ECONOMIC FACTORS AFFECTING RICE PRODUCTION IN THAILAND

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ABSTRACT
The general objective of this study iss to identify and measure the relative magnitude of effect of the key economic factors affecting Thai rice producer planting decisions using an econometric model of the area planted to rice in Thailand. The results suggest that area planted to rice in Thailand is more responsive to changes in area planted in previous years, the amount of rainfall, and the availability of agricultural labor than to changes in paddy rice prices. An important implication of the study is that policies to reduce rural labor shortages could do more to enhance the production of rice in Thailand than annual adjustments in the level of the guaranteed price of rice received by producers.

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EXECUTIVE SUMMARY

Relatively little is known about the economic forces that affect rice production in Thailand. As a consequence, production and policy decisions in the Thai rice sector are often inefficient and ineffective. The general objective of this study is to identify the key economic factors affecting Thai rice producer planting decisions and quantitatively measure their relative statistical significance and magnitude of impact on the area planted to rice in Thailand over time. The conclusions of this study provide a benchmark against which the future and perhaps more in-depth studies of Thai rice production can be compared. Additionally, the insight gained from this study may prove useful in improving decision-making by both rice producers and policymakers in Thailand.

After reviewing the rather sparse literature on the economic factors affecting rice production in Thailand and some related research relevant to this study, a qualitative analysis of rice production in Thailand is provided as background to the subsequent conceptual and quantitative analysis. Based on the literature review and the review of the characteristics of rice production in Thailand, a conceptual model for the area planted to rice in Thailand is developed which provides the basis for developing the empirical model used for the analysis of rice producer behavior in planting rice. The explanatory variables in the empirical model include lagged area planted, the annual amount of rainfall, paddy rice prices, and the availability of agricultural labor. Many models were tested, most of which used different prices (nominal vs. real, lagged vs. current) to represent producer expectations.

In general, the analytical results suggest that the area planted to rice in Thailand is more responsive to past changes in area planted, the amount of rainfall, and the availability of agricultural labor than to changes in paddy rice prices. The results also indicate that the area planted to rice adjusts relatively slowly from year to year which is consistent with the fact that Thai rice farmers face numerous infrastructure, technology, credit, and other factors that constrain annual rice production decisions. The rice area planted is also found to be marginally more sensitive to current market price than to the price of paddy rice in the period just prior to planting. This result may be a consequence of the guaranteed rice price policy operated by the Thai government.

The area planted to rice in Thailand is also found to be positively and significantly related to nominal rice prices but not significantly related to real, deflated prices of rice. In Thailand, rice cultivation is not just food production but a part of the Thai culture. Rice farming is passed on from one generation to the next. Farmers rely on their rice production for household consumption and sell any excess. Even if there were technically viable substitutes available for rice, Thai farmers do not have sufficient knowledge or training to allow them to quickly adjust

the composition of crops planted in response to relative price changes. Also, few purchased inputs are used in the Thai rice production. Thus, from the Thai farmers' perspective, there are virtually no substitutes for rice and few variable inputs other than family labor which is consistent with the finding that nominal rather than deflated prices are most relevant in Thai rice producer decisions regarding adjustments in the area planted to rice.

Perhaps the most important implication of this study for policymaking is that policies to reduce rural labor shortages could do more to enhance the production of rice in Thailand than annual adjustments in the level of the guaranteed price of rice received by producers. Variability of rainfall is also an important constraint to the growth of rice production suggesting the importance of government investment in irrigation systems to reduce the risk of water shortages that rice producers frequently face.

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Rice plays a key role in Thailand's economy and society. Lofgren claims rice "is by far the single most important component of the Thai diet and provides food security for the poorest." Rice is also Thailand's second largest source of foreign exchange income (Lofgren). Therefore, a significant amount of land is dedicated to growing rice. According to Phélinas, rice accounts for about 50% of the total cultivated crop area. Relatively little is known, however, about the economic forces that affect rice production in Thailand. As a consequence, production and policy decisions in the Thai rice sector are often inefficient and ineffective.

The general objective of this study is to identify the key economic factors affecting Thai rice producer planting decisions and quantitatively measure their relative statistical significance and magnitude of impact on the area planted to rice in Thailand over time. The conclusions of this study provide a benchmark against which the future and perhaps more in-depth studies of Thai rice production can be compared. Additionally, the insight gained from this study may prove useful in improving decision-making by both rice producers and policymakers in Thailand.

After reviewing the rather sparse literature on the economic factors affecting rice production in Thailand and some related research of relevance to this study, a qualitative analysis of rice production in Thailand is provided as background to the subsequent conceptual and quantitative analyses. Based on the literature review and the qualitative analysis of the characteristics of rice production in Thailand, a conceptual model of the behavior of Thai rice producers is then presented. The parameters of the model are estimated with data collected from various sources. Finally, conclusions and implications for decision makers in the Thai rice industry are provided.

Previous Economic Studies of Thai Rice Production

A few researchers have attempted an analysis of the factors affecting Thai rice supply and demand, only two of which have included the estimation and analysis of area planted. Insight relevant to factors that may affect Thai rice production can also be gained from research conducted by researchers on rice production in other countries.

Economic Studies of Thai Rice Area Planted

A notable study by Wattnutchariya analyzed rice supply and demand in Thailand. His model includes a representation of Thai rice planted area as a function of the amount of rainfall during the year, irrigated area as a proportion of area planted, and the lagged nominal farm price of paddy rice. He uses data for 1962 to 1975 to econometrically estimate the model parameters. The results suggest that both lagged nominal farm price and the amount of rainfall are significant determinants of the area planted to rice in Thailand with the lagged farm price dominating. The irrigated area as a proportion of area planted was statistically insignificant. The model explained only about half (52%) of the variation in rice planted area over the sample period.

Petcharatana also econometrically estimated the parameters of the area planted to rice in Thailand using data for 1958 to 1977. The estimating equation included only the lagged area planted and the real lagged wholesale price as regressors. Although both regressors were found to be statistically significant, the Petcharatana model explained only 73.8% of the variation in the area planted to rice in Thailand over the sample period.

Relevant Studies for Other Countries

Although relatively few studies of rice producer behavior have focused specifically on Thailand, some insights may be gained for Thailand from such studies of other Asian countries. For example, Rahman conducted a study of rice demand and supply in Bangladesh and Pakistan. His study included equations for rice planted acreage in those two countries in which the dependent variables were the ratio of rice acreage to total acreage of rice and its competing crops (jute and cotton). Independent variable included lagged ratios between the prices of rice and competing crops and time trend. For Bangladesh, he concludes that both the rice to jute price ratio and time trend were statistically significant at the 1% level. In contrast, all price ratios were insignificant for Pakistan while time trend was significant only at the 20% level. The estimated short-run price elasticities of supply were 0.036 and 0.041 for Bangladesh and Pakistan, respectively. The R^2's were respectively 0.74 and 0.39. Price ratios were later dropped from both acreage equations in order to increase the R^2. In Rahman's final analysis, two models with absolute acreage as the dependent variable and only trend as an explanatory variable were used. In both of those models, trend was found to be significant at the 1% significance level with a positive relationship to the acreage ratio. The final R^2's for Bangladesh and Pakistan were respectively 0.89 and 0.94.

A study by Bogahawatte for Sri Lanka included equations for rice area irrigation, lagged rainfall, the proportion of total rice area plated to modern varieties, agricultural credit, the area under crop insurance, the lagged paddy area under production, and a ratio of the guaranteed price of paddy rice to a weighted average of the guaranteed prices of substitute food crops. For the wet zone, Bogahawatte found that only the proportion of rice area planted to modern varieties was statistically significant (5% significance level). For the dry zone, lagged rainfall, the proportion of rice area planted to modern varieties, the area under crop insurance, and the ratio of guaranteed prices were all statistically significant at the either the 1% or 5% level. The R^2's were 0.559 and 0.870 for the wet and dry zones, respectively.

A study by Mellish of U.S. rice acreage in five states (Mississippi, Texas, Louisiana, Arkansas, and California) used harvested acreage as the dependent variable. The independent variables in this study included lagged nominal prices of rice multiplied by the ratio of allotted acreage to potential acreage, carryover stock, lagged area harvested, and technology (represented by a time trend). The lagged price variable was insignificant for most states, except Arkansas and Louisiana, where they were significant at the 10% level. Rice stocks were significant at the 1% level in both Texas and Louisiana but significant at the 10% level in Mississippi. The lagged area harvested was significant at the 5% level in Arkansas. Technology was significant at the 1% significant level in Texas and Louisiana but at the 5% level in California.

A later study of rice production in the same five major U.S. rice producing states by Beach, Grant, and Lin estimated the area planted to rice in each state as a function of lagged area planted, lagged farm price, and an adjustment factor for acreage restrictions. All independent variables were found to be statistically significant and the R^2 for the state acreage planted models ranged from 0.71 to 0.90.

Summary of Literature on the Economics of Rice Area Planted

The studies reviewed provide important insights for analyzing the factors affecting the area planted to rice in Thailand. Wattnutchariya and Petcharatana provide key insight on appropriate explanatory variables such as lagged area planted, rainfall, and rice prices for estimating Thai rice area planted equations. Curiously, the two studies included some questionable explanatory variables and failed to include a number of seemingly important ones. In Petcharatana's study, for example, the real lagged wholesale price was used instead of the real lagged paddy price, which would have been more appropriate for estimating rice farmer price response. Also, Petcharatana does not include rainfall as an explanatory variable despite the apparent dependence of Thai rice production on rainfall. Both the Petcharatana and Wattnutchariya studies are quite dated. Also, the models they used provided relatively poor fits of the data.

Although Rahman provides some evidence of the importance of rice prices and the prices of substitute crops in rice planting decisions in Asian countries (Bangladesh and Pakistan), his final models include only trend as a proxy for technological change as explanatory variables in order to maximize the fit.

The rice models used by Bogahawatte, Mellish, and Beach, Lin and Grant included specifications for the area planted to rice that were similar to those used by Petcharatana, Wattnutchariya, and Rahman. However, they also included a number of policy variables such as acreage restrictions, guaranteed prices, and others. In most cases the policy variables were found to be statistically significant. The implication is that policy may play an important role in determining the area planted to rice in most countries, including Thailand.

Despite the insights provided by these studies for analyzing rice producer behavior in Thailand, none of them provide current estimates of the relationship between key economic factors and rice production specifically for Thailand. Rice production practices, technology, rice policy, and overall economic conditions in Thailand have all changed substantially over time. A more recent study of the economic factors affecting the area planted to rice could come to quite different conclusions which would be important for decision makers at all levels in the Thai rice industry.

Background on Rice Production in Thailand

Thailand is the world's largest exporter of rice, accounting for approximately 30% of the world market. According to Phélinas, rice accounts for 30% of the total value of agricultural production in Thailand and 12% of the value of all Thai agricultural exports. Rice-growing households constitute 75% of the 5 million Thai farming families, accounting for nearly 50% of the agricultural labor force.

Thai rice can be divided into four main types: (1) white, (2) cargo, (3) white glutinous, and (4) parboiled. Each rice type contains different grades as summarized in Table 1. Rice primarily grows in four regions of Thailand: (1) Central, (2) Northeast, (3) Northern, and (4) Southern. The Central Region has perhaps the greatest advantage in production due to the high productivity of the land and the advanced technology used (Yusenas). In 1994/95, the paddy rice production in the Central region accounted for about 30% of total production. The Northeast, however, is where the most production occurs, especially of glutinous and jasmine rice. In 1994/95, almost 40% of total rice production came from the Northeast region (Yusenas).

Rice land can be categorized into four types as well: (1) irrigated with regional surface water, (2) irrigated with local groundwater drawn from shallow aquifers, (3) rainfed lowland, and (4) rainfed upland ecosystems. Most of the rice in Thailand is directly affected by rainfall with rainfed lowlands accounting for approximately 75% of the wet season rice area and 68% of production (Kupkanchanakul). Groundwater and rainfed upland areas account for a further 1.92% and 0.58% of the wet season rice area and about 1.17% and 0.32% of production, respectively.

Typically, the Thai rice growing season starts in May and ends in September. The three critical requirements for rice production in Thailand are: (1) constant and uniform flooding; (2) even but slightly sloped land with a good irrigation system for continual cycles of water flow, and (3) the ability of the soil to provide 90% of the rice field with a constant water depth of 2-3 inches of water for the entire growing season. A number of other factors are also necessary for efficient rice production. As noted, dependable and consistent rainfall is needed. However, rainfall is also captured and used for irrigating the fields as needed when rainfall is less than expected. A good irrigation system is necessary because most rice varieties cannot produce if moisture levels vary dramatically. An advanced irrigation system provides sufficient control of the water flow, in and out of

Table 1: Thai Rice Grades

White rice	Cargo rice	White glutinous rice	Parboiled rice
100% Grade A	100% Grade A	10%	100% Sorted
100% Grade B	100% Grade B	25%	100%
100% Grade C	100% Grade C	Broken A1	5% Sorted
5%	5%		5%
10%	10%		10% Sorted
15%	15%		10%
25% Super			15%
25%			25%
35%			Broken A1
45%			
Broken A1 Extra Super			
Broken A1 Super			
Broken A1 Special			

Source: Narainakorn

the field. Temperature is also important as low temperatures can retard or stunt plant growth (Anonymous). Because rice production is labor-intensive, labor shortages can impose constraints directly on rice growing. In recent years, rapidly growing rural to urban migration has created increasingly severe labor shortages in rural Thailand during the rice planting and harvesting periods when the labor requirements are the highest.

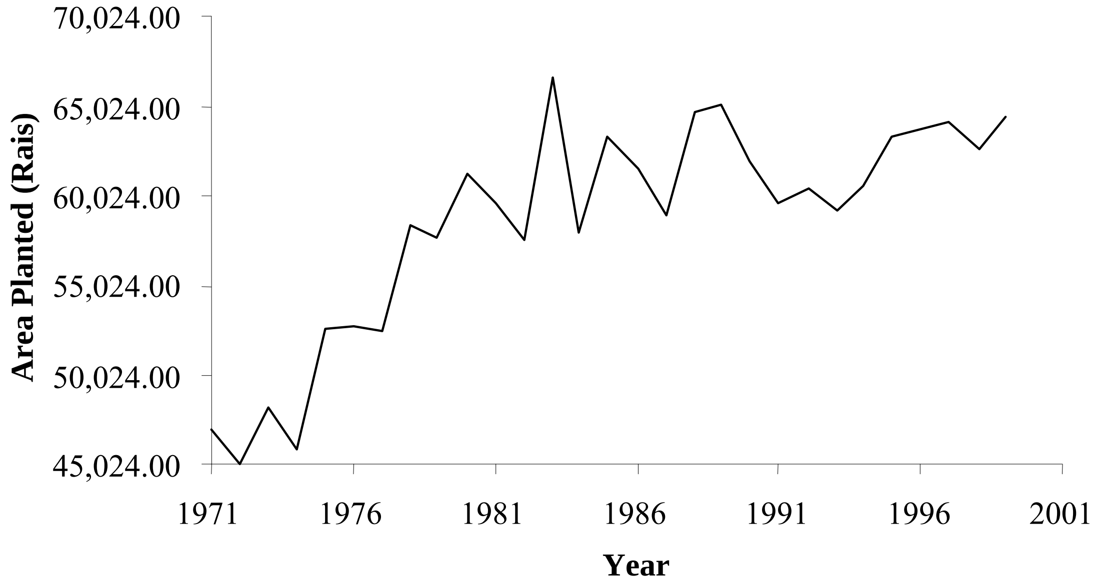
During the 1970s through the 1980s, the area planted to rice in Thailand grew at an annual rate of approximately 20% but leveled off in the 1990s (Figure 1). Average yields increased only by 1.7% annually so that average total production increased by only 3.0% annually over the same time period (Figures 2 and 3). The rise in both yield and production was due primarily to increases in total irrigated and dry season rice production (Kupkanchanakul). Nominal paddy rice prices between 1971 and 1999 increased approximately 8% annually (Figure 4). During the 1970s and 1980s, the Thai agricultural labor force increased about 2% annually. Since 1990, the agricultural labor force in Thailand has experienced a negative average rate of growth with sharp declines in some years and increased instability (Figure 5).

Conceptual Model of Rice Production

Rice production in any country is the result of producers' planting decisions in each year and can be represented mathematically as:

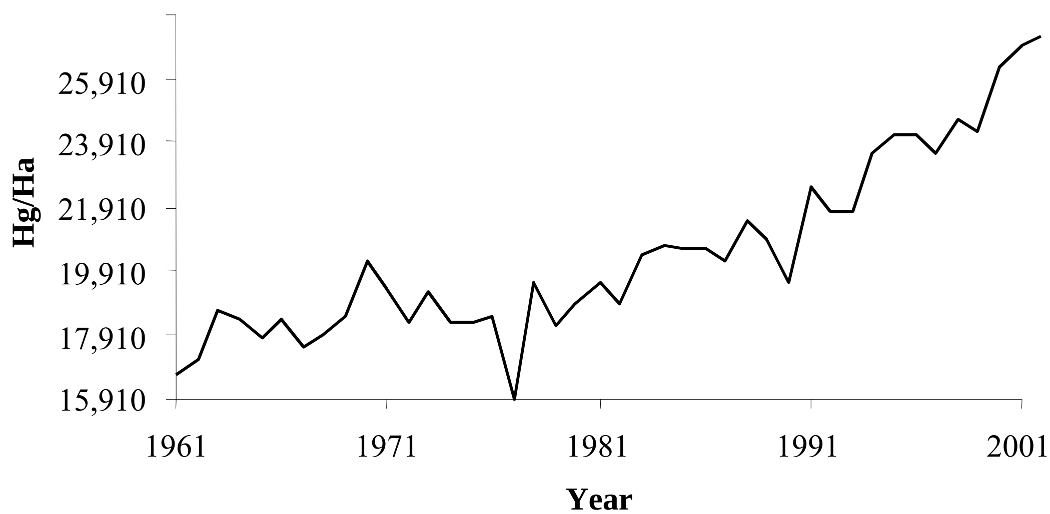
(1) $S_t = H_t * Y_t$

Figure 1: Area Planted to Rice in Thailand, 1971-1999



Source: Ministry of Agriculture and Co-operation, Thailand

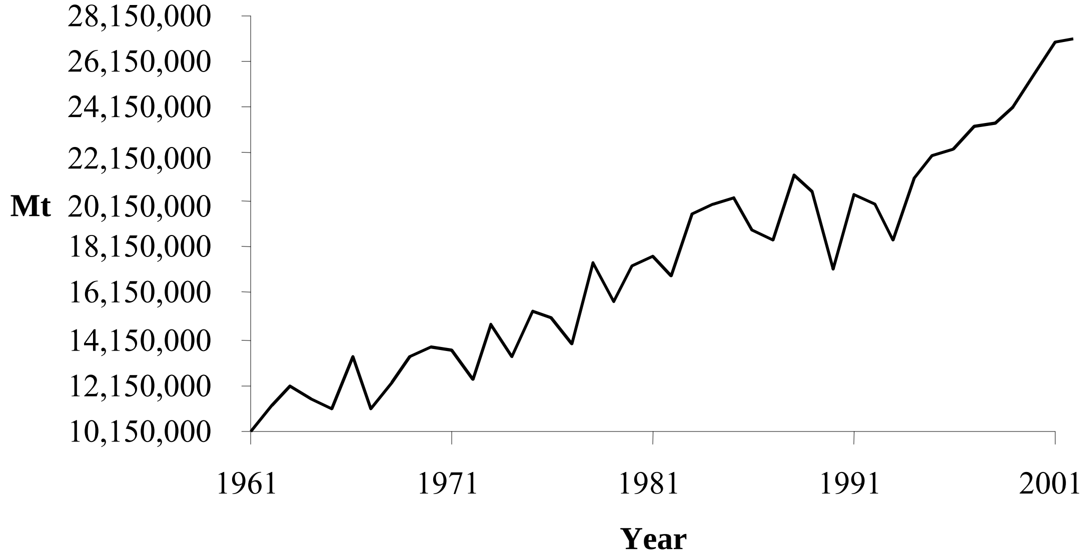
Figure 2: Thai Paddy Rice Yields, 1961-2001



Hg = Hectograms (100 grams)

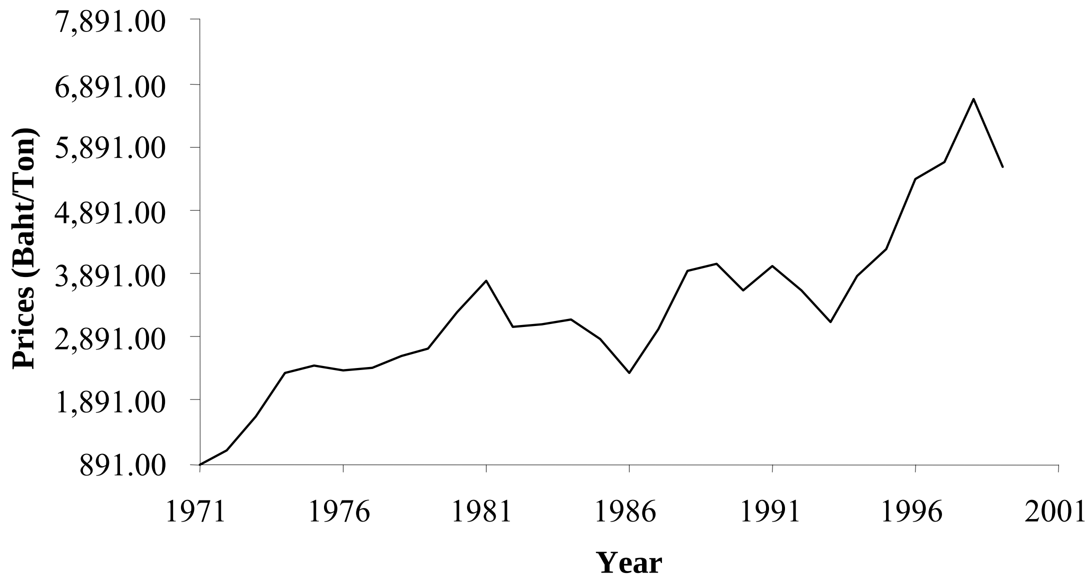
Source: http://apps.fao.org

Figure 3: Thailand Rice Production (Paddy), 1961-2001



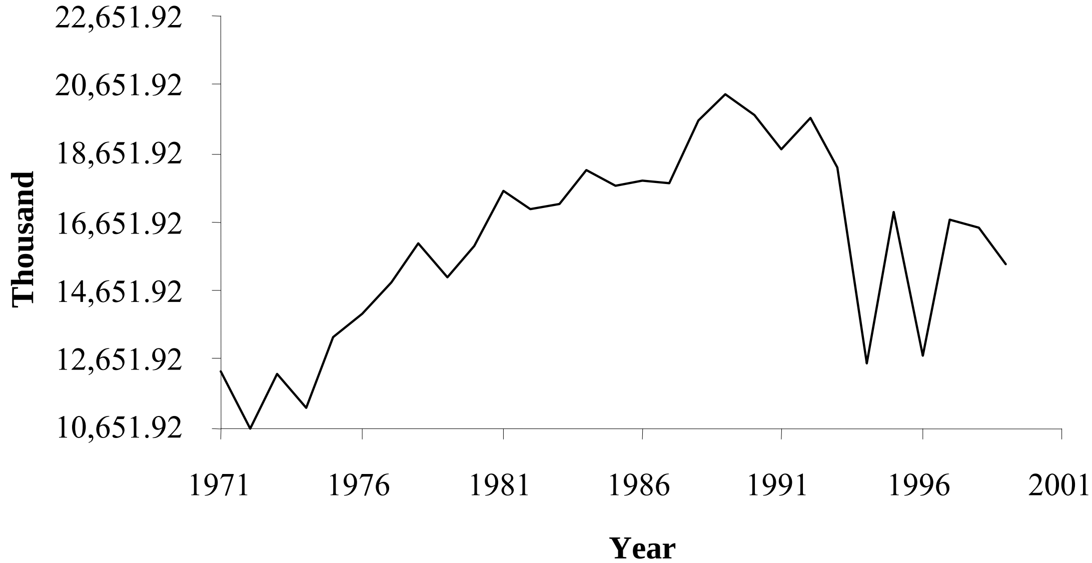
Source: http://apps.fao.org

Figure 4: Thai Paddy Prices, 1971-1999



Source: Ministry of Agriculture and Co-operation, Thailand

Figure 5: Thai Agricultural Labor Force, 1971-1999



Source: Labor Force Survey, National Statistical Office, Thailand

where S is the quantity of rice produced, H is the rice area harvested, Y is the yield of rice per unit of area (acre or hectare), and t represents the current time period. The area harvested is a function of the area planted by producers as affected primarily by weather and possibly some economic variables. Likewise, yield is a function of weather but also of technical change. Thus, the principal behavioral variable is the area planted to rice. In other words, the variable that is most directly affected by rice producer decisions is not production per se but rather the area planted to rice. Production each year, then, is what results from those decisions as affected primarily by weather and technological change.

Theoretically, in any period t, the desired area to be planted each year (A^d) is a function of expected price (P^e), weather (W), and other explanatory factors (Z):

(2) $A_t^d \; f\,(P_t^e, W_t, Z_t)$.

In this study, weather is defined as the amount of rainfall and Z_t includes the availability of agricultural labor. The availability of agricultural labor is included as an explanatory variable in this equation because labor shortages have reportedly had a negative impact on rice production in Thailand, as suggested in the previous section.

The relationships between these variables can be represented as the following linear equation:

(3) $A_t^d = \alpha_0 + \alpha_1 P_t^e + \alpha_2 R_t + \alpha_3 L_t$

where R_t is anticipated level of rainfall, L_t is the projected availability of labor, and α_0, α_1, α_2, and α_3 are the parameters to be estimated.

Farmers are generally unable to respond to sudden changes in economic conditions. Therefore, actual changes in planted area from year to year are usually less than desired due to time and resource constraints. Assuming partial adjustment, the actual change in area planted in time t is specified a fraction (δ) of the difference between desired area planted in time t and the actual area planted at time t-1 (Labys 1973):

(4) $A_t - A_{t-1} = \delta\,(A_t^d - A_{t-1})$

where $0 \leq \delta \leq 1$ and is defined as the coefficient of adjustment which measures the speed with which actual area planted adjusts in response to factors influencing desired area planted. This equation can be rearranged to obtain an equation for A_t^d:

$$\delta A_t^d = A_t - A_{t-1} + \delta A_{t-1}$$

$$A_t^d = [A_t - (1-\delta)A_{t-1}]/\delta$$

(5) $A_t^d = A_t/\delta - [(1-\delta)/\delta]\ A_{t-1}$

Now, substituting equation (5) into equation (3), we derive equation (6):

$$A_t/\delta - [(1-\delta)/\delta]\ A_{t-1} = \alpha_0 + \alpha_1 P_t^e + \alpha_2 R_t + \alpha_3 L_t$$

$$A_t - (1-\delta)\ A_{t-1} = \delta\alpha_0 + \delta\alpha_1 P_t^e + \delta\alpha_2 R_t + \delta\alpha_3 L_t$$

(6) $A_t = \delta\alpha_0 + \delta\alpha_1 P_t^e + \delta\alpha_2 R_t + \delta\alpha_3 L_t + (1-\delta)\ A_{t-1}$

Assuming naive price expectations such that $P_t^e = P_{t-1}$, equation (6) becomes the following for estimation:

(7) $A_t = \beta_0 + \beta_1 P_{t-1} + \beta_2 R_t + \beta_3 L_t + \beta_4 A_{t-1}$

The lagged area planted is intended to capture the effects of fixed production factors such as equipment, technical expertise, and other inputs. Such factors imply that the area planted in year t is determined to some extent by how much area was planted in year t-1 (Petcharatana). All of the independent variables are expected to have a positive effect on rice area planted.

Data and Econometric Estimation Results

Secondary data on area planted to rice in Thailand and the independent variables (such as the paddy rice price, rainfall, etc.) were used to estimate the parameters of the model. These data were obtained from several sources, including the Division of Agricultural Economics, Office of the Thailand Under-Secretary of State; the Thai Ministry of Agriculture & Co-Operatives; the Thai Department of Agricultural Extension Service, Division of Agricultural Economics, Thailand; and the Meteorological Department of Thailand. Data for all variables in the model were available only for the period 1971 through 1999 (Table 2).

To estimate the parameters of equation (7), the real producer price of rice should be used because relative and not nominal price changes are theoretically most relevant for producer decision-making. Of course, if the cost of producing rice increases relative to the nominal price producers expect to receive for the rice they sell, producers will have a tendency to reduce the area plated to rice. Likewise, if the expected nominal prices of alternative crops increase relative to the expected nominal price of rice, farmers will tend to switch to the production of the alternative crops. An input price index for rice production in Thailand would be an appropriate deflator since it reflects the adjusted annual cost of rice production. Unfortunately, such an index is not published in Thailand. Likewise, the government does not publish an index of prices received by agricultural producers in Thailand. Prices of competing crops could be used to represent the opportunity cost of producing rice. However, in Thailand, there are no other crops that are potential close competitors with rice due to historical and cultural factors.

Consequently, to deflate the nominal paddy price of rice received by producers, two alternative price indices were tried: (1) the Thai producer price index (PPI) which is the index of prices received by producers of all goods in Thailand and (2) the GDP (Gross Domestic Product) deflator which represents wholesale price changes.

The results of estimating equation (7) with price deflated by the alternative deflators are given in Table 3 as Models 1 and 2, respectively. Because the estimated coefficients for the deflated rice price in both models were negative rather than positive as expected, the two models were re-estimated using current rather than lagged price because the price data is annual (January to December) and the production data is on a May/April crop year basis. Using "current" prices implies at least reasonably accurate rice price forecasting by producers. The estimation results are given in Model 3 and Model 4 in Table 3. In Models 3 and 4, the estimated coefficients of the real prices are still negative and statistically insignificant.

Two reasons might help explain these findings. First, the Producer Price Index and the GDP deflator may be inappropriate since they capture not only changes in prices of agricultural commodities but also of many other commodities that have little relation to rice. To rice farmers, the prices of non-agricultural products such as automobiles are likely irrelevant when deciding how much to plant as these commodities represent neither substitute crops or costs of production for rice producers in Thailand. Relevant indices would be those for prices of alternative crops or production input costs, both of which are unavailable for Thailand.

A second explanation for the unexpected results for the estimated coefficients for rice price may be that rice cultivation is not just food production but a part of culture in Thailand. As a consequence, Thai rice production may not be particularly sensitive to price changes. Rice farming is passed on from one generation to the next. Typically,

Table 2: Data Used in the Thai Rice Planted Area Model, 1971-1999

Year	Area Planted (A)	Lagged Area Planted (A_{t-1})	Average Rainfall (R)	Paddy Prices (P)	Agricultural Labor Force (L)
	(1,000 rais[a])	(1,000 rais[a])	(millimeters)	(baht/tonne)	(1,000 workers)
1971	47,043.00	46,840.00	1,581.00	891.00	12,321.69
1972	45,024.00	47,043.00	1,418.00	1,125.00	10,651.92
1973	48,188.00	45,024.00	1,550.00	1,612.00	12,270.48
1974	45,804.00	48,188.00	1,698.65	2,344.00	11,226.27
1975	52,571.00	45,804.00	1,886.55	2,445.00	13,270.04
1976	52,746.00	52,571.00	1,658.63	2,377.00	13,948.39
1977	52,492.00	52,746.00	1,414.45	2,416.00	14,921.90
1978	58,410.00	52,492.00	1,654.83	2,607.00	16,018.00
1979	57,637.00	58,410.00	1,346.13	2,700.00	15,028.50
1980	61,276.00	57,637.00	1,645.46	3,265.00	15,942.60
1981	59,529.00	61,276.00	1,555.47	3,765.00	17,517.30
1982	57,576.00	59,529.00	1,525.33	3,033.00	16,984.90
1983	66,682.00	57,576.00	1,652.34	3,100.00	17,107.20
1984	57,914.00	66,682.00	1,530.40	3,176.00	18,130.20
1985	63,422.00	57,914.00	1,566.39	2,871.00	17,664.40
1986	61,571.00	63,422.00	1,608.11	2,342.00	17,815.50
1987	58,888.00	61,571.00	1,514.09	3,015.00	17,799.10
1988	64,677.00	58,888.00	1,762.64	3,932.00	19,576.30
1989	65,218.00	64,677.00	1,433.97	4,059.00	20,401.90
1990	61,910.00	65,218.00	1,521.12	3,618.00	19,725.60
1991	59,671.00	61,910.00	1,447.85	3,998.00	18,777.30
1992	60,453.00	59,671.00	1,368.37	3,640.00	19,704.70
1993	59,251.00	60,453.00	1,452.53	3,131.00	18,244.50
1994	60,677.00	59,251.00	1,750.40	3,867.00	12,549.70
1995	63,353.00	60,677.00	1,680.00	4,278.00	16,929.20
1996	63,728.00	63,353.00	1,632.41	5,388.00	12,765.30
1997	64,189.00	63,728.00	1,390.92	5,659.00	16,691.00
1998	62,699.00	64,189.00	1,419.10	6,661.00	16,471.70
1999	64,445.00	62,699.00	1,855.56	5,579.00	15,399.40

[a] 1 rai = 0.4 acre.

Table 3: Estimation of Thai Area Planted to Rice with Alternative Price Deflators

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Model 1 (Lagged price deflated by PPI)

$$A_t = -658.4 + 0.593A_{t-1} + 11.009R_t - 0.395PR_{t-1} + 0.603L_t$$
$$\quad (14650.2) \quad (0.151) \quad (4.747) \quad (0.898) \quad (0.337)$$

$R^2 = 0.694$ $\bar{R}^2 = 0.638$ AIC = 16.184 DW(h) = -2.091

Model 2 (Lagged price deflated by the GDP deflator)

$$A_t = 414.01 + 0.575A_{t-1} + 11.005R_t - 0.452PRG_{t-1} + 0.632L_t$$
$$\quad (13729.2) \quad (0.153) \quad (4.699) \quad (0.668) \quad (0.336)$$

$R^2 = 0.698$ $\bar{R}^2 = 0.643$ AIC = 16.172 DW(h) = -1.973

Model 3 (Current price deflated by PPI)

$$A_t = -6900.34 + 0.624A_{t-1} + 12.210R_t - 0.081PR_t + 0.659L_t$$
$$\quad (12532.6) \quad (0.143) \quad (4.321) \quad (0.958) \quad (0.324)$$

$R^2 = 0.757$ $\bar{R}^2 = 0.715$ AIC = 16.157 DW(h) = -2.178

Model 4 (Current price deflated by the GDP deflator)

$$A_t = -5078.47 + 0.606A_{t-1} + 12.358R_t - 0.271PRG_t + 0.662L_t \qquad (8)$$
$$\quad (11789.8) \quad (0.148) \quad (4.316) \quad (0.699) \quad (0.316)$$

$R^2 = 0.759$ $\bar{R}^2 = 0.717$ AIC = 16.151 DW(h) = -2.127

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* Numbers in parentheses below the estimated coefficients are the standard errors

Table 4: Estimation of Thai Area Planted to Rice Using Nominal Rice Prices

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Model 5 (Lagged nominal price of rice)

$$A_t = 1562.257 + 0.421A_{t-1} + 10.593R_t + 1.25P_{t-1} + 0.746L_t$$
$$\quad (10557.2) \quad (0.172) \quad (4.071) \quad (0.660) \quad (0.294)$$

$R^2 = 0.813$ $\bar{R}^2 = 0.782$ AIC= 15.993 DW(h) = -2.896

Model 6 (Current nominal price of rice)

$$A_t = 3707.276 + 0.328A_{t-1} + 10.258R_t + 1.584P_t + 0.898L_t$$
$$\quad (9790.7) \quad (0.170) \quad (3.842) \quad (0.613) \quad (0.290)$$

$R^2 = 0.832$ $\bar{R}^2 = 0.804$ AIC = 15.886 DW(h) = -2.206

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* Numbers in parentheses below the estimated coefficients are the standard errors

farmers rely on their rice production for household consumption and sell any excess. Most Thai farmers are people with low incomes and limited education. So even if there are technically viable substitutes available for rice, farmers usually do not have sufficient knowledge or training to allow them to adjust the composition of crops planted quickly in response to relative price changes. At the same time, very few purchased inputs are used in the production of rice in Thailand so that changes in the cost of typical inputs may also have little impact on rice producer behavior. Thus, from the farmers' point of view, there are virtually no substitutes for rice and few variable inputs other than family labor. This suggests that perhaps nominal rather than real prices might be more appropriate for estimating the area planted to rice in Thailand as was done by Wattnutchariya.

Consequently, the parameters of equation (7) were estimated once again but this time using lagged nominal price and then using current nominal price. The estimation results are presented in Models 5 and 6 in Table 4. In Model 5 (lagged nominal rice price), lagged area planted, rainfall, and agricultural labor force are all statistically significant at the 5%. The lagged nominal paddy rice is significant at the 10% level. All of the independent variables, including price, display the expected signs.

While the results for Model 6 are quite similar to those of Model 5, the R^2 is higher and the Akaike Information Criteria (AIC) is lower than is the case for Model 5. The AIC involves a trade-off between minimizing the SSE and limiting any increase in the number of explanatory variables (Griffiths, Hill, and Judge). Thus, a lower AIC is generally preferred. In Model 6, all the independent variables were found to be significant at the 5% significance level except lagged area planted which is significant at the 10% level.

Interestingly, the current price (P_t) in Model 6 is marginally superior to the lagged price (P_{t-1}) in Model 5 in explaining the area planted to rice in Thailand. This might be the result of certain rice price policies, such as the guaranteed price floor. Prior to the beginning of the planting season, the government announces a minimum price that it will be willing to pay for paddy rice at harvest. At the end of the harvest season, rice farmers can option to sell their paddy rice to the government if the market price is below the guaranteed price. Because market prices have been close to or equal to the guaranteed price in most years, the current market price reflects the announced guaranteed price and is the effective expected selling price so that farmers tend to disregard prices in past periods when making production decisions.

Nevertheless, because the area planted data are on a crop year basis and the price data are on an annual basis, there is some question as to whether "current" or "lagged" prices better reflect the price producers consider when making production decisions. Thai rice is planted and harvested two times during the year. The first crop is typically grown in the rainy season. The growing period for the first crop is generally between May and November each year depending on the region. The second crop is planted immediately after the first crop is harvested and generally utilizes irrigated water. Second crops are primarily regional and are planted in the Central part of Thailand where irrigation systems are more advanced. Planting and harvesting periods are summarized in Table 5.

Table 5: Thai Rice Planting and Harvesting Calendar

Crop by Region	Planting Season	Harvest Season
First crop		
North region	May-June	Nov-Jan
Northeast region	June-July	Nov-Jan
Central region	June-Aug	Nov-Feb
South region	Feb-Nov	Mar-Nov
Second crop		
North region	Jan-Mar	May-Jul
Central region	Feb-May	June-Aug

Source: Yusenas

The Thai rice planting and growing season starts in about the middle of the year. In making planting decisions, farmers consider prices in the time period just prior to planting. In Thailand, the prices relevant to planting decisions are actually the prices from about May of the previous year. Thus, for example, the relevant price for the crop planted in May to June of a given year is the average price over the previous 12 month period. Because the available farm-level price data are for January to December of each year, the problem is that the price data for the calendar year in which the crop was planted include price information beyond the planting period, which is not relevant to that year's planting decisions. At the same time, however, the price data for the previous calendar year does not include price information for the first months of the year just prior to planting that is important to planting decisions. Consequently, rather than either the current or previous calendar year prices, a more relevant expected price for rice planting decisions might be the average of the two prices which span the planting decision period.

To test this hypothesis, a new price variable ($PA_t = (P_t+P_{t-1})/2$) was used as the expected price variable in estimating equation (7) and the parameters of the equation re-estimated with and without deflating the price variable by the PPI and the GDP deflator. The results are provided in Models 7, 8, and 9 in Table 6. In Model 7 (Table 6), all independent variables are significant at the 5% level of significance except the lagged area planted which is significant at the 10% level. Also, the signs of all estimated coefficients, including the price variable, are consistent with *a priori* expectations. The R^2 for Model 7 is higher than is the case for Model 5 but lower than for Model 6 while the AIC is lower than for Model 5 but higher than for Model 6 (see Table 4). The estimated coefficients of the deflated price variables in Models 8 and 9 are again negative as was the case for Models 1 through 4.

Table 6: Estimation of Thai Area Planted to Rice Using Average Rice Price

Model 7 (Nominal average price)

$$A_t = 3972.6 + 0.347A_{t-1} + 10.203R_t + 1.571PA_t + 0.830L_t$$
$$(10221.9)\ (0.174)\quad (3.93)\quad (0.663)\quad (0.289)$$

$R^2 = 0.826$ $\bar{R}^2 = 0.797$ AIC = 15.922 DW(h) = -2.481

Model 8 (Average price deflated by Producer Price Index)

$$A_t = -6900.3 + 0.624A_{t-1} + 12.210R_t - 0.081PAI_t + 0.659L_t$$
$$(12532.6)\ (0.143)\quad (4.32)\quad (0.96)\quad (0.324)$$

$R^2 = 0.757$ $\bar{R}^2 = 0.715$ AIC = 16.157 DW(h) = -2.110

Model 9 (Average price deflated by GDP deflator)

$$A_t = -5377.1 + 0.607A_{t-1} + 12.408R_t - 0.3PAG_t + 0.678L_t$$
$$(11232.9)\ (0.146)\quad (4.325)\quad (0.730)\quad (0.317)$$

$R^2 = 0.759$ $\bar{R}^2 = 0.717$ AIC = 16.150 DW(h) = -2.047

* Numbers in parentheses below the estimated coefficients are the standard error

Table 7 compares the results of Models 5, 6 and 7, the only 3 models in which the signs of the expected price variable are positive as expected. The AIC for Model 6 which uses the current price as the expected price variable is marginally lower than the AIC for the other two models. The adjusted R^2 of all three models are also fairly close to each other at between 0.78 and 0.80. Thus, for all 3 models, about 80% of the variation in the rice area planted over the sample period is explained by lagged area planted, rainfall, the farm price of rice, and the availability of agricultural labor. Even though the estimated coefficient of the price variable in each of the 3 models in Table 7 (Models 5, 6, and 7) is positive and statistically significant, planted area is estimated to be highly unresponsive to changes in price over both the short and long runs. The estimated short-run price elasticities range from 0.07 to 0.09 while the estimated long-run price elasticities ranges from only 0.12 to 0.13 (Table 7). The estimation results suggest that both year-to-year and long-run changes in the area planted to rice in Thailand are more the result of changes in labor availability and the level of rainfall than to changes in price. The short-run elasticity of planted area with respect to labor availability range from 0.20 to 0.25 and from 0.27 to 0.28 for rainfall over the 3 models. The long-run elasticities range from 0.35 to 0.37 for labor and from 0.41 to 0.49 for rainfall.

The adjustment coefficient, the speed with which actual area planted adjusts in response to factors influencing desired area planted, is estimated to range from 0.58 in Model 5 to 0.68 in Model 6. This result suggests that the planted area adjusts slowly from year to year towards desired levels. Given the lack of technology and infrastructure, problems with the availability of credit, and other constraints facing rice producers in Thailand, such a slow adjustment of desired to actual rice area in Thailand is not surprising.

Table 7: Comparison of Regression Results for Models 5-7

Model	Statistics	Results for Independent Variables						Model Results		
		A_{t-1}	R_t	L_t	P_{t-1}	P_t	PA_t	$\bar{R}^2$	AIC	Durbin-h
Model 5 (Lagged nominal price of rice)								0.782	15.993	-2.896
	estimated coefficient	0.421	10.593	0.746	1.250					
	elasticity									
	short-run	0.416	0.284	0.205	0.068					
	long-run	0.718	0.491	0.354	0.117					
	standard error	0.172	4.071	0.294	0.660					
	t value	2.442	2.602	2.535	1.893					
	adjustment coefficient (δ)	0.584								
Model 6 (Current nominal price of rice)								0.804	15.886	-2.206
	estimated coefficient	0.328	10.258	0.898		1.584				
	elasticity									
	short-run	0.325	0.275	0.247		0.090				
	long-run	0.484	0.409	0.368		0.134				
	standard error	0.170	3.842	0.290		0.613				
	t value	1.924	2.670	3.099		2.586				
	adjustment coefficient (δ)	0.675								
Model 7 (Nominal average price of rice)								0.797	15.922	-2.481
	estimated coefficient	0.347	10.203	0.830			1.571			
	elasticity									
	short-run	0.343	0.274	0.228			0.088			
	long-run	0.525	0.420	0.349			0.135			
	standard error	0.174	3.930	0.289			0.663			
	t value	1.987	2.596	2.871			2.370			
	adjustment coefficient (δ)	0.657								

To determine whether the errors in any model are correlated, a Durbin-Watson test is often used. However, because the models in this study contain the lagged value of the dependent variable (area planted), the Durbin-Watson test is biased. Consequently, the Durbin-h statistic is reported in Table 3 to indicate the presence of autocorrelated error terms. The Durbin-h statistic is calculated as:

(8) $$h = (1 - \frac{d}{2}) \times \sqrt{\frac{N}{(1 - N \cdot var(ß)}}$$

where d = the Durbin-Watson statistic, N = sample size, and β = coefficient of the lagged dependent variable.

While autocorrelated error terms could be the cause of the relatively large negative values of the Durbin-h statistics for all three models, the cause could also be exclusion of an important variable or variables or an incorrect functional form. Plots of the residuals from Models 5 to 7 (Figures 6, 7, and 8) indicate unusual aberrations in planted area in 1983 and 1984. Exhaustive research to determine the cause of the sharp rise in planted area in 1983 followed by the sharp decline in 1984 failed to provide insight into the cause of these large and historically unusual shifts in rice planted area in those two years. Consequently, those two data points were treated as outliers. A dummy variable (D_t) was created in an attempt to capture the effect of whatever event or force impacted the area planted to rice in those two years. A value of 1 was assigned to the year 1983 when the residuals in the three models in Table 7 were unusually high and a value of -1 was assigned to the year 1984 when the residuals were unusually low. The dummy variable (D) was then included as an explanatory variable in the Models 5, 6, and 7 and the coefficients of the model were re-estimated. The regression results for these three additional Models (Models 10, 11, and 12) are presented in Table 8.

The estimated coefficient of the dummy variable is highly significant in all three models. With the inclusion of the dummy variables, the Durbin-h statistic indicates that the hypothesis of no autocorrelation of the error terms cannot be rejected in any of the three models (Table 8). Also, the explanatory power of all three models has improved substantially. The short- and long-run price elasticities are marginally smaller in Models 10-12 compared to Models 5-7. On the other hand, while the short-run elasticities of area planted with respect to rainfall and labor availability are marginally smaller, the long-run elasticities with respect to both variables are higher in all three models. At the same time, the statistical significance of the lagged area planted is greater in all three models while the estimated coefficient of adjustment is smaller implying even slower adjustment of area planted to desired levels than estimated in Models 5-7.

Summary and Conclusions

Rice is an important crop to Thailand, both economically and socially. It is the basic food supply for the people and a major export. More of Thailand's land is dedicated to rice than to any other crop. Relatively little is known, however, about the economic forces that affect rice

Figure 6: Residuals for Model 5, 1971-1999

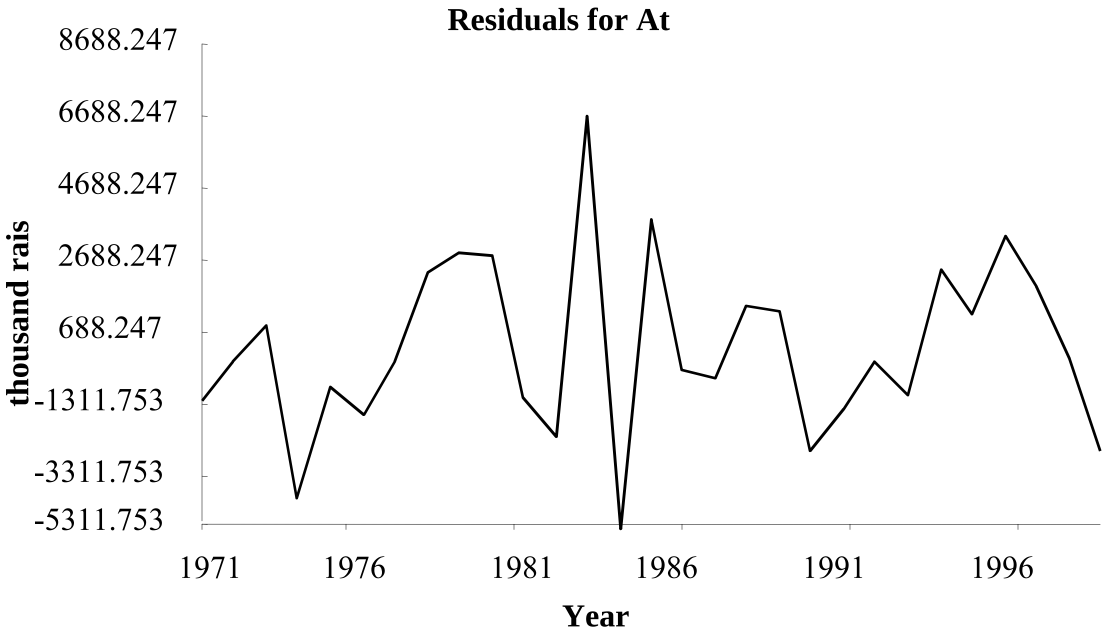


Figure 7: Residuals from Model 6, 1971-1999

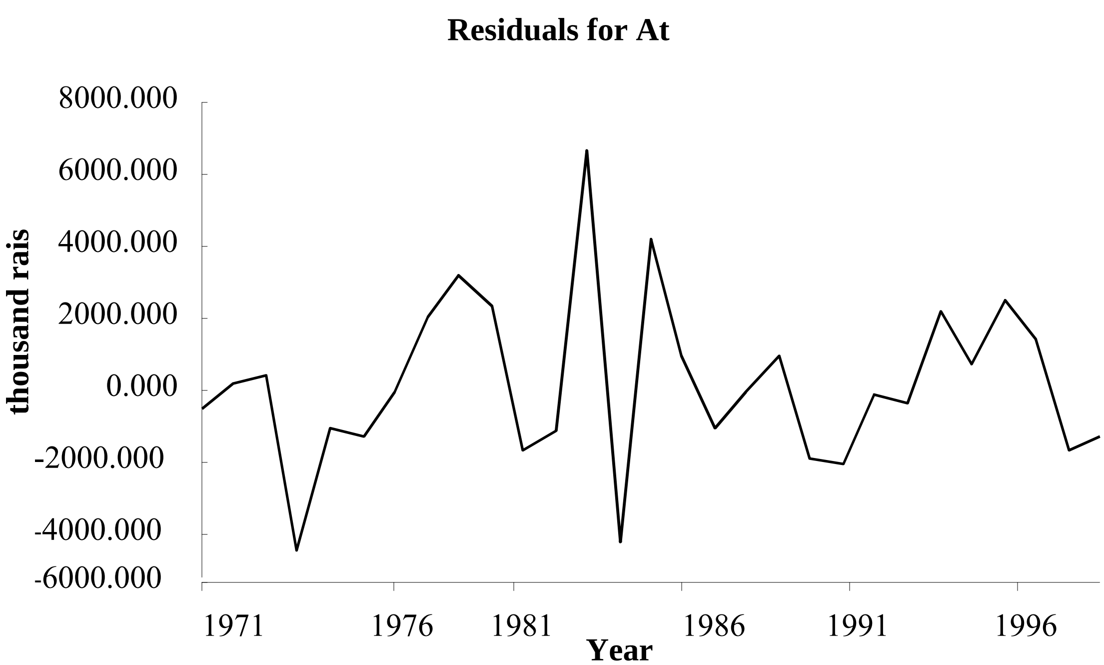
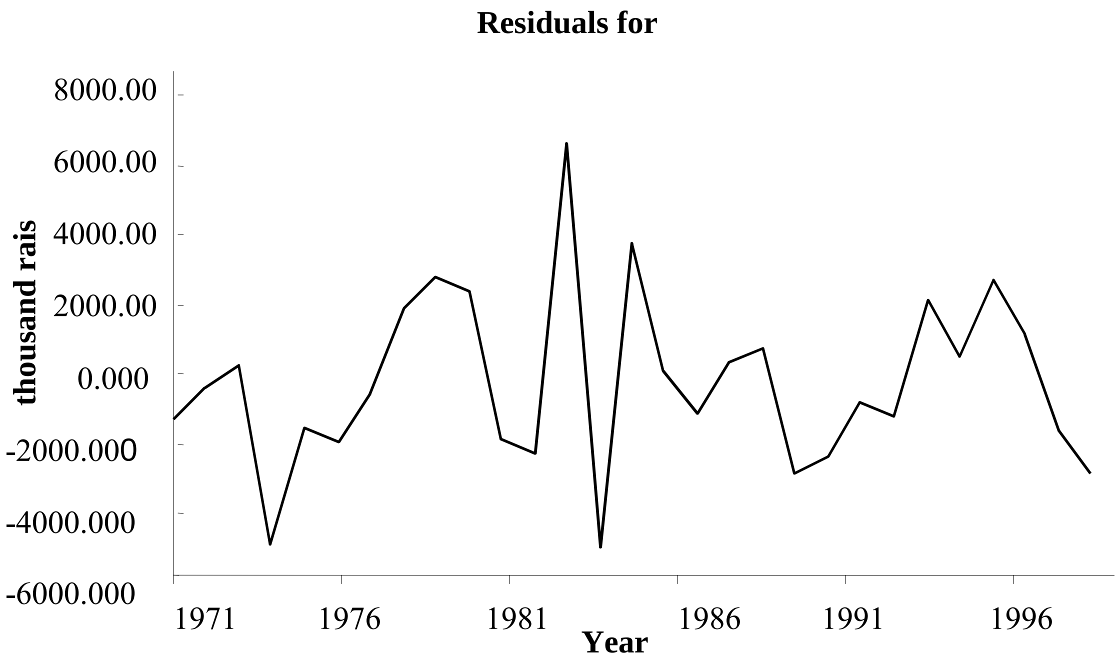


Figure 8: Residuals from Model 7, 1971-1999



production in Thailand, which affects the efficiency and effectiveness of rice production and policy decisions in Thailand.

The general objective of this study was to identify and measure the relative magnitude of effect of the key economic factors affecting Thai rice producer planting decisions. The existing literature on the economic factors affecting rice production in Thailand is quite sparse and dated. Most studies have focused on the supply of rice and some have included a quantitative assessment producer behavior in planting rice.

A conceptual model for the area planted to rice in Thailand was first developed which provided the basis for developing the empirical model used for the analysis of rice producer behavior in planting rice. The explanatory variables in the empirical model included lagged area planted, the annual amount of rainfall, paddy rice prices, and the availability of agricultural labor. Many models were tested, most of which used different prices (nominal vs. real, lagged vs. current) to represent producer expectations. Models 1-4 included current and lagged prices deflated by two alternative price indices (the general producer price index and the GDP deflator). However, the estimated price coefficients in four models were negative. The cause of the unexpected signs for the price variable was likely due to the inappropriateness of the price indices used as deflators. Indices of farm prices in Thailand or of the cost of purchased inputs would have been the appropriate deflators but were simply unavailable.

Table 8: Comparison of Regression Results for Models 10-12

		Results for Independent Variables							Model Results		
Model	**Statistics**	A_{t-1}	R_t	L_t	P_{t-1}	P_t	PA_t	D_t	$\bar{R}^2$	**AIC**	**Durbin-h**
Model 10 *(Lagged nominal price of rice)*									0.870	15.503	0.799
	estimated coefficient	0.605	10.052	0.574	0.751			6842.7			
	elasticity										
	short-run	0.598	0.270	0.158	0.041						
	long-run	1.514	0.684	0.400	0.104						
	standard error	0.140	3.147	0.231	0.524			1648.4			
	t value	4.310	3.194	2.487	1.433			4.151			
	adjustment coefficient (δ)	0.402									
Model 11 *(Current nominal price of rice)*									0.884	15.389	1.172
	estimated coefficient	0.516	9.715	0.692		1.094		6536.18			
	elasticity										
	short-run	0.511	0.261	0.190		0.062					
	long-run	1.056	0.539	0.393		0.128					
	standard error	0.139	2.960	0.228		0.486		1561.87			
	t value	3.720	3.282	3.031		2.252		4.185			
	adjustment coefficient (δ)	0.489									
Model 12 *(Nominal average price of rice)*									0.884	15.389	1.219
	estimated coefficient	0.540	9.739	0.638			1.029	6613.80			
	elasticity										
	short-run	0.535	0.261	0.175			0.057				
	long-run	1.163	0.567	0.380			0.124				
	standard error	0.143	3.044	0.229			0.529	1601.64			
	t value	3.781	3.199	2.793			1.944	4.129			
	adjustment coefficient (δ)	0.465									

In Thailand, rice cultivation is not just food production but a part of the Thai culture. Rice farming is passed on from one generation to the next. Farmers rely on their rice production for household consumption and sell any excess. Even if there were technically viable substitutes available for rice, Thai farmers do not have sufficient knowledge or training to allow them to quickly adjust the composition of crops planted in response to relative price changes. Also, few purchased inputs are used in the Thai rice production. Thus, from the Thai farmers' perspective, there are virtually no substitutes for rice and few variable inputs other than family labor.

Consequently, the hypothesis that nominal rather than real prices are more relevant for estimating the area planted to rice in Thailand was tested. For testing this hypothesis, the parameters of the model were estimated once again but this time using the lagged nominal paddy price of rice and then using the current nominal price and the average of the current and lagged nominal prices. The three new models (Models 5-7) explained substantially more of the year-to-year variations in the planted area as indicted by higher R^2 statistics. At the same time, the estimated coefficients turned positive as expected and were statistically significant although the short- and long-run price elasticities were quite low (between 0.07-0.09 and 0.12-0.14, respectively).

Unfortunately, the Durbin-h statistic indicated the presence of autocorrelated error terms in all three models. An inspection of the residuals from each model estimated indicated a sharp increase in the planted area in 1983 and a sharp decline in 1984. No explanations for these unusually large changes were found so they were treated as outliers. A dummy variable was introduced to account for the intercept shifts in those two years and the parameters of the 3 models were re-estimated. With the dummy variable included, the Durbin-h statistic moved substantially closer to zero and substantially improved the fit of all 3 models to the data. Both the short- and long-run price elasticities were marginally smaller in all three equations while the long-run elasticities of both rainfall and labor availability increased.

In general, the regression results indicate that the area planted to rice in Thailand is more responsive to changes in lagged area planted, the amount of rainfall, and the availability of agricultural labor than to changes in paddy rice prices. Moreover, rice area planted is marginally more sensitive to current market price than to lagged paddy rice price. This result may be a consequence of the guaranteed rice price policy operated by the Thai government. Farmers likely use the announced guaranteed price as the expected selling price instead of lagged prices. The reported market paddy prices have generally been at the guaranteed price level so that the farm price of rice reported is a proxy for the announced support price in each year. The results also indicate that the area planted to rice adjusts relatively slowly from year to year which is consistent with the fact that Thai rice farmers face numerous infrastructure, technology, credit, and other constraints that affect annual rice production decisions.

Perhaps the most important implication of the results of this study for policymaking is that policies to reduce rural labor shortages could do more to enhance the production of rice in Thailand than annual adjustments in the level of the guaranteed price of rice received by producers. Variability of rainfall is also an important constraint to the growth of rice production suggesting the importance of government investment in irrigation systems to reduce the risk of water shortages that rice producers frequently face.

Further research is needed in at least two areas regarding the modeling of the area planted to rice in Thailand. First, the effects of the guaranteed price policy and related policies could be incorporated into the model if the appropriate data could be located. Second, an appropriate price deflator needs to be developed to account for relative prices changes in Thailand. The appropriate deflator would be either an index of farm prices received by producers in Thailand or an index of input costs.

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