rice producing states. Moreover, previous studies suggest that Texas has the highest per unit production costs as well as highest yields of any southern state, while Louisiana has typically the lowest yields of all states and considerably lower production costs than Texas. California, which produces the bulk of the U.S. medium and short grain rice and plants long grain in only a small portion of total rice acreage, has the highest total costs per planted acre but substantially higher yields offset higher production costs. For these reasons, this study estimates three separate equations for the supply section; California, Texas, and the remaining southern states.

Production is equal to harvested acreage times yield, with U.S. production a summation of the individual state/region's production. Therefore, equations are formulated separately for acreage harvested and yield. A farmer would decide how much to plant to rice in response to various factors such as the expected price of rice, government programs, the previous acreage planted, and so forth. Then he would decide how much of the acreage planted he should harvest. But, in fact, planted and harvested acreage move together with little difference in the two series. Such a tendency implies that farmers' decisions about how much to harvest is closely related to their decisions about how much to plant. Since there seems to be nothing else except planted acreage that determines harvested acreage, harvested acreage is estimated directly, rather than transformed from planted acreage, in this model.

Total quantity supplied is the sum of the quantity produced in the current year and the ending stock of the previous year. Since the quantity of rice imported into the United States during the estimation period (1972-1987) was negligible, it is not considered as a component of supply in this model.

Area Harvested

Economic theory suggests that acreage harvested is a function of the expected farm price of rice, the farm price of competing crops, input prices, the previous year's acreage harvested, the state of technology, weather and pests, and government programs (Tomek et al.). The acreage harvested also depends on the amount of stocks carried over from the preceding year.

In a supply analysis, it is important to know whether changes in output occur as a result of movements along a static supply schedule (change in quantity supplied) or because of shifts in the supply curve. If acreage is assumed solely to determine the quantity supplied, the farm price of rice affects the movement along the supply curve, while other factors shift the location and slope of the supply curve.

The area of rice planted was restricted by government programs (allotments and marketing quotas) from 1955 through 1973 to prevent large surpluses. Acreage reduction programs have been implemented as well since the 1982 crop. Rice acreage expanded dramatically in most regions with the suspension of quotas in 1974 and plummeted in 1983, when a PIK program was in effect. Therefore, it would seem logical to regard acreage harvested as a predetermined variable in the model for the period when acreage restrictions were in effect. However, since the administrators have included the economic variables considered by farmers in planting rice in the implementation of these restrictions, acreage harvested can be considered an endogenous variable over time (Jolly et al.).

Area harvested is assumed to be influenced by the price the farmer expects to receive for his crop. A rational farmer who anticipates a price above normal for his rice will expand his acreage to increase his total revenue. On the other hand, if the farmer expects a price below normal he will plant less. Farmers estimate the expected price from several sources such as the price for the previous crop, the loan rate, and the target price. In this model, the expected farm price is either the actual farm price lagged one year, or the loan rate, or the target price, whichever is the greatest.

Area planted is also hypothesized to respond to expected costs of production. Conceptually, a change in the price of a factor is treated as a supply shifter; an increase in factor prices, other variables constant, shifts the cost curves of each farm, and hence the supply curve, to the left, and vice versa. If a farmer anticipates higher input prices in relation to the expected price of rice, he will reduce the acreage to be planted. A common practice is to include the ratio of the price of output to the price of a principal input. But a farmer will plant less if his capital resources available at the planting time are limited, even when the two prices rise proportionally. Also, in statistical analyses of supply, using separate variables for these prices sometimes yield more satisfactory results than using the price ratio as a single explanatory variable (Tomek, et. al.). In this model, therefore, variable costs of production per acre in the previous year is included separately from the expected farm price of rice.

The rice acreage planted by a farmer in the current year is influenced by his previous planting decisions. A farmer can develop a preference for growing rice because of natural disposition, already acquired knowledge and skill, or because of constraints brought about by soil quality and/or available water for irrigation. Rice farmers tend to have a lagged response due to fixity of resource stocks (such as land and machinery), government programs, risk aversion, and constraints of their management capacity (Grant et al. 1984). Thus, it takes more than one season for full adjustments to occur.

A large ending stock of rice usually has a negative impact on acreage planted. A large ending stock in a given year indicates that the quantity supplied is greater than the total quantity demanded in the year. It also transmits a signal to the farmers that they should plant less so as not to create a glut on the market which will further lead to a lower price for their crop. World ending stocks, rather than domestic ending stocks, in the preceding market year are included in the initial model.

The prices of other crops competing for the same production resources, such as soybeans and cotton, may influence acreage of rice planted. A high price of soybeans relative to that of rice means that more soybeans and less rice will be planted if they are true substitutes. However, these crops have little substitutability because of the relative economic advantage of producing rice under the present government program. Grant, et. al. (1984), demonstrated that the farm prices of these crops had no effect on rice production. Therefore, the prices of alternative crops are not included in the economic model.

Improvements in technology are important causes of long-term shifts in rice supply functions. Such improvement may include not only the development of high-yielding varieties which increases yields but also mechanization which makes it possible to plant and harvest more with a fixed amount of labor. The effects of these changes are well-known, but it is often difficult to directly measure "changes in technology." The most common proxy is a trend variable. However, since the specification of the trend variable would appear to be inconsistent with the actual trend in the acreage of rice harvested, the concept "changes in technology" was omitted from the acreage model.

Acreage harvested is also influenced by "unusual" weather and insect or disease damage. However, since these effects are generally treated as random shifts in the supply function, they are incorporated in the random disturbance term of the equations.

Yields

In contrast to acreage planted and harvested, yields may be influenced by factors over which farmers have little or no control (moisture, temperature, pests, etc.). Some factors, like level of fertility, can be controlled, but yield equations are typically difficult to specify, and they frequently exhibit strong underlying trends (Tomek, et. al.).

Changes in technology such as development of high-yielding varieties and better methods of pest control seem to be the dominant factor in explaining improvement in yields. In California, short-stemmed, high-yielding varieties of short and medium grain rice were released in 1978, and again in 1984 (Daddow). In the southern states, high-yielding varieties of long grain rice were released mainly in 1983-1984 (Moldenhauer, et. al.). Other factors thought to be related to technology could be represented by trend variables.

Farmers pay more for new, high-yielding varieties, which often require intensive management and raise production costs per acre. Therefore, the initial model includes variable costs of production, rather than some dummy variables and/or trend variables that represent changes in technology.

Yields are also influenced by the acreage harvested. As more land area is brought into rice production, the yield per acre is expected to decrease. Thus, acreage harvested is expected to have a negative impact on yields.

Economic theory suggests that yields are influenced by the expected price for rice. When farmers anticipate a higher price for their crop, they seem to use more fertilizers and pesticides and to intensify overall crop care to improve yields (so as to gain higher profits). However, previous studies have found no significant effects of farm prices on rice yields (Grant, et. al., 1984; Jolly, et. al., Kincannon, and Nakagawa). Grant, et. al. (1984), explain this by arguing that price variations which were too small to have a statistically significant impact on yields. Expected price is not included in the initial model, though price effects are evaluated in estimating the equations.

Demand Section

The demand section of the model considers domestic use, exports, and ending stocks of U.S. rice. Total demand is the sum of quantities of domestic use, exports, and a change in ending stocks. Though the demand for U.S. rice is largely at the consumption level, this model is concerned with demand at the farm level. Hence, all quantities and prices of rice are expressed on a rough rice basis, except for the U.S. and Thai export prices of rice, which are on a milled rice basis. They are included in the model expressed as a ratio in order to avoid multicollinearity problems.

The primary interest of this study is in estimating how changes in the price of rice have affected the quantity demanded for U.S. rice. Hence, quantity is a dependent variable in the following demand equations while the price of rice as well as other factors are specified as causal variables.

Domestic Use

Domestic use of U.S. rice is the sum of direct human consumption, rice for manufacturing, especially brewing, seed required for farm production, and residual uses including losses.

The quantity demanded for rice is influenced by its own price. Demand theory suggests an inverse relationship between price and the quantity consumers are willing and able to buy, other factors remaining constant: when the price of rice falls (rises), the quantity demanded for rice rises (falls). U.S. rice prices have been heavily influenced by government programs since the 1930s. However, the rapid increases in rice prices in 1972 and a change in the rice program have made domestic price levels, particularly for consumers, more market oriented. It is, therefore, expected that the quantity of rice demanded is inversely related to the price of rice.

While changes in quantity demanded are shown by movements along a demand curve, changes in demand are represented by shifts in the level of the demand curve. The major factors influencing the level of demand are categorized into four groups: (1) consumer income and its distribution, (2) population size and its distribution by age, geographic area, etc., (3) prices and availability of substitutes and/or complements, and (4) consumer tastes and preferences (Tomek, et. al.).

For most commodities, an increase in income has a positive effect on the amount purchased. This suggests that a higher level of income, prices remaining constant, leads consumers to buy more rice. Previous studies have demonstrated that the level of income is even more important than price in determining domestic demand for rice (Grant, et. al. 1979 and 1984, and Mehren). Disposable personal income of the United States is used as a measure of income in this analysis.

Changes in population have a direct influence on market demand relations. Average per capita rice consumption for direct food use shows a tendency to increase. It is, therefore, expected that as population increases more rice is demanded. Previous studies indicate that population and income are the major variables affecting rice consumption (Grant, et. al. 1984 and Jolly, et. al.). Because income and population are often highly correlated, the population variable is taken into account by putting the quantity and income variables on a per capita basis.

In the United States, changes in the distribution of the population, especially by ethnic origin and region, may have an important impact on demand for rice. Increases in the Asian and Hispanic segment of the U.S. population have contributed to greater domestic rice consumption. Due most probably to such increases in ethnic populations and their influences on tastes of other Americans, milled rice shipments to the South Atlantic and Pacific regions have increased (Childs). Though regional differences in rice consumption are recognized, it is difficult to measure the ethnic factors affecting domestic rice consumption using national data because there is no data series available representing the ethnic distribution of the population.

Changes in prices of such substitutes as potatoes, corn, and wheat products have been shown to have no appreciable effect on rice consumption over the period 1950-1975 (Grant, et. al., 1979). However, the forms in which rice is available on the market have been increasing rapidly. In recent years, more rice is used in processed foods such as breakfast cereals and package mixes, as convenience rice, and in restaurants. This indicates that rice competes with other cereals and carbohydrate foods of similar quality for the consumer's dollar. In fact, a more recent analysis has found a substitution relationship between wheat flour and rice (Huang). For brewers' use, rice competes with corn grits in the United States. Since the variables measuring the influence of these substitutes are often highly correlated, the prices of wheat, which represents major substitutes for food use, and corn are included in this model. The prices of these commodities are expected to have a positive effect on the quantity of rice demanded.

Changes in tastes and preferences influence demand. American consumers have shown a change in tastes towards more grain based food, and this is regarded as one of the major reasons for the rapid increase in U.S. consumption of rice. But, since there is no direct measure of tastes and preferences, such changes are difficult to handle in statistical demand analyses. The most common proxy variable is a linear trend. For this study, however, it is reasonable to assume that there have been no major changes in tastes and preferences during the period analyzed, 1972-87, because a large part of demand for staples such as rice is considered habitual and rather persistent over time.

Consumer habits of eating rice, which develop as a consequence of past behavior, would require a transitional period for one to change from rice to another commodity. Some economists explain a lagged response of consumers by such factors as costs of adjustment and tastes affected by previous consumption experience (Deaton, et. al.). Previous consumption of a person will determine the amount of rice he demands. Therefore, the quantity of domestic rice use lagged one year is included as an independent variable in this model.

Exports

The quantity of rice demanded in the export market is dependent on the U.S. export price of rice, the Thai export price of rice, the quantity of rice supplied in the United States, the world ending stocks of rice, and several other international factors. These may include the production of rice in rice importing as well as exporting countries, the income level of these countries, and the world population. U.S. rice exports are also influenced by government-assisted exports, since a large part of U.S. rice export sales have been made under government programs.

As the U.S. export price of rice rises, other things being equal, the quantity of U.S. rice demanded by importing countries will decrease. This is mainly because of a relative price change: the prices of rice supplied by other exporting countries, as well as of substitute grains, become relatively lower. Among these factors, the Thai export price of rice is considered the most important in determining the quantity of U.S. exports.

The quantity of rice supplied in the domestic market also influences export demand. As rice supply increases, more rice will be exported through private promotional activities as well as government programs. This is due largely to the relatively stable demand for rice in the domestic market in comparison to export demand. Thus, an increase in the quantity supplied is expected to have a positive effect on the quantity of rice exported. International conditions affect the amount of rice demanded by rice importing countries. Domestic rice consumption in many rice importing countries has fluctuated over time due to weather and other factors. Without irrigation facilities, a moderately serious weather problem in just a few countries can lead to a significant increase in import demand in the world rice market.

In order to measure an impact of the world rice market situation on U.S. rice exports, the world ending stock is included as an independent variable. It is expected that a large world ending stock has a negative effect on U.S. rice exports.

Grant, et. al. (1984), have demonstrated that the quantity exported under government programs was negatively related to the demand for commercial exports. This is because the quantity exported under government programs tends to be increased when commercial sales are stagnated. But if commercial sales decline due to the increased government-assisted exports and offset the increase, the total quantity remains unchanged. Nevertheless, the quantity exported under government programs is included in the model, in the expectation that it has a negative impact on the total quantity of rice exported because government-assisted exports accounted for a much smaller portion of total exports than commercial exports during most of the period 1972-1987.

Ending Stocks

The quantity of ending stocks is dependent on the relationship between the farm price of rice, and the quantity of rice supplied in the United States. Since approximately half of the rice produced in the United States has been exported, the relationship between the U.S. export price of rice and the Thai export price of rice is also considered to affect ending stocks of rice.

Loan rates serve as the floor for rice market prices received by farmers. Consequently, when the market price falls to the loan rate, there will be larger ending stocks because more rice is held by farmers for later sale and forfeited to the government as settlement of the loan. Grant, et. al. (1984), have also demonstrated that when the market price received by farmers rises relative to the loan rate, both private and government-held rice stocks decrease. It is, therefore, expected that the farm price/loan rate ratio has a negative effect on rice ending stocks.

The quantity of rice supplied in the domestic market may also influence rice ending stocks. As rice supply increases, the ending stocks become larger unless more rice is demanded both in the domestic market and in the export market to an extent large enough to absorb the increase in supply. Such a relationship between the quantity of rice supplied and ending stocks was observed particularly in the beginning of the 1980s. This is a major reason the acreage reduction program was introduced as a supply control method in 1982. Thus, an increase in the quantity supplied is expected to have a positive effect on rice ending stocks.

Given the relatively stable demand for rice in the U.S. domestic market, the demand in the export market should have an important effect on rice ending stocks. Inverse relationships have been observed between rice exports and ending stocks particularly since the 1970s. In this model, the ratio of the U.S. export price to the Thai export price is included, since it is considered the dominant factor in explaining the quantity of rice exported.

Data Sources

In order to measure the variables included in the model, secondary data were obtained from various USDA sources such as: "Rice Situation and Outlook Report," "Agricultural Statistics," "Agricultural Outlook," "Economic Indicators of the Farm Sector: Costs of Production," "Food Consumption, Prices, and Expenditures," and "Feed Situation and Outlook Report."

The time period for the analysis was from 1972 through 1987 for both the supply and demand sections. The time unit of observation is a year, not only because annual data are readily available for all variables, except for costs of production, but also because most U.S. rice is produced annually. In principle, all observations are on a crop-year (August-July) basis; therefore, data published on a different basis were converted to a comparable basis, e.g., data for the quantity of government-assisted export, published on a fiscal-year (October-September, one year ahead of the rice crop year) basis, were lagged one year.

The number of observations, 16, may seem rather small for reasonable estimates of the coefficients to be obtained. However, there was a structural change in the rice market of the United States as well as in the rest of the world around the 1972 crop year, when the market price of rice began soaring. The subsequent suspension of marketing quotas in 1974 made rice production more market oriented. Another reason for analyzing the period 1972-1987 is the availability of data for costs of production, which have been published for the United States since 1975.

For the supply section, the data are disaggregated into 3 groups: a single state, in the cases of California and Texas, and a region for all other major rice producing states as the model specified. For the demand section, aggregation is at the national level. The data for quantities and prices were all obtained at the farm level, except for the U.S. and Thai export prices of rice, which are at the wholesale level.

In the United States, as well as in the world, it is recognized that there are clear differences in quality and hence in prices among various types of rice; long, medium, and short grain. In this analysis, average price and quantity data are used regardless of length of grain due to lack of consistent data for each separate class.

All of the individual observations used in fitting the respective equations are listed in the Appendix.

Deflators

Economic theory suggests that decision making is derived from relative prices rather than from actual prices. That is, when all prices increase or decrease by the same percentage, demand as well as supply remains unchanged. Demand is influenced more by relative prices and real purchasing power than by nominal prices and income. On the supply side, such price ratios as those between competing products and between output and inputs are more important in determining the quantity to be produced. In this model, therefore, all price and income variables were deflated.

The general level of all prices tends to change over time due to forces operating in the economy, such as government policies, management of the money supply, and international conditions. This suggests that when studying the price for a particular commodity, it is necessary to recognize two sets of market forces, those operating in the economy at large and those specific to the commodity (Johnson et al.). The most common practice to remove the effect of general economic forces is to deflate prices by an appropriate price index.

The implicit GNP deflator (1982=100) was used to deflate all prices, costs of production, and disposable personal income. A common practice in demand analysis for a single food product is to divide the nominal prices by the Consumer Price Index (CPI) for all items. But the CPI is not an appropriate deflator for the demand equations of this analysis since they are at the farm level and do not contain a measure of the marketing margin.

Estimation Results

The supply section of the model was considered to be independent of the demand section because supplies available during a particular marketing year are known and fixed at the beginning of the crop year. Consequently, the coefficients of the supply section were estimated separately from those of the demand section. Each section of the model consists of three subsections of independent equations and, therefore, ordinary least squares (OLS) techniques were used to estimate the coefficients. After the independent variables were selected for each equation using OLS, the seemingly unrelated regression equations (SURE) technique was applied to the sets of equations in each section to find if there were correlations among random components in the disturbance term of each equation. The results of SURE will be discussed at the end of the supply and demand sections respectively.

All of the supply and demand equations were specified in a linear form not only because the linear equation is the simplest and most common specification, but also because the linear relationship is considered to reflect actual economic behavior in the real world. Even if the relationship is not truly linear, a linear form of estimation can approximate the relationship and capture the general direction of movement of economic activity. The linear specification has proved applicable to a rather large number of problems (Tomek, et. al.).

The supply and demand equations estimated by OLS were evaluated based on the following criteria: (1) the signs and magnitudes of the coefficients, (2) the t-statistic to determine statistical significance of the coefficients, (3) the adjusted coefficient of multiple determination (R^2) to measure the degree of association between the observed and expected values of the dependent variable, (4) the standard error of regression to measure the dispersion of the observed values of the dependent variable around the regression line, and (5) the Durbin-Watson statistic (D.W.) or Durbin's h-statistic to test for first- order autocorrelation in residuals. The residuals of each equation were also analyzed by visual inspection to examine how well the equation fits the data, whether the residuals have systematic patterns of behavior, and whether any exceptionally large residuals (outliers) exist.

The SURE models were evaluated, in addition to the above criteria, on the basis of the gain in efficiency yielded by the SURE estimator over OLS.

Table 1. Empirical Estimation Results of the OLS Model for U.S. Rice, 1972- 1987.

Supply Section

1. $AHCA_t = 177.4226 + 6.7820PFCA_{t-1} + 0.4237AHCA_{t-1}$
   (1.76) (1.93) (1.99)
   $R^2 = 0.29$ Durbin's h = 0.58 AHCA = 439.44 S.E. = 76.86

2. $AHTX_t = 60.9333 + 6.3800PFTX_{t-1} + 0.6760AHTX_{t-1}$
   (0.73) (1.82) (3.15)
   $R^2 = 0.69$ Durbin's h = -0.08 AHTX = 468.94 S.E. = 61.27

3. $AHRS_t = 377.8768 + 14.5207PFRS_{t-1} + 0.6961AHRS_{t-1}$
   (0.86) (1.05) (3.56)
   $R^2 = 0.42$ Durbin's h = -0.42 AHRS = 1743.63 S.E. = 298.30

4. $YCA_t = 65.7541 - 0.02407AHCA_t + 15.0492TECH$
   (20.43) (-3.27) (11.49)
   $R^2 = 0.90$ D.W. = 1.94 YCA = 63.64 S.E. = 2.53

5. $YTX_t = 59.3945 - 0.03145AHTX_t + 0.3694TREND$
   (6.40) (-2.14) (1.08)
   $R^2 = 0.54$ D.W. = 1.65 YTX = 47.79 S.E. = 4.29

6. $YRS_t = 44.3458 - 0.003635AHRS_t + 0.6644TREND$
   (14.21) (-1.82) (4.04)
   $R^2 = 0.49$ D.W. = 1.62 YRS = 43.65 S.E. = 2.64

7. $QP_t = (YCA_t \times AHCA_t) + (YTX_t \times AHTX_t) + (YRS_t \times AHRS_t)$

8. $QS_t = QP_t + QES_{t-1}$

Demand Section

9. $(QDOM/POP)_t = -13.1336 - 1.0599(PF/PW)_t + 0.003227YPC_t$
   (-1.21) (-1.05) (2.65)
   $+ 0.3827(QDOM/POP)_{t-1}$
   (2.00)
   $R^2 = 0.80$ Durbin's h = -032 QDOM/POP = 24.43 S.E. = 2.10

10. $QEXP_t = 80356.02 - 31572.57(PUS/PT)_t + 0.1976QS_t$
    (5.44) (-3.35) (3.55)
    $R^2 = 0.56$ D.W. = 1.90 QEXP = 69768.25 S.E. = 7784.58

11. $QES_t = -87648.44 + 34612.96(PUS/PT)_t + 0.4787QS_t$
    (-4.15) (2.57) (6.01)
    $R^2 = 0.75$ D.W. = 1.37 QES = 36923.13 S.E. = 11137.63

12. $QD_t = QDOM_t + QEXP_t + (QES_t - QES_{t-1})$

Note: Numbers in parentheses are the t-values for each estimated coefficients.

Table 2. Empirical Estimation Results of the SURE Model for U.S. Rice, 1972- 1987.

Supply Section

1. $AHCA_t = 146.5711 + 4.0157PFCA_{t-1} + 0.5659AHCA_{t-1}$
   (2.16) (1.44) (4.00)
   $R^2 = 0.23$ Durbin's h = -0.33 AHCA = 439.44 S.E. = 79.80

2. $AHTX_t = 61.9186 + 4.8768PFTX_{t-1} + 0.7144AHTX_{t-1}$
   (1.02) (1.74) (4.73)
   $R^2 = 0.69$ Durbin's h = 0.06 AHTX = 468.94 S.E. = 61.75

3. $AHRS_t = 191.8987 + 11.1633PFRS_{t-1} + 0.8301AHRS_{t-1}$
   (0.73) (1.15) (7.11)
   $R^2 = 0.39$ Durbin's h = -0.81 AHRS = 1743.63 S.E. = 307.32

4. $YCA_t = 65.5639 - 0.02355AHCA_t + 14.9737TECH$
   (26.74) (-4.16) (14.09)
   $R^2 = 0.90$ D.W. = 1.92 YCA = 63.64 S.E. = 2.54

5. $YTX_t = 58.0891 - 0.02821AHTX_t + 0.3443TREND$
   (8.76) (-2.71) (1.32)
   $R^2 = 0.54$ D.W. = 1.59 YTX = 47.79 S.E. = 4.32

6. $YRS_t = 45.0832 - 0.003817AHRS_t + 0.6149TREND$
   (19.16) (-2.59) (4.54)
   $R^2 = 0.48$ D.W. = 1.63 YRS = 43.65 S.E. = 2.66

7. $QP_t = (YCA_t \times AHCA_t) + (YTX_t \times AHTX_t) + (YRS_t \times AHRS_t)$

8. $QS_t = QP_t + QES_{t-1}$

Demand Section

9. $(QDOM/POP)_t = -4.4885 - 1.7359(PF/PW)_t + 0.002606YPC_t$
   (-0.52) (-2.16) (2.72)
   $+ 0.3512(QDOM/POP)_{t-1}$
   (2.32)
   $R^2 = 0.79$ Durbin's h = 1.61 QDOM/POP = 24.43 S.E. = 2.18

10. $QEXP_t = 77481.38 - 27936.21(PUS/PT)_t + 0.1851QS_t$
    (5.92) (-3.38) (3.71)
    $R^2 = 0.55$ D.W. = 1.80 QEXP = 69768.25 S.E. = 7836.62

11. $QES_t = -80574.35 + 25679.71(PUS/PT)_t + 0.5095QS_t$
    (-4.45) (2.29) (7.22)
    $R^2 = 0.74$ D.W. = 1.28 QES = 36923.13 S.E. = 11360.80

12. $QD_t = QDOM_t + QEXP_t + (QES_t - QES_{t-1})$

Note: Numbers in parentheses are the t-values for each estimated coefficients.

The estimation results by OLS are given in Table 1, and those by SURE in Table 2. These equations are considered to provide the best estimates of the coefficients. For the supply section, the equations estimated by OLS, and for the demand section, the equations estimated by SURE will be used for the policy analysis. The t-ratios associated with each estimated coefficient are shown in parentheses.

SUPPLY SECTION

Area Harvested

The first component of the recursive supply model for each of the producing regions is a harvested acreage equation. The equations which included acreage harvested, lagged one year, and domestic ending stocks, lagged one year, as independent variables had acceptable statistical properties as well as expected signs for all regions. The variables for the expected farm price (farm price lagged one year, the loan rate or the target price of the crop year), variable costs of production lagged one year, and world ending stocks lagged one year in the economic model were excluded in the final specification of the acreage models because of their low t-ratios and/or inappropriate signs. Instead, the variables for the farm price of rice lagged one year were included in all equations and provided improved estimates.

In addition, the farm price of soybeans, a likely competing crop, was evaluated but found to be statistically insignificant or to have an inappropriate sign. The coefficients estimated by OLS for the variables affecting acreage harvested are shown in equations 1, 2, and 3 by region in Table 1. All parameter estimates of these equations agree in sign with expectations, and at the 5 percent level are significant with the exception of the farm price lagged one year for Arkansas, Louisiana, Mississippi, and Missouri. The R^2's are generally low, especially in the acreage equation for California (0.29). But the low R^2's are due to large variations in rice production during the period analyzed and do not necessarily suggest that logic of the formulation should be rejected. Since these equations include the lagged dependent variable, the Durbin's h-statistic, instead of the Durbin-Watson statistic, was used to detect the presence of autocorrelation. No autocorrelation was detected in the residuals of the equations at the 5 percent level of significance.

In all regions, the acreage harvested in the current year was found to be positively related to the acreage harvested in the previous year. This could be a reflection of the farmer's habitual practices, or his preference for growing rice. It could also be an indication of fixity of capital resources in rice cultivation and the continuity of the services of these fixed resources in the short run.

The farmer is starts each year with a given level of machinery, equipment, and land, but he can use the machinery and equipment for longer hours while including more land in his rice production. The farmer's lagged response may also be due to government programs, risk aversion, and constraints on his management capacity. The smaller coefficients of the lagged acreage variable for California and Texas imply that producers in these states tend to respond more quickly to economic incentives (e.g., a higher price for rice) than producers in the "rest." These results indicate that producers' planting decisions in response to economic incentives may follow a partial adjustment and that, consequently, it may take more than one year for full adjustments to occur.

While the market price of rice received by farmers in the preceding year and the previous acreage harvested were both found to have significant impacts on harvested acreage in California and Texas, the previous price was not statistically significant even at the 10 percent level for the "rest" equation. When the "rest" was disaggregated into Arkansas, Mississippi, and Louisiana, different patterns were observed: the previous price was insignificant for Arkansas and Mississippi, while it had a significant impact on acreage in Louisiana.

Because the government determines the extent of acreage limitations according to the level of ending stocks, the independent variable that best explains acreage harvested may be ending stocks as well as previous acreage harvested. The equations including these two independent variables provide the best estimates for all regions among other equations specified in this analysis. In this case, the conclusion would be that rice farmers make their planting decisions in response to government programs and previous acreage harvested. Furthermore, it may be further inferred that government programs have dominated rice farmers' planting decisions, from the fact that the base acreage, which serves as the basis for rice program payments and acreage control programs, is determined from historical rice plantings.

Yields

The second component of the supply model is an equation relating yields per acre to harvested acreage and other exogenous variables. The variables for variable costs of production were estimated initially and then omitted because of inappropriate signs and/or low t-ratios. Instead, trend variables or technology variables representing new, high-yielding varieties, developed during the study period, were included in the final specification for all regions. The unexpected signs and/or low t-ratios for the cost coefficients may be due to lack of consistency in the data.

The coefficients estimated by OLS are shown in equations 4, 5, and 6 by region in Table 1. All parameter estimates of these equations agree in sign with expectations, and at the 5 percent level are significant with the exception of the trend variable for Texas. The R^2's are low, except for the California equation. The Durbin-Watson statistics show that there is no autocorrelation in the residuals of all equations at the 5 percent level of significance.

An increase in acreage harvested was found to have a negative impact on yields in all regions. This could be explained by such factors as limited capital and human resources in the short run, bringing marginal land into rice production, and decreases in the ratios for soybean-rice acreage.

A dummy variable for technology, representing new, high yielding rice varieties released in 1978 (thus adopted widely from 1979 on), was significant in the yield equation for California. The impact was positive and very large. This technology variable accounted for most of the upward trend in average yields in California. Technology variables had also significant impacts on yields in Texas (for high-yielding varieties released in 1984) and the "rest" (for those released in 1983). But they did not provide estimates better than those shown in Table 1 for these regions due to multicollinearity problems. Hence, they were not included in the final specification for Texas and the "rest."

Trend variables were included in the final specification for Texas and the "rest." Yields had positive linear trends in both regions. The trend variable also had a significant impact on yields in California, but it was highly correlated with the technology variable. Thus, the trend variable was not included in the final specification for California.

The equations estimated using the SURE technique are given in Table 2. However, these equations are little different from those estimated using the OLS technique, except for the slightly higher t-ratios for all coefficients. Therefore, it can be considered that there are no significant correlations among components in the disturbance terms of the set of equations. That is, rice acreage and yields in different regions are not related to each other. The results of the SURE model also indicate that the equations of the OLS model provide a reasonable estimation on the basis of these time series data.

Demand Section

Domestic Use

The first component of the demand section is an equation for the use of domestic rice. Domestic use includes food use, brewers' use, seeds, and residuals. The variables for the farm prices of rice, corn, and wheat were highly correlated to each other and, therefore, were combined in the ratios of the rice price to the corn price and to the wheat price. But the ratio of the rice price to the corn price was not included in the final specification because of its correlation with the rice-to-wheat price ratio and low t-ratios.

The coefficients estimated by OLS are shown in equation 9 in Table 1. All estimated coefficients had the expected signs and all were significant at the 5 percent level with exception of the variable for the rice-to-wheat price ratio. The R^2 (0.80) was the highest among other multiple regression equations specified. The Durbin's h-statistic indicates that there is no autocorrelation in the residuals at the 5 percent level of significance.

An increase in the price of rice in relation to the price of wheat was found to have a negative impact on the quantity demanded in the domestic market. Consumers, faced with a given level of income, will tend to shift their consumption from wheat to rice as the price of wheat increases, since rice becomes a relatively cheap food, and vice versa.

Per capita disposable personal income and the quantity of domestic rice in the previous year were both positively related to the quantity demanded for rice. The magnitudes of the coefficients of these two variables were also very stable with higher levels of significance, indicating that they are important factors in determining domestic rice consumption. The estimated equation was formulated on a per capita basis to avoid multicollinearity problems. Therefore, as the U.S. population increased, the quantity of rice demanded in the domestic market also increased.

Exports

The second component of the demand section is an equation for exports, including both commercial sales and government-assisted exports. The variables for the U.S. export price of rice and the Thai export price of rice were included in a ratio form to avoid multicollinearity problems. The variables for the quantity exported under government programs and the world ending stocks were not included in the final specification because of low t-ratios for the coefficients of government-assisted exports and inappropriate signs for the stocks coefficients. The inappropriate signs on the stocks coefficient may be due to lack of consistency in the data for the world ending stocks. These data are based on an aggregate of different local marketing years, and could not be construed as representing world stock levels at a fixed point in time (USDA, Rice Situation, October 1988).

The coefficients estimated by OLS for U.S. rice exports are shown in equation 10 in Table 1. All estimated coefficients had the expected signs and were significant at the 1 percent level. The R^2 (0.56) was not very high but the highest among other multiple regression equations specified for rice exports in this analysis. The Durbin-Watson statistic indicates that there is no autocorrelation in the residuals at the 5 percent level of significance.

The ratio of the U.S. export price to the Thai export price was found to be the dominant factor affecting U.S. rice exports. The impact of the ratio of these prices on the quantity of U.S. rice exported was negative and very large.

The quantity of rice exported was also significantly influenced by the quantity of rice supplied. When the quantity supplied increased by 1,000 cwt the quantity exported increased by approximately 200 cwt. But this magnitude was smaller than expected. This result seems to be a reflection of the relatively constant level of exports in contrast to the domestic use that had increased rapidly since the early 1980s.

Ending Stocks

The third component of the demand section is an equation for ending stocks, a total of private and government-held stocks. The variable for the ratio of the farm price of rice to the loan rate for rice was not included in the final specification because of lower t-ratios for the coefficient in multiple regression equations in comparison to the ratio of the U.S. export price to the Thai export price. The export market situation, represented by the U.S.-to-Thai export price ratio, was more important in determining the level of ending stocks than the domestic market situation, represented by the farm price-to-loan rate ratio.

The coefficients estimated by OLS for U.S. rice exports are shown in equation 11 in Table 1. All estimated coefficients had the expected signs and were significant at the 5 percent level. The R^2 (0.75) was the highest among other multiple regression equations specified for ending stocks in this analysis. The Durbin-Watson statistic indicates that there is no autocorrelation in the residuals at the 1 percent level of significance.

The ratio of the U.S. export price to the Thai export price was found to have a large positive impact on the level of ending stocks. U.S. ending stocks of rice increased remarkably when the U.S. export price of rice became high in relation to the Thai export price of rice.

The quantity of rice exported was also significantly influenced by the quantity of rice supplied. When the quantity supplied increased by 1,000 cwt the quantity exported increased by approximately 500 cwt. This magnitude was much larger than that of the supply coefficient in the export equation.

The independent variables used for the demand section of the SURE model were the same as for the equations estimated using OLS. The results given in Table 2 display the generally higher t-ratios for the coefficients of these independent variables, especially for the price coefficient in the domestic use equation (equation 9). The rice-to-wheat price ratio was not significant at the 10 percent level with OLS, but became highly significant with SURE. All variables had the expected signs and were statistically significant at the 5 percent level. The R^2's did not change much from those in the OLS model.

The "improvements" in the demand equations estimated by the SURE technique indicate the existence of correlations among random components in the disturbance terms of these equations. These equations are seemingly unrelated, but are in fact shown to be related to each other. Improvements in the results by SURE over OLS also imply that there are some other important factors explaining changes in demand for U.S. rice that were not (or could not be) incorporated in the model, especially in the domestic demand equation. In other words, the demand section of the model was not correctly specified. Thus, the results by SURE are used for estimation of elasticities of demand.

Elasticities

Supply and demand elasticities were computed for use in evaluating the impacts of possible changes in policy on the U.S. rice industry as well as to make relative comparisons among regions and variables.

Supply Elasticities

Rice supply elasticities calculated at the means and the 1987 point using the regression equations estimated by OLS (Table 1) are given in Table 3.

Table 3. SHORT RUN ELASTICITIES OF U.S. RICE SUPPLY

State/Region	$E_{A/P}$ 2/	$E_{Y/A}$ 3/	$E_{Q/P}$ 4/	Point	Time Period
Watanabe 1/					
California	0.175	-0.166	0.146	Means	1972-1987
Texas	0.176	-0.309	0.122		
The Rest	0.104	-0.145	0.089		
U.S. 5/	0.129	-0.178	0.104		
California	0.054	-0.123	0.048	1987	1972-1987
Texas	0.085	-0.149	0.072		
The Rest	0.030	-0.126	0.026		
U.S. 5/	0.040	-0.128	0.035		
Grant, et. al. (1984)					
California	0.184	--	0.184	1982	1950-1983
Texas	0.147	-0.073	0.136		
Arkansas	0.094	-0.346	0.062		
Mississippi	0.089	--	0.089		
Louisiana	0.141	--	0.141		
U.S. 5/	0.125	-0.156	0.110		
Grant et al. (1979)					
U.S. 5/	0.52	-0.28	0.35	1975	1950-1975
Nakagawa					
U.S.	0.217	--	0.217	Constant	1960-1985
U.S.	0.128	--	0.128		1973-1981
Kincannon					
U.S.	0.33	--	--	1954	1923-1940, 1948-1954

1/ Estimated in this study using the OLS model.
2/ $E_{A/P}$ is elasticity of acreage with respect to expected farm price.
3/ $E_{Y/A}$ is elasticity of yield with respect to acreage.
4/ $E_{Q/P}$ is elasticity of production with respect to expected farm price, and $E_{Q/P} = E_{A/P} \times (1+E_{Y/A})$.
5/ Weighted by state/region's acreage.

Area Harvested

The short run elasticities of acreage of rice harvested with respect to the lagged farm price of rice deflated by the GNP deflator ranged from a low of 0.03 measured in 1987 for the "rest" to high of 0.18 at the means for Texas. The generally lower elasticities computed for 1987 seem to reflect the ways in which U.S. rice production has become more dependent on government programs in recent years. The comparatively more elastic estimates found for Texas and California are as expected, since the costs of producing rice were distinctly higher in these states, where the expected farm price is more important for farmers' planting decisions than in states with lower production costs.

Using each region's elasticity and its share of harvested acreage as weights, the elasticity of U.S. harvested acreage with respect to the lagged farm price was estimated to be 0.13 at the means and 0.04 for 1987. The elasticities measured at the means are comparable to the results by Grant, et. al. (1984), who, using equations based on 1950-1983 data, estimated the elasticity of U.S. rice acreage with respect to the effective farm price deflated by cost of production at 0.13 for 1982.

Yields

The present analysis found that rice yield was not affected appreciably by the lagged, deflated farm price of rice during the period 1972-1987. However, because the acreage, which changes in response to price changes, affects yields, the elasticities of average yield with respect to harvested acreage were calculated. These elasticities ranged from -0.12 for California in 1987 to -0.31 for Texas at the means.

The yield elasticities measured at the data points for 1987 were smaller for all regions than those at the means, indicating that farmers planted rice on highest-yielding land under the acreage reduction program in 1987 (and hence yields were less responsive to a change in acreage). The elasticities of U.S. average yield with respect to harvested acreage were estimated to be -0.18 at the means and -0.13 for 1987. These elasticities are also comparable to the estimates by Grant et al. (1984) for an earlier time span.

Production

The short run elasticity of rice production with respect to lagged, deflated farm price of rice is a combination of the direct effect of acreage changes in response to price changes and the indirect effect of yield changes in response to acreage changes. The elasticity of production with respect to lagged, deflated farm price for each region was calculated using the following equation:

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

where $E_{A/P}$ is the elasticity of harvested acreage with respect to the lagged, deflated farm price, and $E_{Y/A}$ is the elasticity of average yield with respect to harvested acreage. Then, the elasticities of U.S. rice production were computed using each region's elasticity and its share of harvested acreage as weights.

The production elasticities with respect to the lagged, deflated farm price ranged from 0.03 in 1987 for the "rest" to 0.15 at the means for California. The weighted average elasticity for the United States was calculated to be 0.10 at the means and 0.03 in 1987. That is, a 1 percent increase in the lagged farm price was associated with 0.10 percent and 0.03 percent increases in the quantity of rice produced at the point of means and in 1987, respectively.

The production elasticity can be regarded as the elasticity of U.S. rice supply with respect to lagged farm price, holding other factors (such as ending stocks) constant.

Demand Elasticities

Rice demand elasticities calculated at the means and for 1987 using the regression equations estimated by SURE (Table 2) are given in Table 4.

Table 4. ELASTICITIES OF U.S. RICE DEMAND

	Own Price	Income	Point	Time Period
Domestic Use:				
Watanabe 1/	-0.200 (farm)	1.040	Means	1972-1987
	-0.159 (farm)	0.939	1987	
Nakagawa	-0.197 (retail)	1.08	Constant	1960-1985 1/
	-0.078 (retail)	1.16		1960-1985 2/
Huang	-0.147 (retail)	-0.366 3/	--	1953-1983
Grant, et. al. (1984)	-0.18 (retail)	0.60	1982	1950-1982 4/
Grant, et. al. (1979)	-0.07 (retail)	0.23	1975	1950-1975 4/
Grant, et. al. (1970)	-0.15 (farm)	0.61	1966	1934-1966
Brandow	-0.04 (farm)	--	1955-57	1947-1961
Kincannon	-0.21 (farm)	0.46	1954	1923-1940, 1948-1954
Mehren, et. al.	-0.56 (farm)	0.99	1952	1921-1952

(Notes are given on the next page.)

Table 4. ELASTICITIES OF U.S. RICE DEMAND (Continued)

	U.S. Export Price	Point	Time Period
Export Use:			
Watanabe 1/	-0.516	Means	1972-1987
	-0.596	1987	
Grant, et. al. (1984)			
Commercial	-0.68	1982	1950-1982
Government-aided	-0.53		
Grant, et. al. (1979)			
Commercial	-0.46	1975	1950-1975
Government-aided	-2.11		
Ending Stocks:	Price	Point	Time Period
Watanabe 1/	-0.896 (export)	Means	1972-1987
	-0.756 (export)	1987	
Grant, et. al. (1984)			
Private	-0.11 (farm)	1982	1950-1982
Government	-0.06 (farm)		
Grant, et. al. (1979)			
Private	-0.03 (farm)	1975	1950-1975
Government	-0.63 (farm)		

1/ Estimated using the SURE model.
2/ Estimated by OLS.
3/ Estimated by GLS.
4/ Expenditure elasticity.
5/ Food use only.

Domestic Use

The elasticity of per capita domestic rice consumption with respect to the deflated farm price of rice was calculated holding the farm price of wheat constant. These elasticities estimated at the points of means and 1987 were - 0.20 and -0.16, respectively. Thus, a 1 percent change in the farm price resulted in 0.20 percent and 0.16 percent decreases in the per capita quantity of rice consumed in the domestic market.

These estimates may appear to be unexpectedly large as the elasticity of U.S. domestic demand for rice with respect to the farm price in comparison with elasticities estimated by other researchers. But such differences may be attributed to the study period; all previous estimates were based on data for the periods when the domestic demand for rice was relatively stable and included longer, less recent time spans. The results of this study are similar to the elasticity of per capita domestic demand with respect to the retail rice price estimated by Grant, et. al. (-0.18 for food use in 1982) and Nakagawa (constant at -0.20 for all uses). Even so, all these estimates of demand elasticity indicate that the domestic demand for U.S. rice is relatively inelastic.

The relatively smaller price elasticity estimated for 1987 is due to the stable, large per capita rice consumption despite the much higher price of rice in relation to the price of wheat in this marketing year.

The income elasticities of per capita domestic rice consumption were estimated to be 1.04 at the means and 0.94 for 1987. That is, a 1 percent increase in per capita disposable income was associated with 1.04 percent and 0.94 percent increases in the per capita quantity of rice consumed in the domestic market, respectively. These income elasticities are larger than most estimates obtained in previous research. A downward trend in income elasticity of total domestic rice use was observed up to 1975, but in the estimate for 1982 such a trend appeared to have been reversed. Grant, et. al. (1984) argue that the increase in income elasticity may be attributable to a shift in ethnic population in the 1970s and a shift in consumer habits, rather than increases in income. The empirical results of this study seem to support such statements. Improvements in the demand equations based on SURE over OLS suggest the presence of some other factors that had significant impacts on the domestic rice demand, which were not incorporated in the model.

The comparatively larger elasticities of per capita consumption with respect to income than with respect to price imply that changes in income had a larger impact on quantity of rice demanded on the domestic market.

Exports

The elasticity of export demand for U.S. rice with respect to the U.S. export price was computed holding the Thai export price constant. In estimating the regression equations, the data for the U.S. export price and the Thai export price were both on a milled-rice basis.

The elasticity of U.S. rice exports with respect to the U.S. export price was estimated to be -0.52 at the means and -0.60 for 1987. The relatively larger price elasticities found for export demand compared with domestic demand reflect the more competitive market for U.S. rice abroad. This result suggests that government price policy for rice is more important in the determination of export demand than domestic demand. Similar estimates were found for price elasticity of export demand by Grant, et. al. (1984).

Ending Stocks

The elasticity of demand for ending stocks with respect to the U.S. export price were also calculated holding the Thai export price constant. The demand for ending stocks was found to be more elastic in absolute terms than export demand; 0.90 at the means and 0.76 for 1987. Because domestic demand for rice is inelastic, the effect of decreased rice exports would result in additional stocks rather than consumption in the domestic market, when the U.S. export price went up in relation to the Thai export price.

Concluding Remarks

The very stable results of the supply equations estimated using the SURE technique support the results by OLS and indicate that the supply model was reasonably specified. On the other hand, the improvements in the demand equations with SURE over OLS suggest that the demand section of the model was not properly specified, that is, there were important explanatory variables that were not (or could not be) incorporated in the demand model, especially in the domestic demand equation. Such variables may include institutional and noneconomic factors, e.g., changes in consumer tastes and preferences, population by ethnic origin, and promotional activities by the industry.

The supply and demand elasticities computed here, which seem to be reasonable, compared with estimates from previous research, indicate that the equations of this study were estimated well enough to use the results for subsequent policy analysis. The final test, of course, is in how well the equations predict behavior of the U.S. rice market in years following the estimation period.

The empirical results also imply that government programs played an important role in the U.S. rice industry, particularly in the determination of supply, during the period 1972-1987. Therefore, any important change in government programs for rice is likely to bring about a significant change in supply with implications for demand as well.

POLICY ANALYSIS OF DECOUPLING RICE PROGRAMS

Decoupling of income support from supply control is considered as a policy alternative to the present rice program. Given the nature of this empirical study, which is based on past phenomena, quantitative analysis can only provide an indication of what might be expected from such an unprecedented scheme as decoupling. Over time, decoupling is likely to bring about structural changes in the rice industry. Nevertheless, the following analysis uses the regression equations just estimated to indicate the directions, rather than the likely extent, of probable changes in supply and demand for U.S. rice that would accompany a move toward decoupling. Finally, the feasibility of decoupling and possible problems in its implementation are examined.

"Decoupling" is an idea or policy proposal intended to move farmers out of an acreage control system into a market oriented decision process where prices direct the use of resources through time. Income payments will be used in a transition period to assist in the move toward a free market system. For the following analysis, it is assumed that: (1) such income payments will not be determined by current production, prices, or acres planted, (2) they will, however, have an upper limit on the amount per person related to past acreage or actual production (the maximum is smaller than the current payment limit of $50,000), (3) given these payments, decisions by individual farmers about what and how much to plant will be guided primarily by market prices and costs of production rather than by government programs.

Application of the Model to Various Cases of Decoupling

In this section, the amounts of U.S. rice that would likely be produced and demanded in various cases of decoupling (and hence with different levels of rice prices) are assessed using the regression equations estimated. Similar to the estimation of elasticities, the equations estimated by OLS are used for the supply section and the equations by SURE for the demand section. Since both sections include recursive equations, changes in successive years, 1988-1992, are estimated on the basis of actual data for 1987.

In the following analysis, estimates are made when: (1) decoupling is undertaken only by the United States, (2) Decoupling is adopted by all countries, and (3) "multilateral decoupling" is followed by a natural disaster in China. In each situation, it is assumed that: (1) the expected farm price for rice being harvested is the same as the actual farm price of rice in the current year, (2) the farm prices of rice and wheat are sustained for the entire period of estimation, (3) there is no difference in farm prices of rice among the three rice-producing regions, and (4) the U.S. export price of rice becomes the same as the Thai export price as a result of decoupling. The prices, as well as income, in the following analysis are all expressed in real terms because the equations were estimated using prices deflated by the GNP deflator. The rice price is set at a level that seems to reflect each situation on the basis of past trends. It is also assumed that U.S. population and per capita disposable income will increase during the period of estimation at the same real annual growth rates as for the period 1972-1987, that is, 1.0 percent and 1.8 percent, respectively. Though the model is static, the ending stock of a particular year computed in the demand section is also used as the ending stock for that year in the supply section in order to obtain estimates for the quantity supplied the following year.

Scenario 1 -- Unilateral Decoupling

Decoupling is undertaken only by the United States, and therefore, the U.S. farm and export prices of rice fall to the level of world market price. The farm price of rice in real terms is assumed to become $5.00 per hundredweight. It is also assumed that the farm price of wheat is not affected by decoupling and remains at the 1987 level. Although the wheat price, too, appears likely to decline due to decoupling, the extent will be relatively small compared to the decline in the price of rice.

The quantity of rice produced in the United States declines due to reduced acreage harvested in total (Table 5). The quantity estimated for 1988 (123.2 million cwt) is approximately 4 percent less than the quantity of rice actually produced in 1987 (127.7 million cwt). However, changes in acreage harvested for three regions are somewhat different. While the "rest" (Arkansas, Mississippi, Missouri, Louisiana) reduces its acreage, Texas expands its acreage. The change in California, though decreasing, is very small. The increase in Texas' acreage seems to reflect the much smaller acreage actually planted than the acreage fitted by the equation for the recent years. The downward trend in quantity produced reverses in 1991 due to the upward trend in acreage of Texas. The quantity supplied decreases partly because of the decreased quantity produced but mainly because of decreased ending stocks estimated in the demand section.

The quantity of rice domestically consumed tends to increase due to the lowered price of rice and growth in per capita income and in population. The quantity of rice exported also increases in 1988 due to the U.S. export price lowered to the level of the Thai export price, but starts decreasing in 1989 because of the decreased quantity supplied. Therefore, despite the increase in domestic rice consumption, the total quantity demanded in the domestic and export markets does not increase so rapidly. It is not possible to estimate the separate effect of a change in the U.S. export price on the quantity demanded for U.S. rice in the export market because of using the U.S.-Thai price ratio in the export equation. But the

Table 5. ESTIMATED SUPPLY AND DEMAND OF U.S. RICE WITH UNILATERAL DECOUPLING, 1988-1992

Scenario 1: Decrease in U.S. Rice Price by Unilateral Decoupling
Supply: Real Farm Price of Rice--$5.00 per cwt (rough)[1]

Year	Acreage harvested in: California	Texas	The Rest	Quantity produced	Quantity supplied[2]
	- 1,000 acres -			- 1,000 cwt -	
Base 1987	367.00	269.00	1,697.00	127,725	182,300
1988	366.83	274.68	1,631.76	123,182	154,582
1989	366.76	278.52	1,586.35	122,524	146,389
1990	366.73	281.11	1,554.74	122,366	142,057
1991	366.72	282.86	1,532.73	122,567	140,050
1992	366.71	284.05	1,517.41	123,024	139,485

1 Computed using the equations estimated by OLS (See Table 4).
2 Computed using the previous ending stock estimated in the demand section except 1988, for which the actual data for 1987 was used.

Demand: Real Farm Price of Rice--$5.00 Per CWT (rough)[3][4]
Real Farm Price of Wheat--$2.18 Per Bushel
U.S. Export Price = Thai Export Price

Year	Per capita quantity domestic consumers	Quantity domestic consumers (a)	Quantity exported[5] (b)	(a) + (b)	Ending stocks[5]	Quantity demanded
				- 1,000 cwt -		
Base 1987	32.18	78,500	72,200	150,700	31,400	130,700
1988	32.49	80,042	78,158	158,200	23,865	150,665
1989	33.13	82,443	76,642	159,089	19,691	154,910
1990	33.90	85,201	75,840	161,040	17,483	158,833
1991	34.73	88,141	75,468	163,610	16,461	162,587
1992	35.58	91,213	75,364	166,577	16,173	166,289

3 Computed using the equations estimated by SURE (See, Table 4).
4 Assuming annual growth rates of per capita income and U.S. population as 1.8 percent and 1.0 percent, respectively.
5 Computed using the quantity supplied estimated in the supply section.

amount of U.S. rice exports would not increase significantly because Thailand, which produces a similar quality of rice at lower costs than the United States, and other exporters are likely to attempt to match the lower U.S. price.

The quantity demanded is shown to exceed the quantity supplied every year after 1988. In this analysis, it is assumed the farm price of rice remains at the same level for the entire period of estimation, omitting the feedback of a change in supply-demand relationships into the farm price. But such a tight situation in the domestic rice market will certainly increase the farm price of rice in the real world. The higher price will then lead to an increase in quantity produced and a decrease in quantity demanded. Nevertheless, these results seem to imply that unilateral decoupling will not necessarily have a favorable effect on the U.S. rice industry as a whole. Politically it would also be nearly impossible to institute decoupling without other nations making concessions concurrently.

Scenario 2 -- Multilateral Decoupling

Agricultural subsidies and import barriers are simultaneously eliminated by other nations. Multilateral decoupling is assumed to lead rice consuming countries that now impose restrictions on rice imports to move toward liberalization. Increases in quantity demanded by such a large rice consumer as Japan will raise the world market price of rice and hence the U.S. farm price. Although the immediate effect of Japan's import liberalization will be only on the farm price in California, which produces most of U.S. medium and short grain rice, it is assumed that farm prices in all rice producing regions are similarly affected and rise to $15.00 per cwt in real terms. Again, it is assumed that the U.S. farm price of wheat is not affected by the decoupling. Japan would demand more wheat due to elimination of state control over its wheat marketing, but the increase in quantity would not be as large as in rice because most of the wheat consumed in Japan is already imported. Even if the world price of rice is considerably higher than the wheat price, Japan would be unlikely to increase wheat imports because wheat is not a good substitute for rice for many Japanese consumers. Probable effects of changes in other countries due to multilateral decoupling on the U.S. farm price of wheat is likely to be small. Thus, no change in the U.S. wheat price is assumed.

The quantity of rice produced in the United States significantly increases due to expansion of acreage harvested (Table 6). Such expansion in rice acreage is brought about by the large increase in farm price. The quantity estimated for 1988 (136.6 million cwt) is approximately 7 percent larger than the quantity of rice actually produced in 1987 (127.7 million cwt). The largest change in acreage harvested occurs in Texas, followed by California. An upward trend in quantity produced can be observed for the entire period of estimation.

The per capita quantity of rice domestically consumed continues to decline due to the higher price of rice until 1990, but the downward trend reverses in 1991 because of an increase in per capita income. Population growth further expands total quantity of rice demanded in the domestic market. The quantity of rice exported tends to increase due to the U.S. export price lowered to the level of the Thai export price and the increased quantity supplied. Such increase in U.S. rice exports is induced by increased demand (and hence higher prices) in the world rice market, though it is not shown explicitly because the export equation includes no variable representing the world rice demand. The estimated total quantity demanded in the domestic and export markets is smaller than in Scenario 1, but it increases at a higher rate.

In short, multilateral decoupling appears to have positive effects on the U.S. rice industry. However, possibilities of U.S. rice, especially for the export demand, would depend on its competitiveness in the world market. If Thailand and other rice producers could supply high quality rice to the U.S. consumers at lower prices thanks to the multilateral decoupling, the U.S. rice producers would lose not only export markets but also domestic markets and prices would fall to reflect these conditions.

Table 6. ESTIMATED SUPPLY AND DEMAND OF U.S. RICE WITH MULTILATERAL DECOUPLING, 1988-1992

Scenario 2: Increase in U.S. Rice Price by Multilateral Decoupling
Supply: Real Farm Price of Rice--$15.00 per cwt (rough)[1]

Year	Acreage harvested in: California	Texas	The Rest	Quantity produced	Quantity supplied[2]
	- 1,000 acres -			- 1,000 cwt -	
Base 1987	367.00	269.00	1,697.00	127,725	182,300
1988	434.65	338.48	1,776.97	136,594	167,994
1989	463.31	385.45	1,832.64	144,032	174,730
1990	475.46	417.20	1,871.39	149,092	183,223
1991	480.61	438.66	1,898.36	152,828	191,286
1992	482.79	453.17	1,917.14	155,778	198,344

[1] Computed using the equations estimated by OLS (See Table 4).
[2] Computed using the previous ending stock estimated in the demand section except 1988, for which the actual data for 1987 was used.

Demand: Real Farm Price of Rice--$15.00 Per CWT (rough)[3][4]
Real Farm Price of Wheat--$2.18 Per Bushel
U.S. Export Price = Thai Export Price

Year	Per capita quantity domestic consumers	Quantity domestic consumers (a)	Quantity exported[5] (b)	(a) + (b)	Ending stocks[5]	Quantity demanded
				- 1,000 cwt -		
Base 1987	32.18	78,500	72,200	150,700	31,400	130,700
1988	24.53	60,425	80,641	141,066	30,698	140,364
1989	22.38	55,674	81,888	137,562	34,131	140,994
1990	22.16	55,702	83,460	139,161	38,458	143,488
1991	22.64	57,465	84,952	142,417	42,566	146,525
1992	23.37	59,915	86,257	146,173	46,162	149,769

[3] Computed using the equations estimated by SURE (See, Table 4).
[4] Assuming annual growth rates of per capita income and U.S. population as 1.8 percent and 1.0 percent, respectively.
[5] Computed using the quantity supplied estimated in the supply section. These levels are increasing because there is no adjustment mechanism to allow prices to decline built into the model.

Scenario 3 -- Multilateral Decoupling plus Disaster

The third scenario assumes that as a result of a natural disaster, China is faced by serious failure of its rice crop and, consequently, substantial imports of rice are required instead of exporting rice. The increase in demand for imported rice are partially filled by imports of wheat and other substitute cereals because of their generally lower prices than rice in the world markets. Therefore, in addition to the world market price of rice, the wheat price will also increase. The U.S. farm prices are assumed to become $20.00 for one hundredweight of rice and $7.00 for one bushel of wheat.

As in Scenario 2, the quantity of rice produced in the United States significantly increases due to expansion of acreage harvested. The expansion in rice acreage is larger than that of Scenario 2 because of the larger increase in farm price. The quantity estimated for 1988 (143.1 million cwt) is 12 percent larger than the quantity of rice actually produced in 1987 (127.7 million cwt). Again, an upward trend in quantity produced can be observed for the entire period of estimation.

The per capita quantity of rice domestically consumed declines due to the higher price of rice in 1988. But the extent of decline is smaller than in Scenario 2 because the change in the rice price relative to the wheat price is smaller in this case than in Scenario 2, and an increase in per capita income soon begins to enhance the per capita quantity of rice consumed. Again, the downward trend reverses in 1991 due to an increase in per capita income. Population growth further expands total quantity of rice demanded in the domestic market. The quantity of rice exported tends to increase due to the U.S. export price lowered to the level of the Thai export price and the increased quantity supplied. The increasing rate of rice exports is higher than in Scenario 2, reflecting the more rapid increase in total quantity of rice supplied. Thus, the total quantity demanded in the domestic and export markets expands more rapidly than in Scenario 2.

Multilateral decoupling plus a disaster in China also appears to have generally positive effects on the U.S. rice industry. If it was assumed that the Chinese people would not substitute wheat for rice but merely import rice to fill the loss in domestic production, the U.S. farm price of rice and the rice-to-wheat price ratio would become greater than the price of rice and the ratio assumed for Scenario 3. There might even be a shortage of rice in the world market because China alone accounts for nearly half of the total quantity of rice produced in the world and the quantity of rice internationally traded is less than 5 percent of total world production.

Table 7. ESTIMATED SUPPLY AND DEMAND OF U.S. RICE WITH MULTILATERAL DECOUPLING PLUS DISASTER, 1988-1992

Scenario 3: Increase in U.S. Rice Price by Multilateral Decoupling And a Disaster in China

Supply: Real Farm Price of Rice--$20.00 per cwt (rough)[1]

Year	Acreage harvested in: California	Texas	The Rest	Quantity produced	Quantity supplied[2]
	- 1,000 acres -			- 1,000 cwt -	
Base 1987	367.00	269.00	1,697.00	127,725	182,300
1988	468.56	370.38	1,849.57	143,063	177,463
1989	511.59	438.91	1,955.78	154,183	188,177
1990	529.82	485.24	2,029.71	161,532	202,514
1991	537.55	516.56	2,081.17	166,787	215,073
1992	540.82	537.73	2,116.99	170,802	225,487

1 Computed using the equations estimated by OLS (See Table 4.1).
2 Computed using the previous ending stock estimated in the demand section except 1988, for which the actual data for 1987 was used.

Demand: Real Farm Price of Rice--$20.00 Per CWT (rough)[3,4]
Real Farm Price of Wheat--$7.00 Per Bushel
U.S. Export Price = Thai Export Price

Year	Per capita quantity domestic consumers	Quantity domestic consumers (a)	Quantity exported[5] (b)	(a) + (b)	Ending stocks[5]	Quantity demanded
				- 1,000 cwt -		
Base 1987	32.18	78,500	72,200	150,700	31,400	130,700
1988	31.51	77,632	81,838	159,470	33,994	162,064
1989	31.81	79,152	84,377	163,529	40,982	170,516
1990	32.46	81,577	87,030	168,607	48,286	175,912
1991	33.24	84,374	89,355	173,730	54,685	180,129
1992	34.08	87,363	91,283	178,646	59,991	183,952

3 Computed using the equations estimated by SURE (See Table 4.2).
4 Assuming annual growth rates of per capita income and U.S. population as 1.8 percent and 1.0 percent, respectively.
5 Computed using the quantity supplied estimated in the supply section. These levels are increasing because there is no adjustment mechanism to allow prices to decline built into the model.

ECONOMIC ANALYSIS OF DECOUPLING BEYOND THE REGRESSION RESULTS

Supply Section -- Production

A USDA study points out that rice acreage response to price changes is less than for other major field crops because of its higher fixed costs and the limited number of alternative uses of the cropland (USDA, Rice: Background). Our analysis has also demonstrated that the production elasticity with respect to farm rice price was 0.10 during the period 1972-87. These results imply that the effect of a lower price support for U.S. rice production will be small in the short run. But these results were all obtained based on observations under the present policy regime, particularly the high level of price and income support. Therefore, such a drastic policy change as a move away from the price and income support features of the current rice program would likely change the characteristics of rice production described above, though relative fixity of capital resources in rice cultivation would still cause a lagged response to economic incentives by rice producers.

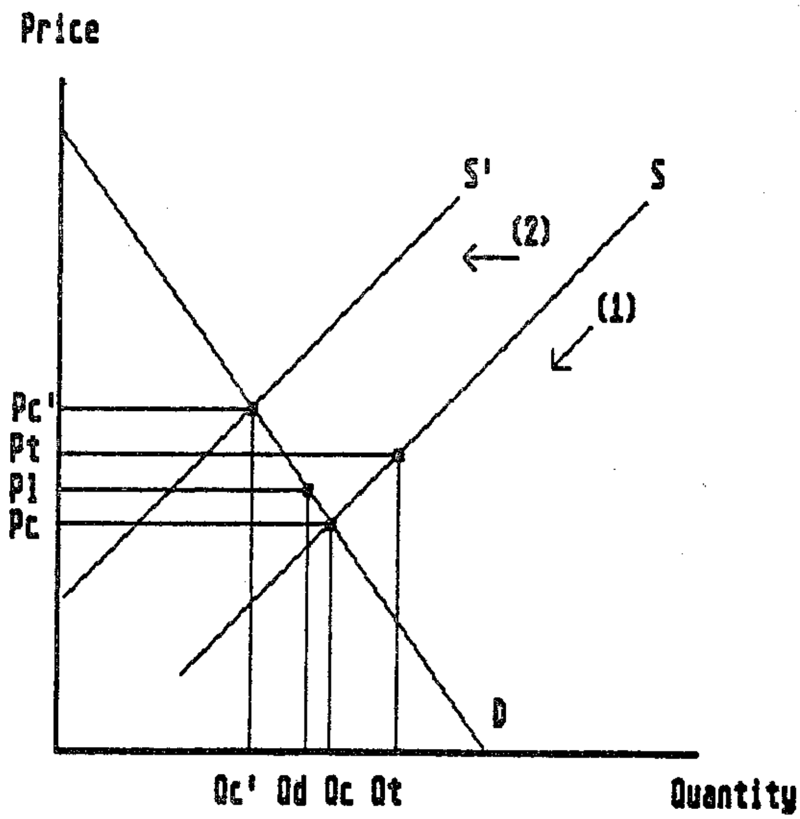
Probable effects of unilateral decoupling on the quantity produced will be significantly different from those of multilateral decoupling. Multilateral decoupling is more likely to enhance U.S. rice production due to an increase in the world market price, though it will depend on U.S. efficiency relative to other rice producing countries.

On the other hand, in the case of unilateral decoupling, the absence of a high level of support/target prices would lead to a decline in acreage of rice planted because the expected farm price for rice is important for rice farmers' planting decisions. The supply model has also shown that yields increased when less acreage was planted. Because the production elasticity with respect to the expected farm price, which is a combination of the effects of acreage changes in response to price changes and yield changes in response to acreage changes, is positive, the decrease in expected farm price would lead to less quantity produced.

Such a change in the quantity produced in response to a reduction in the farm price of rice could be viewed as a combination of a shift to the left in the supply schedule and a downward movement along a nearly static supply schedule (Figure 2). The reduction in the quantity of rice produced would be brought about by changes in the relative profitability of nonprogram crops competing for the same resources, such as soybeans and cereal grains. The empirical analysis showed the farm price of soybeans statistically insignificant in the acreage equations for all regions. But this is probably because of the estimation period, during which rice received a tremendously high level of target prices while soybeans were not supported by direct payments.

Thus, in the absence of the high level of income support, it is logical that farmers will choose to plant whatever crop is the most profitable.

Figure 2. **POTENTIAL EFFECTS OF UNILATERAL DECOUPLING ON SUPPLY AND DEMAND OF U.S. RICE**



A change in the quantity produced in response to reduction in the farm price can be viewed as:

1. A downward movement along the static supply schedule.
2. A shift to the left in the supply schedule from S to S'.

In case (1), quantity produced decreases from Qt to Qc in response to the decline in price from Pt (the target price) to Pc (the competitive market price). But quantity demanded increases from Qd to Qc in response to the decline in price from Pl (the loan rate) to Pc. In case (2), quantity produced decreases from Qt to Qc' due to the shift in the supply schedule. However, the positions of the Pc' (the resulting market price) in relation to Pt and Pl, and Qc' (the resulting quantity) in relation to Qd depend on the extent of the shift in the supply schedule.

The size of a shift in planted acreage in response to a farm price (and income) change will depend on profit opportunities with substitute crops as well as income opportunities outside the farm sector available in the region or to individual farmers. If farmers still find rice farming profitable relative to other crops or other activities, they will stay in rice farming. Otherwise, they will go out of business.

Even if the expected farm price falls, the acreage of rice planted might rise (i.e., a shift to the right in the supply schedule) in the short run as the acreage reduction programs are eliminated, due to fixity of capital resources in rice cultivation. In the long run, unilateral decoupling is likely to shift the present supply schedule to the left because of decreased profitability per unit of rice and land used primarily for rice. There would be no program-induced surplus of rice. Consequently, over time, with fewer producers, the farm price of rice would rise in relation to the present level of market price and might exceed the support-target prices, depending on the extent of the shift in the supply schedule.

Farm Income

While farmers will respond to changes in the farm price brought about by decoupling, effects on net income is crucial in determining their behavior. Because deficiency payments account for a significant portion of rice growers' net income under the present regime, gross income from rice farming will decline with decoupling initially. It is expected that eliminating a high level of price and income support will lower cost structures, especially land values, which have increased on the basis of expected program benefits. The net effect on the net income position of rice producers is uncertain. Unless costs of producing rice fall to an extent large enough to offset the loss in government payments, many farmers will be forced to stop producing rice. The number of farmers exiting the industry as well as their sizes and efficiency will finally determine the extent of the shift in the rice supply function.

It is not possible to assess probable effects of the transition payments on farmers' decisions based on the economic model presented because such a concept of payments is new to the U.S. rice industry. If transition payments account for a significant portion of a farmer's income, then at some point some farmers with relatively high production costs will prefer no production or production only in the land best suited to rice. This will occur particularly when the market price is so low that farmers will lose money if they plant rice. Rice producers claim that deficiency payments are necessary to continue growing rice because the current market prices barely cover average cash costs of production. In theory, therefore, if the transition payments were as much as the deficiency payments, many rice producers could be expected to stop planting rice on the high cost acres.

One probable effect of decoupling on U.S. rice production seems to be suggested partly by the progress of the 50/92 provision of the 1985 Food Security Act. Most of the 50/92 enrollment has occurred in Texas where costs of producing rice are the highest among all major rice-producing states. Under decoupling, too, high-cost producers are expected to take advantage of these income payments and reduce production accordingly.

Limits on transition payments suggest that farmers of different sizes will be affected differently by decoupling. Large acreage producers will be less affected; farmers with moderate to small acreages are likely to respond the most due to their inflexibility in adjusting their costs. Some farmers with small acreages may increase their net incomes by stopping production in the short run. Cochrane argues, by his "theory of the treadmill," that increased program benefits have been bid into higher land values, hence into higher cost structures. A study conducted for the U.S. Senate Committee on the Budget has shown that larger farmers tend to receive the largest share of program payments currently.

If farmers' planting decisions were determined solely by market forces, there certainly would be more price variability and hence greater instability in the incomes of rice farmers. This would be true of both unilateral and multilateral cases of decoupling. A concern about price variability would be particularly strong for rice, because more than half of U.S. rice is exported. The world rice market has been characterized as "thin, volatile, and risky." Such a concern may lead to a strong push toward a CCC purchase program for surplus rice, though the level of support necessarily would be much reduced. A loan rate set at or near the variable cost of production, without forced land diversions, has already been proposed by Senator Boschwitz.

Demand Section -- Domestic

The demand elasticities indicate that disposable income is a more important factor affecting per capita rice consumption in the United States than the farm price of rice. When evaluated at the quantities and levels of 1987, the per capita quantity of rice demanded in the domestic market will, other factors remaining constant, increase by 1.6 percent if the farm price of rice decreases by 10 percent. It will increase by 9.4 percent if per capita income increases by 10 percent. That is, using the actual data for 1987, the per capita quantity of rice demanded increases only 0.5 lbs by a 10 percent change in the farm price ($0.62 per hundredweight), while it increases 3.0 lbs asa result of a 10 percent change in income ($1,118). If decoupling were introduced, these results are more likely to hold, because consumer behavior, unlike producers' planting decisions, would not be structurally changed by the new policy.

Under unilateral decoupling, the domestic quantity demanded for rice likely would increase in response to decreased market prices as a result of eliminating high price supports. The quantity demanded for rice in the domestic market, however, would change very little in response to changes in the farm price. In the long run, as illustrated by a shift in the supply schedule (Figure 2), the decreased quantity supplied might raise market prices, and consequently a smaller amount might be demanded. Under multilateral decoupling, U.S. consumers may be adversely affected over time when a higher price is finally established with an increased quantity demanded in the international market.

Nevertheless, increases in income of consumers and additions to the population are likely to enhance the quantity of rice demanded. Income has the more significant effect on the per capita quantity of rice demanded. Per capita income and population are expected to continue to increase, even though actual growth rates may not be as high as assumed.

Moreover, tastes and preferences towards grain-based foods such as rice, which have been developed among health-concerned Americans in recent years, could lead to a further expansion in domestic rice demand. Increases in the Asian and Hispanic segment of the U.S. population and their influences on eating habits of other segments would also contribute to greater rice consumption in the United States.

Exports

Decoupling will have more significant effects on the export market for U.S. rice. The export demand for U.S. rice is comparatively more price-elastic than domestic demand. In particular, the relationship of the U.S. export price with the world market price (represented by the Thai export price) is the dominant factor in determining the quantity of U.S. rice exported. U.S. rice and Thai rice likely will be traded at nearly the same price; if decoupling lowered the U.S. export price relative to the Thai export price, then U.S. rice will be more competitive in the world rice market.

Possibilities for U.S. rice in the world market also depend on the response of other major rice exporters and producers to such a change in U.S. rice programs and openness of world markets as well as the supply-demand situation of rice and other cereals in rice producing/importing countries. Thailand is expected to continue to improve its efficiency in rice production and the quality of export products. But even without those improvements, Thailand is likely to remain a leader in the world rice market due to their generally low costs of production

Current rice importers may increase their domestic rice production or become self-sufficient in rice and other cereals, as experienced by such traditional importers of U.S. rice as Indonesia and India. But rice supplies in these countries are hardly predictable because rice production is dependent on weather and the availability of key inputs. A small change in rice production in importing countries can cause significant shocks in the world rice trade because the amount traded in the international market is so small compared to the amount produced in the world.

If decoupling is implemented, the United States is not likely to continue export subsidies. Thus, if decoupling were unilateral, U.S. rice exports would be disadvantaged by losing more customers to those nations subsidizing their exports of surplus rice on the international market.

Multilateral decoupling might open new markets for U.S. rice. The most promising customers for U.S. rice would be Japan and South Korea. Multilateral decoupling would raise the world market price due to an increase in export/import demand for rice and could cause U.S. rice production to expand. Under such "unusual" circumstances as a natural disaster in a major rice-consuming country, there might even be a temporary shortage of rice in the world market. In the case of rice, however, major exporters, except for the United States, are all developing countries, which have been competing efficiently without such a high level of price and income support to their producers as provided by the U.S. government. Therefore, multilateral decoupling might benefit other rice exporting countries more than the United States.

Feasibilities and Possible Problems

The feasibility of decoupling and major problems in bringing such a program into implementation must be recognized. Without solving these problems, decoupling of the U.S. rice program is not likely to occur. Politics is a dominant factor in determining the course of the U.S. agricultural policies, as it is in every nation of the world. This is particularly true of U.S. rice, which is thought of as one of the most "political" crops in the United States.

"Political power" of U.S. rice seems to come from rice production confined to a small number of states, which makes political association and negotiation for farm programs easier. And more important, out of the six major rice producing states, five are located in the South, which traditionally returns relatively senior politicians to Congress. The commodity pressure groups, such as the Rice Millers Association, have also been active in fighting any reduction in the level of price and income support. The National Farmers Union claims that the principal purpose of decoupling is to lower farm prices, which can only mean lower farm income and lower land prices (Harsch). Many farmers prefer a deficiency payment, which they get in exchange for meeting planting requirements, to a payment that may be thought of as welfare. Therefore, expected benefits from decoupling must be large enough to compensate for such political objections in order to gain support.

Several questions have arisen in regard to the possibility of "transitional" income support. These issues include: (1) who should receive the payment; (2) whether the payment should be the same for every producer; (3) if not, how the amount of payment to an individual producer should be determined; (4) whether it should be subject to a fixed upper limit per person; (5) if so, how the limit should be determined and how much it should be; (6) whether the payment should be paid only once or over a certain period; (7) if over a period, how long the payment should be paid and whether it should decline each year; and (8) whether the payment should require certain socially desired practices (such as soil conservation). Though there have been a number of proposals such as the one by Senator Boschwitz, none of them has been defined in detail. Unless these criteria for payments are made clear, the groups that resist change in farm programs are unlikely to agree to decoupling. But the reverse is also true. Unless there is a national consensus over decoupling, the political debate is unlikely to generate feasible criteria for payments.

Decoupling may reduce overall government expenditures if the new program is implemented as lump sum payments fixed to each producer. The traditional formulation of support and target price levels places no formal limit on total spending, though the budget process sets upper limits for all programs and there is an upper limit on program payments per person. Such income transfers could be established in terms of total expenditures per year, duration of payments, and the distribution of payments among recipients.

There is a need for mechanisms that improve nonfarm employment opportunities for persons leaving the farm sector. These may include training and counseling for dislocated workers and assistance to such rural areas to pay for rural infrastructure and development. If there are few opportunities outside the farm sector, many farmers will choose to stay in farming. Although there may be regional differences, absorbing those who leave farming will not be easy, as shown by government efforts for rural development in the past. Such assistance may cost the government and taxpayers more than the present programs in the short run.

Unilateral decoupling is likely to have negative effects on the U.S. rice industry because of a decline in rice production and loss in export markets. Therefore, the United States is unlikely to undertake decoupling unilaterally unless other countries agree to a similar elimination of supports for their farmers which distort trade. Except for the case of multilateral decoupling, the United States will be disadvantaged by unilateral decoupling.

The United States proposed multilateral decoupling at the Uruguay Round of the GATT negotiations in 1987. This concept has some appeal to many countries. Yet, the GATT talks indicate that multilateral decoupling will only come about slowly, if at all. The EC emphasizes that it cannot accept the social and political consequences of abandoning its large farm population and would examine the longer-term reform only after managing to freeze and reduce existing supports (Farnsworth). Japan takes a similar position. Taking account of the EC's and Japanese positions, as well as opposition within the United States, it is more realistic to conclude it will take a long time to reach international agreement on multilateral decoupling. In the long run, multilateral decoupling is undoubtedly necessary if decoupling is to occur for rice in the United States.

APPENDIX

Appendix 1
DATA FOR SUPPLY SECTION: ENDOGENOUS VARIABLES

obs	AHCA	AHTX	AHRS
1972	331.0000	468.0000	1019.000
1973	401.0000	549.0000	1220.000
1974	467.0000	562.0000	1507.000
1975	525.0000	548.0000	1745.000
1976	399.0000	508.0000	1573.000
1977	308.0000	501.0000	1440.000
1978	490.0000	558.0000	1922.000
1979	522.0000	557.0000	1790.000
1980	565.0000	586.0000	2161.000
1981	593.0000	579.0000	2620.000
1982	535.0000	474.0000	2253.000
1983	328.0000	318.0000	1523.000
1984	450.0000	408.0000	1944.000
1985	390.0000	329.0000	1773.000
1986	360.0000	289.0000	1711.000
1987	367.0000	269.0000	1697.000

obs	YCA	YTX	YRS
1972	57.00302	47.26923	43.62022
1973	56.16209	37.39526	40.74918
1974	53.76874	44.94306	41.15859
1975	57.48381	45.61314	41.98396
1976	55.18045	48.09055	43.99301
1977	58.15909	46.70659	40.21528
1978	52.20000	47.00000	42.33403
1979	65.21456	42.04309	41.57765
1980	64.40000	42.34471	39.31051
1981	69.01180	47.04491	43.73244
1982	67.00561	46.86498	42.42122
1983	70.39330	43.41195	41.25148
1984	71.24445	49.41177	44.54218
1985	72.99487	54.92705	49.84433
1986	77.01945	62.50173	51.17826
1987	71.00000	59.00000	50.55804

Appendix 2
DATA FOR SUPPLY SECTION: EXOGENOUS VARIABLES

obs	AHCA	AHTX	AHRS
1971	331.0000	468.0000	1019.000
1972	331.0000	468.0000	1019.000
1973	401.0000	549.0000	1220.000
1974	467.0000	562.0000	1507.000
1975	525.0000	548.0000	1745.000
1976	399.0000	508.0000	1573.000
1977	308.0000	501.0000	1440.000
1978	490.0000	558.0000	1922.000
1979	522.0000	557.0000	1790.000
1980	565.0000	586.0000	2161.000
1981	593.0000	579.0000	2620.000
1982	535.0000	474.0000	2253.000
1983	328.0000	318.0000	1523.000
1984	450.0000	408.0000	1944.000
1985	390.0000	329.0000	1773.000
1986	360.0000	289.0000	1711.000
1987	367.0000	269.0000	1697.000

obs	COPCA	COPTX	COPRS
1971	102.6279	128.3439	90.62373
1972	108.5038	135.5286	95.74324
1973	124.1706	154.1801	108.9631
1974	159.4848	199.5127	140.5676
1975	185.7047	235.5276	165.7379
1976	182.0831	229.3387	160.0853
1977	210.5322	218.7072	168.1848
1978	187.2200	197.2599	148.3539
1979	204.4700	219.5618	160.9382
1980	238.3200	269.1933	198.3747
1981	268.1900	298.9346	221.4880
1982	282.7100	308.2251	218.3144
1983	278.8300	297.5451	214.8991
1984	268.9000	331.4600	210.3302
1985	272.0800	347.4924	217.6839
1986	260.9000	327.8789	201.0708
1987	259.1400	326.8525	199.3537

Appendix 2 (Continued)
DATA FOR SUPPLY SECTION: EXOGENOUS VARIABLES

obs	PFECA	PFETX	PFERS
1972	5.270000	5.350000	5.370000
1973	6.830000	6.440000	6.830000
1974	11.10000	14.80000	14.60000
1975	11.70000	10.90000	11.16000
1976	8.250000	8.810000	8.470000
1977	8.250000	8.250000	8.250000
1978	9.150000	9.550000	9.560000
1979	9.050000	9.270001	9.050000
1980	9.550000	11.60000	10.57000
1981	14.10000	12.80000	12.27000
1982	10.85000	10.85000	10.85000
1983	11.40000	11.40000	11.40000
1984	11.90000	11.90000	11.90000
1985	11.90000	11.90000	11.90000
1986	11.90000	11.90000	11.90000
1987	11.66000	11.66000	11.66000

obs	PFCA	PFTX	PFRS
1971	5.240000	5.350000	5.366180
1972	6.830000	6.440000	6.828347
1973	11.10000	14.80000	14.60274
1974	11.70000	10.90000	11.15519
1975	7.650000	8.810000	8.473659
1976	6.910000	7.210000	6.976462
1977	9.150000	9.550000	9.562911
1978	7.060000	9.270001	8.142407
1979	9.550000	11.60000	10.56559
1980	14.10000	12.80000	12.26925
1981	7.350000	10.40000	9.337052
1982	6.650000	8.940000	8.464141
1983	6.960000	9.970000	9.149150
1984	6.430000	8.900000	8.464982
1985	5.330000	7.380000	6.876201
1986	3.180000	4.220000	3.789853

Appendix 2 (Continued)
DATA FOR SUPPLY SECTION: EXOGENOUS VARIABLES

obs	QES	QESW
1971	11434.00	887500.0
1972	5139.000	731250.0
1973	7842.000	890625.0
1974	7058.000	881250.0
1975	36875.00	1215625.
1976	40501.00	1181250.
1977	27398.00	1371875.
1978	31618.00	1684375.
1979	25679.00	1637500.
1980	16493.00	1475000.
1981	48987.00	1356250.
1982	71461.00	1350000.
1983	46919.00	1459375.
1984	64700.00	1715625.
1985	77300.00	1690625.
1986	51400.00	1562500.

Appendix 3
DATA FOR DEMAND SECTION: ENDOGENOUS VARIABLES

obs	QDOM	QEXP	QES
1972	38227.00	54029.00	5139.000
1973	40503.00	49722.00	7842.000
1974	43661.00	69540.00	7058.000
1975	42128.00	56536.00	36875.00
1976	46512.00	65560.00	40501.00
1977	39607.00	72786.00	27398.00
1978	53276.00	75743.00	31618.00
1979	55364.00	82584.00	25679.00
1980	64131.00	91424.00	16493.00
1981	68665.00	81968.00	48987.00
1982	62900.00	68900.00	71461.00
1983	54900.00	70300.00	46919.00
1984	60500.00	62100.00	64700.00
1985	65800.00	58700.00	77300.00
1986	77700.00	84200.00	51400.00
1987	78500.00	72200.00	31400.00

Appendix 4
DATA FOR DEMAND SECTION: EXOGENOUS VARIABLES

obs	PC	PF	PG	POP
1972	1.570000	6.730000	5.270000	209896.0
1973	2.550000	13.80000	6.070000	211909.0
1974	3.020000	11.20000	7.540000	213854.0
1975	2.540000	8.350000	8.520001	215973.0
1976	2.150000	7.020000	6.190000	218035.0
1977	2.020000	9.490000	6.190000	220239.0
1978	2.250000	8.160000	6.400000	222585.0
1979	2.480000	10.50000	6.790000	225055.0
1980	3.120000	12.80000	7.120000	227757.0
1981	2.470000	9.050000	8.010000	230138.0
1982	2.550000	7.910000	8.140000	232520.0
1983	3.210000	8.570000	8.140000	234799.0
1984	2.630000	8.040000	8.000000	237001.0
1985	2.230000	6.530000	8.000000	239279.0
1986	1.500000	3.750000	7.200000	241613.0
1987	1.940000	7.270000	6.840000	243915.0

obs	PT	PUS	PW
1972	8.490000	14.45000	1.760000
1973	26.97000	31.75000	3.950000
1974	19.89000	22.05000	4.090000
1975	13.76000	18.35000	3.550000
1976	12.49000	14.95000	2.730000
1977	16.39000	21.70000	2.330000
1978	15.44000	18.30000	2.970000
1979	18.61000	22.05000	3.780000
1980	22.38000	25.55000	3.910000
1981	17.25000	21.15000	3.660000
1982	12.71000	18.70000	3.550000
1983	12.62000	19.90000	3.510000
1984	10.90000	18.70000	3.390000
1985	10.22000	16.85000	3.080000
1986	10.03000	11.60000	2.420000
1987	13.35000	19.85000	2.570000

Appendix 4 (Continued)
DATA FOR DEMAND SECTION: EXOGENOUS VARIABLES

obs	QDOM	QESW	QGEXP
1971	37120.00		
1972	38227.00	731250.0	35000.00
1973	40503.00	890625.0	19125.00
1974	43661.00	881250.0	24843.75
1975	42128.00	1215625.	19062.50
1976	46512.00	1181250.	22031.25
1977	39607.00	1371875.	18125.00
1978	53276.00	1684375.	16500.00
1979	55364.00	1637500.	22125.00
1980	64131.00	1475000.	25375.00
1981	68665.00	1356250.	12125.00
1982	62900.00	1350000.	25093.75
1983	54900.00	1459375.	33875.00
1984	60500.00	1715625.	34875.00
1985	65800.00	1690625.	25406.25
1986	77700.00	1562500.	35937.50
1987		1321875.	29781.25

obs	QS	YPC	GNPDEF
1971			44.40000
1972	97395.00	4000.076	46.50000
1973	98067.00	4482.112	49.60000
1974	120259.0	4855.649	54.00000
1975	135539.0	5291.402	59.30000
1976	152573.0	5744.949	63.00000
1977	139791.0	6262.742	67.30000
1978	160637.0	6969.023	72.20000
1979	163627.0	7683.900	78.60000
1980	172048.0	8420.817	85.70000
1981	199620.0	9244.889	93.90000
1982	203238.0	9725.614	100.0000
1983	171941.0	10341.19	103.9000
1984	187299.0	11259.87	107.9000
1985	201800.0	11863.56	111.2000
1986	213300.0	12497.67	113.9000
1987	182300.0	13159.09	117.7000

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