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Supply analysis of important crops in Thailand

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Supply analysis of important crops in Thailand

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CHAPTER I. INTRODUCTION

Thailand is predominantly an agricultural economy. Although the share of agriculture in gross domestic product (G.D.P.) has fallen from 40 percent in 1961 to about 27 percent in 1978, agriculture[1] still remains the principal occupation of the great majority of the Thai people. Approximately 65 percent of the population is engaged in agriculture, a proportion that has declined very slowly (36). Furthermore, agricultural exports are Thailand's major source of foreign exchange earnings and provide other types of public revenues, e.g., export taxes.

Traditionally, the agricultural economy of Thailand has been dominated by a single crop, rice. After World War II, crop diversification has occurred in almost all regions of the country. Currently, Thailand's major agricultural products are rice, corn, cassava (tapioca), kenaf, and sugarcane[2]. From crop years 1960/61 to 1978/79, the area planted in rice rose only about 58 percent, while area planted in corn, cassava, sugarcane, and kenaf rose about 385, 1312, 223 and 128 percent, respectively (30, 35).

The analysis of the price responsiveness of agricultural supply, particularly in countries such as Thailand where agriculture is dominant in the economy, is very important for making suitable policy for the country. If the study shows that farmers are responsive to price, changes in production can be accomplished by using price as an in-

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[1]"Agriculture" includes forestry, fishing and hunting.

[2]Others include perennial crops, forestry and fishery.

centive for farmers. On the other hand, if supply is not price responsive, the increase in production must be achieved by other means such as changing the underlying technological or social conditions under which the crops are produced. There are at least two different views regarding the price responsiveness of farmers in developing countries. One view is that the degree of responsiveness is very small or does not exist at all, while the other view is that they are very price responsive. The question of farmer responsiveness has been the subject of several investigations in recent years. Despite the numerous studies done in this area, the question remains a widely debated and a controversial issue and is still an interesting subject for further research.

Statement of the Problem

Given the quantitative importance of agriculture in the country, the importance of agricultural exports in earning foreign exchange, and the potential contribution to the growth of the economy, the knowledge of agricultural supply is important. Since the major economic problem of agriculture is directly or indirectly related to supply functions, policy recommendations are implied by a priori hypotheses about the responsiveness of a supply function, which is an empirical question. Even though information on supply is needed for policy formulation, research studies on Thailand's agricultural supply seem to be inadequate for the purpose of policy formulation. Most of the research has concentrated heavily on the demand side and very often has considered supply as an exogenous variable in the system of equations. There was, however, research conducted by Behrman (4) who did an extensive study of the supply response of four major annual crops of Thailand during 1937-63. One of the problems he encountered was the reliability and consistency of the data. Previously, there were at least two agencies which published agricultural statistics, one of which was the National Statistical Office (NSO) and the other the Ministry of Agriculture and Cooperatives (MAC). Very often, there were great discrepancies between the two sources. Currently, only the MAC is responsible for collecting and publishing agricultural data. Furthermore, the method of data collection has changed from using local agricultural officer's reports to the use of probability sampling which has resulted in an improvement in the quality of data. Since there is limited research related to Thai agricultural supply during the period after Behrman's study, the present study may be useful and shed some light on the nature of the price responsiveness of Thai agriculture during this later time period.

Objectives of the Study

This study will, in general, attempt to contribute to the knowledge of the influence of price on the supply of agricultural production in Thailand. Because of their importance to the Thai economy, the five major crops, rice, corn, cassava, sugarcane and kenaf have been chosen for the study.

The acreage response under alternative formulations of the farmer's decision variable is estimated at the agroeconomic zone[1] level in order to better represent the relevant variables and make possible comparison of parameters across zones under the assumption that the differences across zones are greater than the differences within the zone (i.e., each zone is assumed homogeneous). Specifically, the objectives of this study are as follows:

1. To analyze and compare the effect of alternative formulations of economic decision variable.
2. To estimate the short-run and long-run elasticities of supply of each crop in each major zone and compare the results with other studies.
3. To use knowledge of the supply response of each crop to derive some policy recommendations.

The data period used in the study was from 1967-1977.

The outline of this thesis is as follows:

In Chapter II, the empirical literature related to the crop supply analysis is reviewed. In Chapter III, the nature of Thai agriculture with emphasis on the production of the five major crops above is discussed. The general Nerlove supply model and its problems are presented in Chapter IV. Chapter V deals with the empirical analysis of the acreage response of each crop in each zone. The statistical results are presented and discussed. Summary, conclusions, and policy implications are presented in Chapter VI.

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[1]Delineation of the zones will be discussed in Chapter III.

CHAPTER II. LITERATURE REVIEW

This chapter summarizes the past and the present status of efforts to derive statistical supply functions from time series data. Lack of sufficient statistical tools prevented early research workers from doing adequate empirical work on supply analysis, especially in the field of agriculture, even though the economic theory of demand and supply was available long before the empirical studies started.

The book by Henry Moore (22), Forecasting the Yield and Price of Cotton, was the immediate source of inspiration and methodology for the development of numerous demand and supply studies during the 1920s. Using the data period 1890-1913, Moore related the logarithmic first difference of cotton acreage to the one year lagged logarithmic first difference of undeflated cotton prices, but he made no attempt to relate yields to price. He did not find much of a relationship with the simple correlation coefficient between the two being only 0.5 for this period. In spite of its shortcomings, his technique and the use of price lagged one year in the model specification has been carried through in almost all subsequent supply analyses.

During the 1920s, economists in the U.S. Department of Agriculture and in the state universities made numerous analyses of price-quantity relationships for agricultural commodities. The primary objective of these studies was to provide information by means of which farmers could adjust their production and marketing plans, e.g., Fox (8).

Smith (28) related absolute changes in cotton acreage to presowing prices deflated by the wholesale price index of agricultural commodities and a time trend variable. He concluded that January price and the lagged first difference of cotton production may be used as explanatory variables for forecasting purposes.

In 1929, Bean (3) in his study of farmers' response to price, used the short-cut graphic method to analyze the data for the period 1921-1929, with the absolute change in acreage harvested used as the dependent variable. The explanatory variables were prices received by farmers during the preceding two seasons deflated by an index of the general level of farm prices. He was one of the research workers who introduced the price of a competing crop explicitly into his analysis. In his study, both at national and state levels, he found that the elasticities of supply of potatoes, sweet potatoes, cabbage, strawberries, and cotton were all less than unity, while the elasticities of rye, flax, and watermelons were greater than unity.

During the thirties and forties, the number of empirical studies on supply decreased considerably. However, Cochrane (6, p. 1161) pointed out the scarcity of work in this area. He states,

> "Serious papers, or research publications, dealing with some aspect of supply relation in agriculture have not been plentiful over the years; one every three to five years, with perhaps some bunching recently, has been the average over the past 35 years. And only a scant few provide estimates of supply elasticities that most of us would want to use today. This is not a good record. The question is why. Why has there been so little good work in this area?"

In 1956, Nerlove (24, 25) modified Cagan's adaptive expectations hypothesis and applied this model to the estimation of elasticities of supply of U.S. agricultural commodities. He obtained very satisfactory results. Since then, his model, with some modification, has been widely used and has become a standard tool in the estimation of agricultural supply functions. Some of these studies relevant to the present study will be reviewed here.

Three models were used by Mules and Jarrett (23) to study the price response of the South Australian potato industry. In the first model, only price lagged one year was used as an explanatory variable, while the two year lagged price was added in the second model. The third model was a typical Nerlovian distributed lag model. Ordinary least squares was used as the estimation procedure. They found that the distributed lag model seems the most satisfactory and gives a short-run elasticity of acreage planted to changes in price of 0.36 and a long-run elasticity of 1.09.

Mangahas, Recto, and Rattan (19) did a comprehensive study on area and yield response functions for rice and corn for the Philippines as a whole and for nine major regions by means of both traditional regression and distributed lag models. Three formulations of price variables were used: the absolute price, the price deflated by the price index for a single alternative crop, and the price deflated by the price index of all alternative crops. All price variables are lagged one year. Other explanatory variables included in the model were the lagged factor-price index measured by the wage rate for hired agricultural workers, the lagged technology index, measured by the lagged index of the ratio of the yield of rough rice or corn to the yield of alternative crop(s), and trend. They found that the short-run supply elasticities calculated from the area response functions typically fall in the 0.10-0.30 range, although estimates as high as 0.6 were obtained. Significant price parameters were not, except in one case, obtained for the yield response functions. They concluded that even though prices of rice and corn in the Philippines have apparently been fairly effective in allocating resources, there is little evidence to indicate that price changes are an effective device for influencing aggregate agricultural output.

Krishna and Roa (17) hypothesized that the supply response coefficients change substantially depending on the nature of the price expectation models used. Nine alternative price expectation models and six different response equations were used in their study. The data of acreage and price of wheat in Uttar Pradesh, India, during the period of 1950-1962 were used. In addition to yield lagged one year, the total rainfall in the area from June to October was also included in the model. The results of the study indicated that acreage under wheat is fairly responsive to changes in relative prices of wheat and substitute crops. Furthermore, the three-year average of presowing prices of wheat deflated by the three-year average of presowing prices of substitute crops, along with the yield of wheat deflated by the yield of substitute crops and rainfall are the most important factors influencing the farmer's decision concerning acreage allocation among wheat and substitute crops. The model involving gross income in place of the relative price did not give satisfactory results, nor did the substitution of wheat yield in place of relative yield improve the results. Of the nine price expectation models used in the study, the model based on a three-year average of presowing prices proved to be decidedly superior to the other eight models. The results of the study further indicate that traditional regression models for estimating supply response coefficients, if properly specified, can give as satisfactory, if not superior, results as those obtained by using the adjustment-lag models of the Nerlovian type. The Nerlovian type models, however, were found to have an edge over the traditional models regarding the proportion of the variation in wheat acreage explained by the explanatory variables.

Another major contribution to supply analysis was the study by Behrman (4). He used a modified Nerlove model together with a nonlinear estimation technique to estimate structural parameters for both acreage and yield response of rice, corn, cassava, and kenaf cultivated in each province in Thailand. The study period was between 1937 and 1963. Since the Behrman study is the most relevant to the present study, we will discuss his model in some detail. Four equations were specified as follows:

$$A_t^d = a_{11} + a_{12}P_t^e + a_{13}Y_t^e + a_{14}\sigma P_t + a_{15}\sigma Y_t + a_{16}N_t + a_{17}M_t + U_{1,t} \quad (2.1)$$

$$A_t = a_{21} + A_{t-1} + a_{22}(A_t^d - A_{t-1}) + U_{2,t} \quad (2.2)$$

$$P_t^e = a_{31} + P_{t-1}^e + a_{32}(P_{t-1} + a_{33}D_{t-1} - P_{t-1}^e) + U_{3,t} \quad (2.3)$$

$$Y_t = a_{41} + a_{42}[R_t - \bar{R}] + a_{43}t + a_{44}t^2 + U_{4,t} \quad (2.4)$$

where A_t^d = the desired planted area in the crop of concern.

A_t = the actual planted area in the crop of concern.

P_t^e = the expected normal farmer's price of crop concern relative to alternative crops.

P_t = the actual farmers' price of the crop of concern relative to alternative crops.

D_t = a dummy variable representing transportation changes which alter the Bangkok-upcountry price differential.

Y_t^e = the expected harvested yield.

Y_t = the actual harvested yield.

σP_t = the standard deviation of the price of the crop of concern over the last three preceding production periods relative to the standard deviation of the index of prices for alternatives over the last three preceding production periods.

σY_t = the standard deviation of actual yields of the crop of concern over the last three preceding production periods.

N_t = the farm population in the geographic area of concern.

M_t = the annual malaria death rate per 100,000 occupants in the area of concern.

R_t = the annual rainfall in the area of concern.

$\bar{R}$ = mean annual rainfall in the area of concern.

$U_{i,t}$ = a disturbance term for the ith relationship.

a_{ij} = the jth structural parameter in the ith structural equation.

t = a time trend variable, and a subscript t refers to the tth production period.

Equation (2.1) expresses the desired area planted in the crop of concern as a linear function of six variables and a disturbance term.

Assuming that farmers are risk averters, the first four right-hand side variables (P^e_t, Y^e_t, σY_t, and σY_t) are, therefore, referred to as the farmers' subjective probability distributions of normal relative prices and yields. One would expect a_{12} and a_{13} to be positive since increases in the expected price (or expected yield), <u>ceteris paribus</u>, presumably would make production of the crop under consideration more desirable. The actual standard deviations for the price of the crop concern relative to the standard deviation of the price index of alternatives (σP_t) and the actual standard deviations for yields (σY_t) in the last three production periods were included as proxies for the variances of the subjective probability distributions. The selection of a three-year period was arbitrary. One would expect the coefficients a_{14} and a_{15} to be negative because increased variance, <u>ceteris paribus</u>, would make production of the crop less desirable. The variable N_t was added in order to test the hypothesis that near subsistence farmers may attempt to lessen the impact of market fluctuations by first planting enough area in staple crops to assure sufficient food for the farm family, and only thereafter allocating the remainder of their land on the basis of expected returns. If farmers always attempt to assure enough grain production for on-farm consumption needs, the parameter a_{16} should be positive. Similarly, to test the hypothesis that malaria control has expanded the available land which is suitable for cultivation, the variable M_t was included in the model. If this hypothesis is supported by statistical analysis, a_{17} will be negative because the malaria death rate declines as malaria control is extended. The first hypothesis was tested only for rice while the second hypothesis was tested for all the remaining upland crops.

Equations (2.2) and (2.3), respectively, relate the desired area planted and the expected normal relative price to observable variables. Both relations were identical to Nerlove's formulation except for the dummy variable (D_{t-1}) in the price expectation relation, the constants, and the disturbance terms. The area planted adjustment Equation (2.2) states that the area actually planted in production period t equals the area actually planted in the previous period, plus a term proportional to the difference between the desired planted area in the tth period and the actual planted area in the previous period, plus a constant and a disturbance term. The proportional parameter (a_{22}) is called the area adjustment coefficient. The expected normal relative price Equation (2.3) states that the expected normal relative price equals the expected normal price in the previous period, plus a term proportional to the difference between the expected normal relative price and the actual relative price in the previous period, plus a constant and a disturbance term. The proportionality parameter (a_{32}) is called the price expectation coefficient. Equation (2.4) states that the actual harvest yield in period t is equal to the sum of a constant term, a term proportional to amount of rainfall in the tth period (R_t) deviates from the mean annual rainfall ($\bar{R}$), linear and quadratic time trend terms, and a disturbance term. The deviation from mean annual rainfall was included in Equation (2.4) to represent any abnormalities in the weather which occurred in the tth period.

The model in the original structural form (Equations 2.1, 2.2 and 2.3) is not directly estimable because several unobservable variables are included. The three equation model, therefore, is reduced to one equation in terms of observable variables. The resulting reduced form expression is of the form

$$A = Xb + W \tag{2.5}$$

where A = a column vector of observation of planted areas.

X = a matrix in which the tth row contains the following elements: $[1, A_{t-1}, A_{t-2}, P_{t-1}, D_{t-1}, Y^e_t, Y^e_{t-1}, \sigma P_t, \sigma P_{t-1}, \sigma Y_t, \sigma Y_{t-1}, N_t, N_{t-1}, M_t, M_{t-1}]$.

$$b = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \\ b_6 \\ b_7 \\ b_8 \\ b_9 \\ b_{10} \\ b_{11} \\ b_{12} \\ b_{13} \\ b_{14} \\ b_{15} \end{bmatrix} = \begin{bmatrix} a_{12}a_{22}a_{31} + a_{32}(a_{21} + a_{11}a_{22}) \\ [(1 - a_{22}) + (1 - a_{32})] \\ - (1 - a_{22})(1 - a_{32}) \\ a_{12}a_{22}a_{32} \\ a_{12}a_{22}a_{32}a_{33} \\ a_{13}a_{22} \\ - a_{13}a_{22}(1 - a_{32}) \\ a_{14}a_{22} \\ - a_{14}a_{22}(1 - a_{32}) \\ a_{14}a_{22} \\ - a_{15}a_{22}(1 - a_{32}) \\ a_{16}a_{22} \\ - a_{16}a_{22}(1 - a_{32}) \\ a_{17}a_{22} \\ - a_{17}a_{22}(1 - a_{32}) \end{bmatrix}$$

W = a column vector of disturbance term.

The reduced form Equation (2.5) still contains one unobservable variable, Y_t^e. Behrman further assumed that $E(R_t) = \overline{R}$ and $E(U_{4,t}) = 0$ for all t, and obtained the equation of expected yield as

$$Y_t^e = a_{41} + a_{43}t + a_{44}t^2 \quad (2.6)$$

Instead of using the relationship in (2.6) together with the relationship in (2.2) and (2.3) and deriving the reduced form that will contain all observable variable, Equation (2.4) is estimated directly and the parameters so obtained were used in (2.6) in order to conserve degrees of freedom when Equation (2.5) is estimated. W in (2.5) was assumed independently and normally distributed with mean zero and constant variance. The maximum likelihood method was used to estimate the structural parameters directly. The desired yield equation was also formulated in a similar form as the desired area and the same method of estimation was used.

Using the models and method of estimation as mentioned above, Behrman arrived at several conclusions about his hypotheses. Some significant results are that Thai farmers' decisions are rational and respond positively to price while responding negatively to risk. The extension of malaria control has opened up new upland area for cultivation. The study also supported the hypothesis that subsistence farmers always attempt to produce enough rice for on-farm consumption in order to lessen risk by assuring a basic food supply, independent of fluctuation in relative market prices. Significant response to the expected values of the relative harvest prices was obtained in 48 of the 50 provinces for rice, in about fifty percent of cassava and one-hundred percent for kenaf. The short-run price response for rice is generally inelastic and of the same order of magnitude as the estimated short-run response to prices for food grains in other countries. For the other upland crops, cassava, corn, and kenaf, the short-run elasticities are generally greater than one. These elasticities are generally larger in magnitude than the estimated short-run price elasticities for crops in other countries. No significant evidence was found for the hypothesis that institutional constraints preclude significant response to economic incentives in Thai agriculture. However, in the yield response model, significant price responses were found in relatively few provinces. The elasticities are generally smaller in magnitude than are the elasticities of planted area with respect to the same variables in the same provinces.

Houck, Ryan, and Subotnik (12) also applied the Nerlove model in their soybean supply analysis to measure the impact of government programs. The basic model for acreage supply response used in the analysis was

$$A_t = b_0 + b_1 A_{t-1} + b_2 P^*_t + b_3 P^*_{2t} + U_t$$

$$P^*_{it} = W_{i1} P_{i,t-1} + W_{i2} P^f_{i,t} \qquad i = 1, 2$$

where $P^*_{1,t}$ = the expected price for the crop in question.

$P^*_{2,t}$ = the expected price for the competing commodities.

$P_{i,t}$ = the actual farm price for crop i.

$P^f_{i,t}$ = the effective support price for crop i.

U_t = random, mean-zero disturbances with finite variance.

The reduced form was

$$A_t = b_0 + b_1 A_{t-1} + d_1 P_{1,t-1} + e_1 P^f_{1,t} + d_2 P_{2,t-1} + e_2 P^f_{2,t-1}$$

where $d_1 = b_2 W_{11}$, $e_1 = b_2 W_{12}$, $d_2 = b_3 W_{21}$, $e_2 = b_3 W_{22}$

Since P^f_{1t} and $P^f_{2,t}$ cannot be observed directly, they approximated these variables by the relationship

$$P^f_{it} = (A^S_i / A^0_i) P^S_{i,t} \qquad i = 1, 2$$

where P^S_{it} = the announced support price for crop i.

A^S_i = the acreage of crop i under the support price.

A^0_i = the acreage of crop i that would be harvested without restriction at the price P^S.

Where no acreage restrictions are employed, $P^S = P^f$, since $(A^S/A^0) = 1$.

Each region was estimated by ordinary least squares. In all of the selected regions except the Atlantic states, more than 90 percent of the variation in soybean acreage during the sample period was associated with the specified variables. In the Atlantic region, the distributed lag model did not produce usable results. The coefficient estimated for lagged acreage was larger than unity. This led to long-run instability in the adjustment process and unacceptable elasticity estimates. Therefore, they dropped the lagged acreage variable from the function. With regard to the elasticities, they found the market-price elasticities generally larger than effective support-price elasticities. Among the alternative crops, corn is the most related to soybeans. A similar model was also employed by Houck and Ryan (11) in supply analysis of the U.S. corn.

In the sixties and seventies, there were numerous agricultural supply analyses (of annual crops, perennial crops and livestocks) that utilized the Nerlove model and almost all the published articles have been summarized and discussed by Askari and Cummings (1, 2).

CHAPTER III. AN OVERVIEW OF THE THAI AGRICULTURE

Thailand, located in Southeast Asia, extends from 6° to 20° north latitude and stretches from 97° to 106° east longitude with a total area of 514,000 square kilometers (almost 200,000 square miles) or 321.25 million rai[1]. It shares a border with Burma and Laos to the north, Cambodia and Laos to the east, Burma and the Indian Ocean to the west, and Malaysia and the Gulf of Thailand to the south.

The kingdom of Thailand is divided into four geographic regions: Central, Northern, Northeastern and Southern regions, and is subdivided into seventy-two administrative units called changwads or provinces. However, for agricultural development and planning purposes, the seventy-two changwads have been grouped by the Ministry of Agriculture and Cooperatives into nineteen agroeconomic zones. Each zone is considered homogeneous in terms of climatic and agronomic conditions, and agricultural activities. Zones 1 to 5 represent the Northeast, zones 6 and 8 through 10 represent the North, zones 7 and 11 through 16 represent the Central, and zones 17 through 19 represent the South[2]. The map of Thailand, its zone and region boundaries are shown in Figure 3.1. The statistical analysis of the supply of crops in the present study is primarily at the zone level of aggregation.

In Thailand, generally, the weather is warm and humid and the climate is under the influence of the seasonal monsoon winds. The

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[1] 2.5 rai = 1 acre.

[2] Names of provinces in each zone are given in Appendix B.

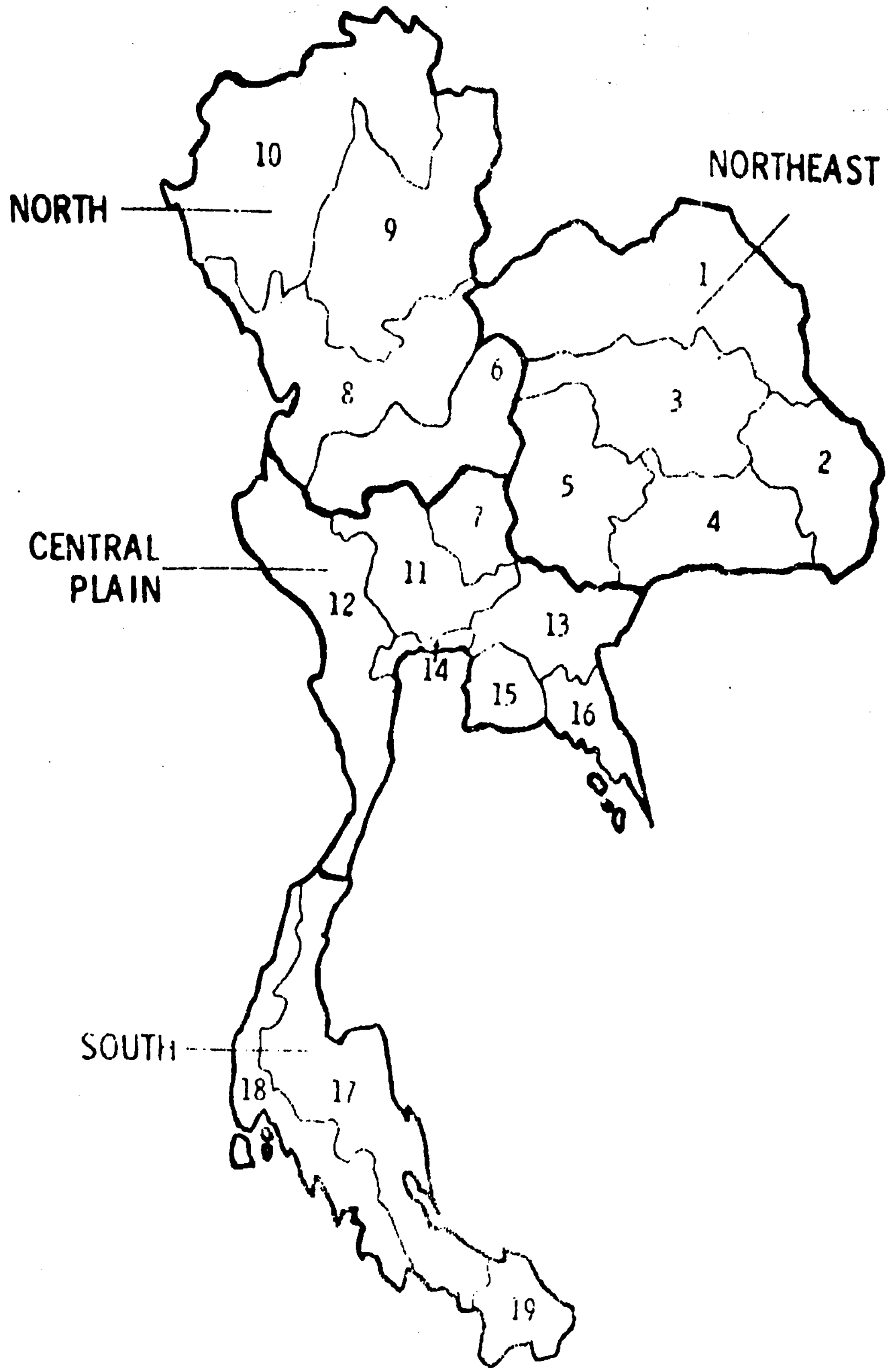

Figure 3.1. Agroeconomic zones of Thailand

Southwest monsoons come during May through October, bring warm moist air up from the Indian Ocean and the Gulf of Thailand providing a season of heavy rains over the whole country. November through February is the time of the Northeast monsoon winds. The cold and dry air that sweeps down from the mainland China brings the period of the dry season. The five-year average annual rainfall, number of rainy days, average temperature and its minimum and maximum temperature between 1974 to 1978 in each selected changwad in each region are shown in Table 3.1.

In 1978, the total population was estimated at 45.1 million with 29.5 million or 66.4 percent forming the agricultural population. Furthermore, about 9.7 million out of 15.6 million of the economically active population between 15-64 years of age or 61.7 percent were engaged in agriculture. The national income was 378.5 billion baht[1] and per capita income was 8,370 baht. The total farm land holding was 116.4 million rai or 36 percent of the total land in the country (36). Only about 15 million rai or 13 percent of farm holding land was irrigated. Of this irrigated area, 58 percent was in the Central plain, particularly in zones 11 and 12. The other irrigated zones with over one million rai were zones 9 and 10 in the Northern region (35). The size of farm is very small; in 1974, the average farm size was about 30 rai for the whole country (9, Table 12, p. 27).

The economy of Thailand is heavily dependent upon agriculture, although recently, other sectors are gaining some importance. Economic

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[1]U.S. $1 = 20 baht.

Table 3.1. Five years average annual rainfall, number of rainy days, minimum and maximum and average temperature between 1974-1978 in selected changwads (35)

Region	Changwad	Average annual rainfall (mm.)	Number of rainy days	Minimum temperature °C	Maximum temperature °C	Average temperature °C
North	Chiangmai	1,280	115	3.7	40.0	24.7
Northeast	Khonkaen	1,264	110	5.6	42.0	26.3
Central	Bangkok	1,362	130	10.5	38.7	27.6
South	Nakhonsithammarat	2,534	166	17.2	36.5	26.4

activities are still centered on producing, marketing, and processing of farm products. In 1978, 27.1 percent of 444.2 billion baht of the gross domestic product and 65.7 percent of 81.3 billion baht of the total value of export were derived from the agricultural sector (35, 36). However, very few commodities account for a large portion of total exports. These include rice, cassava, rubber, sugar, corn, kenaf, and canned pineapple. The export values of these commodities from the year of 1968 to 1978 are shown in Table 3.2 and Figure 3.2.

Because of the great importance attached to these crops, and the availability of disaggregate time series data at the zone level, the supply analysis of five major crops, rice, cassava, corn, kenaf, and sugarcane, are chosen for the present study. For each crop, its relative importance to the Thai economy and its cultivation practices will be discussed in some detail in the next five sections. The planted area of important crops in Thailand and its average yield per rai between 1968 to 1978 are shown in Table 3.3 and Figure 3.3.

Rice

Rice is, by far, the most important agricultural crop in Thailand and its two important uses are: (a) domestically, it is the main staple food, and (b) it is the main agricultural export. For more than a century, the country has produced more rice than needed for domestic consumption. Although Thailand accounts for only 5 percent of the world's rice production, it has been one of the world's leading rice exporters since the early 1960s and currently is responsible for

Table 3.2. Export values of important agricultural commodities of Thailand, 1968-1978 (35) (Unit: million baht)

Year	Rice	Tapioca products	Corn	Sugar	Baled kenaf and gunny bags	Rubber	Canned pine-apples	Tobacco	Total agricul-tural products	Total exports	Percent of agri-cultural exports
1968	3,775	773	1,647	16	747	1,816	—	199	10,592	12,987	81.6
1969	2,945	876	1,767	80	849	2,662	—	150	11,112	14,101	78.8
1970	2,517	1,223	1,969	406	771	2,249	—	202	11,109	14,250	78.0
1971	2,910	1,239	2,286	468	1,102	1,905	—	236	12,615	16,683	75.6
1972	4,437	1,547	2,086	1,357	1,246	1,862	—	284	15,416	21,616	71.3
1973	3,594	2,537	2,969	1,483	1,358	4,573	75	317	23,088	31,147	74.1
1974	9,810	3,836	6,078	4,300	1,185	5,037	277	451	36,846	49,164	74.9
1975	5,853	4,596	5,706	6,183	923	3,473	346	571	34,108	47,505	71.8
1976	8,603	7,527	5,677	7,353	693	5,297	605	699	46,506	60,189	77.3
1977	13,383	7,720	3,348	8,204	571	6,271	898	924	50,793	70,398	72.1
1978	10,424	10,892	4,281	4,491	868	6,198	1,201	1,161	53,354	81,252	65.7

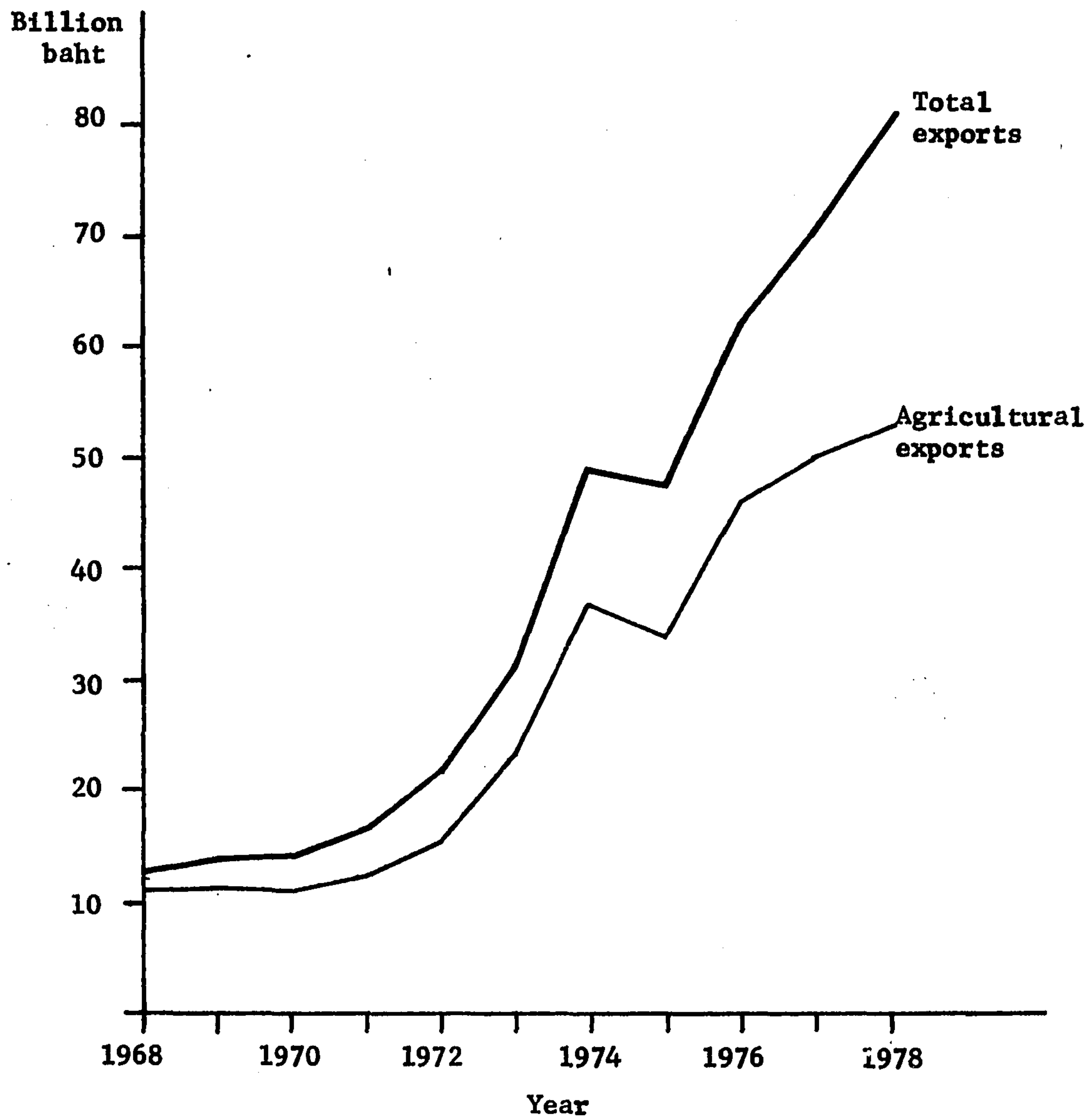

Figure 3.2. Agricultural and total export values of Thailand

Table 3.3. Planted area and average yield per rai of important crops and total farm land holding of Thailand, 1968-1978 (33, 35, 36)

Year	Rice[a] Area 1,000 rai	Rice[a] Yield kg	Corn Area 1,000 rai	Corn Yield kg	Cassava Area 1,000 rai	Cassava Yield ton	Sugarcane Area 1,000 rai	Sugarcane Yield ton
1968	44,608	229	4,763	279	1,066	2.4	646	6.8
1969	47,400	283	4,503	380	1,193	2.6	739	6.9
1970	46,840	290	5,180	374	1,403	2.4	862	7.6
1971	47,043	292	6,368	361	1,384	2.3	991	6.0
1972	44,620	261	6,231	211	2,069	1.9	1,133	8.4
1973	50,232	276	7,172	326	2,725	2.1	1,616	8.3
1974	47,821	260	7,749	323	3,000	2.1	1,935	7.5
1975	53,244	265	8,200	349	3,715	2.2	2,444	8.1
1976	50,859	269	8,029	333	4,373	2.3	3,119	8.4
1977	53,465	231	7,534	223	6,000	2.1	3,541	5.3
1978	58,410	260	8,661	322	6,313	2.4	3,190	6.4

[a]Does not include second crop rice.

Kenaf		Mungbeans		Soybeans		
Area 1,000 rai	Yield kg	Area 1,000 rai	Yield kg	Area 1,000 rai	Yield kg	Total farm land holding 1,000 rai
1,585	199	1,250	147	329	136	85,782
2,358	158	1,297	131	299	161	89,065
2,631	145	1,494	101	368	137	92,833
2,891	145	984	156	359	151	98,563
2,951	145	1,418	144	525	138	104,499
2,714	173	1,596	131	766	136	113,095
2,524	152	1,293	145	823	134	113,270
2,038	151	1,022	118	738	154	112,211
1,023	182	1,392	90	635	179	113,112
1,603	153	2,720	76	958	94	113,796
2,003	169	2,638	98	1,010	157	116,441

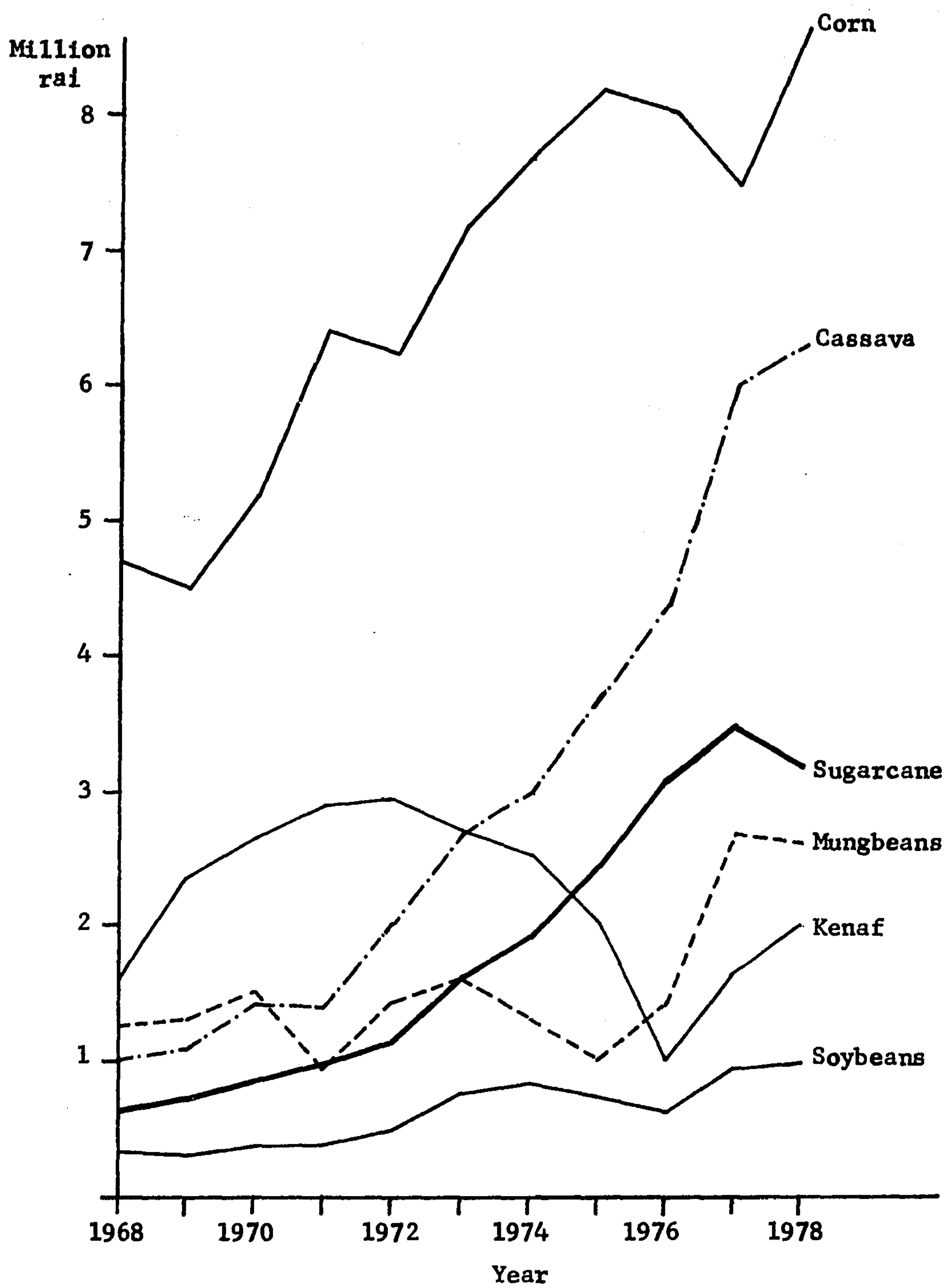

Figure 3.3. Planted area of important crops (excluding rice) of Thailand

about 25 percent of the total international rice trade. The quantity exported averages around 25 percent of the total production (7, 26). Revenues from rice export contribute a major share of the total export earnings. Furthermore, the export taxes, the so-called "rice premium" also provide a substantial amount of the government income. The rice premium has always been a controversial issue in the rice policy in Thailand. It was established after World War II when the Thai government was required by the Allies to ship all rice surplus to the areas that were short of rice free of charge as war reparations. This agreement was the starting point of government intervention into the rice trade. The primary objectives of the rice premium were: (a) as an instrument in preventing high world prices from being transmitted to domestic prices, thus stabilizing, although depressing, farmers' income; (b) to prevent rice shortage by increasing the rice premium to regulate the rice exported; (c) to improve the competitive position of Thai rice exporters by reducing the rice premium when competition in the international market is keen; and finally (d) to provide revenue to the government. The rice premium rate was not, however, the only tool that the government used to control the volume of rice exports. Among others were an export quota, export licenses, the rice reserve requirement, and a multiple exchange rate system (now abolished). The most controversial issue has been centering around the question of who bears the burden of the rice premium, the farmers or the exporters. Theoretically, if the domestic rice market is highly competitive and if the foreign elasticity of demand for Thai rice is very high, then all the burden is borne by the farmers. This is, of course, an empirical question. Nevertheless, with regard to the government revenue deriving from the rice premium, it becomes less important since the government is now able to obtain revenue from other sources (27). In fact, since 1970, the share of government revenue from the rice premium has declined continuously from 8 percent to only 1 percent in 1976, except in 1974, where its share was very high at 11 percent (38).

Rice growing is regarded as the Thai farmers' basic way of life. Most of the Thai farmers in all regions produce rice to meet their own families' subsistence demands and sell only the surplus on the market. This is the evidence of Table 3.4 where the five years average of rice planted area as percentage of total farm land holding in 12 zones out of 19 zones are above 40 percent. In particular, in 1978, the rice planted area in Thailand was 60 percent of total crop land[1] or 50 percent of total farm land holding. During the 1968 to 1978 period, the rice planted area increased about 30 percent. However, it has fluctuated from year-to-year (Table 3.3). Shortage of inputs such as seed and water were attributable to this fluctuation. By contrast, during the same period, rice yields have been relatively constant, even though some high yield varieties have been introduced. The acquisition of marginal land and the relative price of rice and fertilizer may play a major role in the negative aspects of yield.

In general, rice is planted in the wet season in May through July, and harvested during October through January (Figure 3.4). The harvesting date generally is determined by the varieties planted.

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[1]Crop land does not include tree crops, grass and idle land.

Table 3.4. Five years average (1974-1978) of planted area and its relative importance in each zone of five major crops (35)

Zone	Rice				Corn				Cassava			
	Area 1,000 rai	Per-cent[b]	Per-cent[c]	Rank[a]	Area 1,000 rai	Per-cent[b]	Per-cent[c]	Rank[a]	Area 1,000 rai	Per-cent[b]	Per-cent[c]	Rank[a]
1	6,070	11.5	51.8	3	663	8.4	5.7	5	358	7.7	3.1	5
2	3,749	7.1	57.1	5	24	0.3	0.4	14	51	1.1	0.8	11
3	6,228	11.8	53.1	2	21	0.3	0.2	15	672	14.4	5.7	3
4	5,317	10.1	55.8	4	194	2.4	2.0	7	334	7.1	3.5	6
5	3,021	5.7	34.0	8	1,200	15.1	13.5	3	1,129	24.1	12.7	1
6	3,183	6.0	40.6	7	2,716	34.2	34.6	1	34	0.7	0.4	12
7	1,778	3.4	42.4	13	1,622	20.4	38.7	2	24	0.5	0.6	13
8	3,666	6.9	51.6	6	670	8.4	9.4	4	76	1.6	1.1	10
9	2,021	3.8	43.6	12	391	4.0	8.4	6	7	0.1	0.2	18
10	2,464	4.7	59.4	10	165	2.1	4.0	8	10	0.2	0.2	16
11	6,569	12.5	65.4	1	67	0.8	0.7	10	80	1.7	0.8	9
12	1,400	2.7	29.6	14	84	1.0	1.8	9	121	2.6	2.6	8
13	2,340	4.4	52.8	11	44	0.6	1.0	11	459	9.8	16.0	4
14	411	0.8	48.9	18	–	–	–	–	–	–	–	–
15	481	0.9	17.3	17	–	–	–	–	–	–	–	–
16	242	0.5	17.4	19	36	0.5	2.6	13	176	3.8	12.6	7
17	2,712	5.1	31.9	9	38	0.5	0.4	12	23	0.5	0.3	14
18	549	1.0	18.9	16	–	–	–	–	16	0.3	0.6	15
19	557	1.0	28.5	15	–	–	–	–	9	0.2	0.5	17
Total	52,758	100	46.3		7,935	100	7.0		4,679	100	6.1	

[a]According to the planted area in each zone.

[b]Percent of total planted area of each crop in the country.

[c]Percent of total farm land holding in each zone.

Table 3.4. Continued

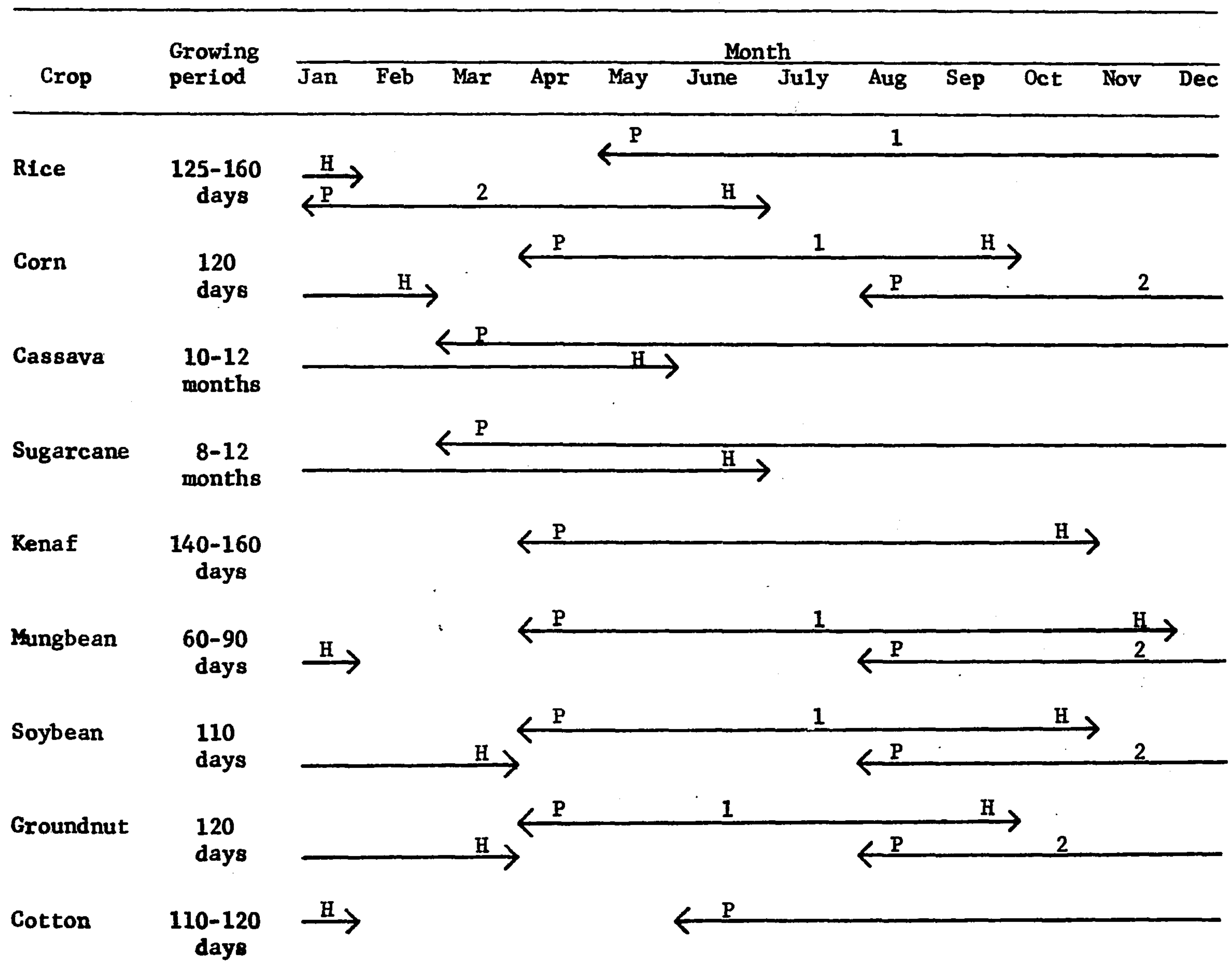
Sugarcane Area 1,000 rai	Sugarcane Per-cent[b] 1	Sugarcane Per-cent[c] 2	Sugarcane Rank[a] 3	Kenaf Area 1,000 rai	Kenaf Per-cent[b] 1	Kenaf Per-cent[c] 2	Kenaf Rank[a] 3	Total of Five crops	Total farm land holding[d] 4	Percent[e] 5
191	6.8	1.6	4	244	13.3	2.1	5	7,526	11,714	64.2
—	—	—	—	254	13.8	3.9	4	4,078	6,560	62.2
30	—	—	8	527	28.8	4.5	1	7,478	11,739	63.7
16	—	—	9	378	20.6	4.0	3	6,239	9,527	65.5
3	—	—		407	22.2	4.6	2	5,760	8.881	64.9
85	3.0	1.1	7	2	—	—	—	6,020	7,842	76.8
4	—	—	—	—	—	—	—	3,428	4,194	81.7
141	5.0	2.0	5	—	—	—	—	4,553	7,110	64.0
125	4.4	—	6	—	—	—	—	2,544	4,632	54.9
2	—	—	—	20	1.1	—	—	2,641	4,151	63.6
532	18.8	5.3	2	—	—	—	—	7,248	10,040	72.2
1,246	44.1	26.4	1	—	—	—	—	2,851	4,723	60.4
2	—	—	—	—	—	—	—	2,865	4,433	64.6
—	—	—	—	—	—	—	—	411	840	48.9
448	15.6	16.1	3	—	—	—	—	2,029	2,775	73.1
—	—	—	—	—	—	—	—	454	1,393	32.6
—	—	—	—	—	—	—	—	2,773	8,493	32.7
—	—	—	—	—	—	—	—	565	2,906	19.4
—	—	—	—	—	—	—	—	566	1,957	28.9
2,825	100	2.5		1,832	100	1.6		70,029	113,910	61.5

[d]Only four years average is used because the 1974 data is not available.

[e]Percent of five crops to the total farm land holding.

Figure 3.4. Calendar of major crops in Thailand (32). (Does not include the Southern region where the planting and harvesting times are different from other regions considerably; furthermore, the planted area of these crops (except rice) is very small and will not be included in the present study.)

P = planting; H = harvesting; 1 = first (main crop) 2 = second crop.


Crop
Growing period
Month
Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
Rice 125-160 days
P 1
H
P 2 H
Corn 120 days
P 1 H
H P 2
Cassava 10-12 months
P
H
Sugarcane 8-12 months
P
H
Kenaf 140-160 days
P H
Mungbean 60-90 days
P 1 H
H P 2
Soybean 110 days
P 1 H
H P 2
Groundnut 120 days
P 1 H
H P 2
Cotton 110-120 days
H P

The early variety can be harvested in September or October while the late variety has to wait until December or January, regardless of the planting date. In some irrigated areas, however, rice can be grown as a second crop in the dry season, planted between January to March and harvested in April to June. But the planted area of the second crop is still small compared to the first crop[1].

Rice is by no means a homogeneous crop. Several classifications of Thai rice are possible by the method of planting and the type of grain. There are three classifications of rice according to the method of planting: broadcasting, transplanting and upland rice. The decision regarding the method of planting is dependent on the water conditions in the area. If the area is quite dry and there is not sufficient water, then upland rice can be grown on this land. It is planted early in the rainy season by plowing or hoeing the soil, and then making holes with a sharp stick, dropping three to five rice grains into the hole and then covering the grains with the soil around it. Only very limited weed control is done during the growing period. Upland rice is not so important because it is a very small percentage of the total as compared to the other two types of rice.

For broadcast rice, the land is plowed as early as the rains permit, usually from February to May. The seed is broadcast at the beginning of the rainy season in May or June. Immediately after the seed is broadcast, a second plowing is done in order to cover the

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[1] The area planted to second crop rice has been increasing rapidly in the last two to three years and is not small compared to other important crops.

seeds to protect them from birds, rodents, sun and wind. In some areas where the water level is a little high during the sowing months, the seeds are sprouted by soaking them in water for several days before they are sown. In the first month after sowing, the right amount of rain at the right time is critical. If too much rain comes too early, the seed may not be able to germinate or dies just after it germinates. In later months, however, the rice plant can easily adjust itself according to the water level. In some areas, it can grow as high as three meters and it is called floating rice. Therefore, this kind of rice is suitable in the low and flooded areas where other crops cannot be grown during the rainy season. Harvesting this rice crop may take place while the paddy field is still wet or even sometimes using a small boat if necessary.

In the area where it is possible to control the water level to some degree, the transplanted rice is grown. The farmer constructs a small permanent dike around his field so that it contains the water from either the rain or the irrigated canal. The muddy seedbed is prepared as early as possible, usually in May to June, if water is sufficient. The sprouted seed is then sown on the muddy but drained seedbed. After about a month, the seedlings are uprooted and transplanted; they must be transplanted within a day or two after being uprooted. At the same time, the other field must be prepared and made ready for transplanting. The field is plowed two to three times and then harrowed. Again, sufficient water is necessary at this stage in order to plow and harrow the field, especially when the animal power (buffalo or oxen) is used in preparing the soil. This type of planting is the most practiced in Thailand.

In addition to the different methods of planting, there also is a distinction between two major types of rice; namely, glutinous and nonglutinous (or white) rice. This distinction is attributable to a stickiness property of the glutinous rice after it has been cooked. Nonglutinous rice is the most important of two types both for export and domestic consumption. Glutinous rice made up only 33 percent of total production in 1973 (9, Table 6, p. 11). Glutinous rice, although exported in small amounts, is mainly grown for domestic consumption especially in the Northern and Northeastern regions.

After rice has been harvested, it is threshed and cleaned by human and animal power at the paddy field and ready for transport to the farmers' storage. Most farmers have their own storage facilities of varying size. Most storage facilities are built near the farmer's house in the village in order to store rice for home consumption. The capacity of the storage facilities ranges from 9 to 17 thousand kilograms for temporary storage which lasts less than 10 years and 15 to 30 thousand kilograms for permanent storage which lasts more than 10 years (20). However, most farmers sell their paddy (rice) immediately after it has been harvested. The percentage of paddy sold by the farmers in each region and the average for the whole country are shown in Table 3.5 and Figure 3.5. The relatively high percentage in the month of January through March can be explained by the need of cash for paying back debts incurred during the growing season. In some cases, rice has been sold long before harvesting occurred by an agreement between the farmer and a local middleman who lends the

Table 3.5. Percentage of monthly sale by the Thai farmer in each region, 1973 (31)

Crop	Region	Month											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Rice	North	17.5	22.8	41.2	5.7	4.2	1.5	0.7	0.5	1.5	0.8	1.9	1.8
	Northeast	6.7	24.7	32.3	9.2	4.5	2.6	3.5	2.3	3.3	2.6	3.3	5.0
	Central	16.3	38.5	25.1	2.0	0.6	1.5	2.8	4.5	3.2	0.9	1.3	3.5
	South	38.1	1.8	5.2	5.4	11.1	6.2	7.0	4.6	7.5	4.6	4.4	8.6
	Average	15.6	33.1	26.1	3.8	2.1	2.0	3.0	3.9	3.4	1.4	1.9	3.7
Corn	North	6.8	10.5	4.5	—	0.5	—	3.3	3.2	25.3	21.5	19.7	4.8
	Northeast	26.3	9.4	4.8	0.2	—	2.5	12.2	17.8	3.6	5.1	7.9	10.3
	Central	6.8	4.4	1.8	—	—	0.2	0.5	4.8	15.7	13.5	20.0	26.4
	South	—	—	—	—	—	—	—	—	—	—	—	—
	Average	9.0	5.3	2.3	—	—	0.4	2.0	6.2	14.8	13.0	23.6	23.4
Cassava	North												
	Northeast	5.7	19.8	14.9	14.5	5.5	9.9	7.5	5.4	4.8	7.9	4.3	2.7
	Central	3.9	7.9	20.4	8.0	5.2	6.7	5.0	6.1	7.6	9.0	7.4	12.9
	South	—	—	—	—	—	—	—	—	—	—	—	—
	Average	4.5	12.8	17.1	9.2	5.1	7.8	8.7	6.8	6.1	8.1	5.8	7.9
Sugarcane	North	10.9	22.0	25.0	5.9	—	—	20.3	—	—	—	—	15.7
	Northeast	28.7	22.0	34.5	14.8	—	—	—	—	—	—	—	—
	Central	12.7	13.6	12.0	7.8	11.3	13.5	3.7	—	—	1.2	7.9	16.3
	South	—	—	—	—	—	—	—	—	—	—	—	—
	Average	17.2	15.9	17.3	8.4	7.4	8.8	5.7	—	—	0.8	5.2	13.2
Kenaf	North	—	—	—	—	—	—	—	—	—	—	—	—
	Northeast	11.1	11.0	8.8	7.8	3.5	4.7	3.2	7.7	11.0	12.8	9.0	9.5
	Central	—	—	—	—	—	—	—	—	—	—	—	—
	South	—	—	—	—	—	—	—	—	—	—	—	—
	Average	9.8	11.7	13.1	4.4	3.9	3.9	3.1	5.0	10.4	11.7	8.8	14.0

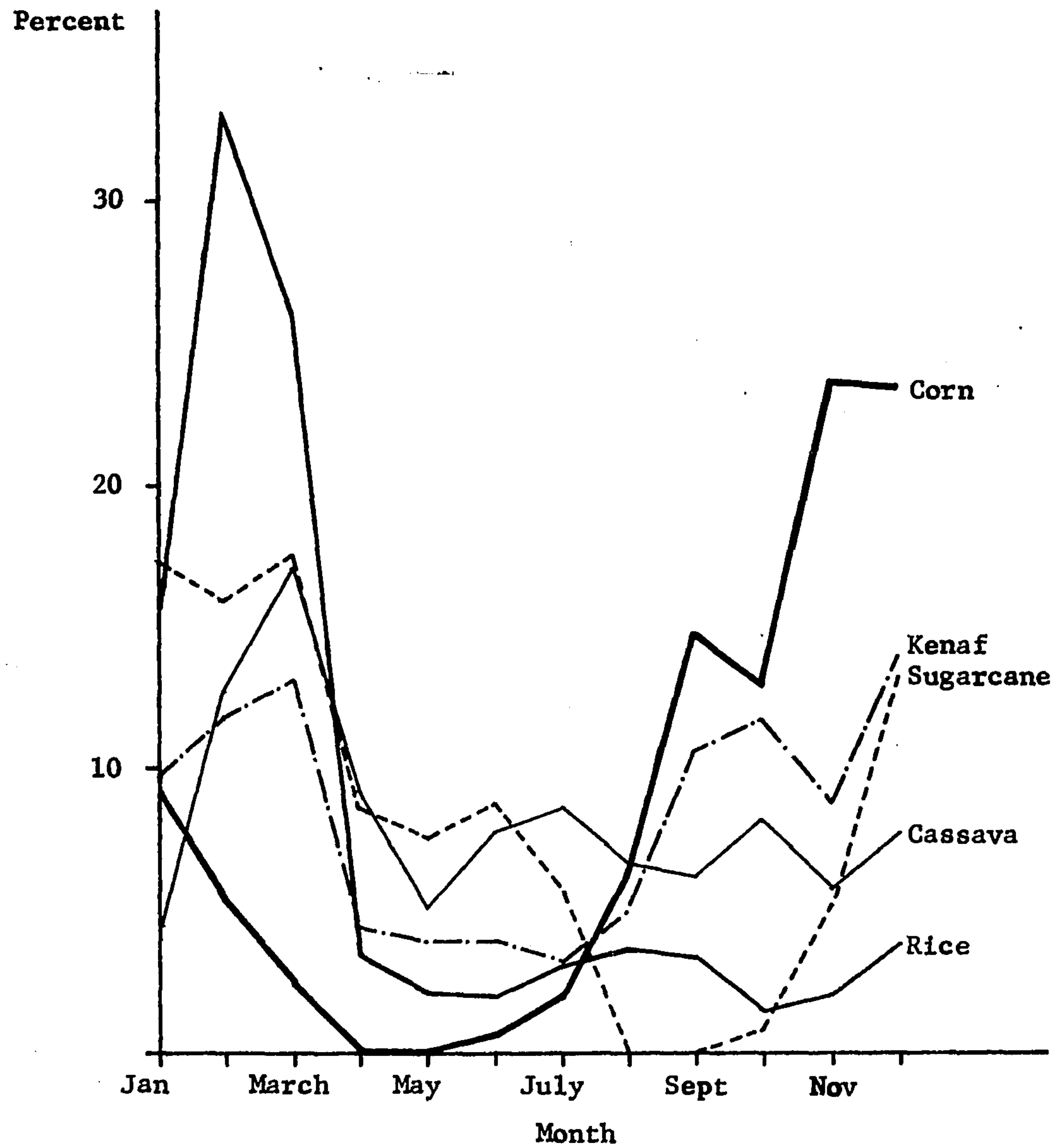

Figure 3.5. Average selling pattern of major crops by the Thai's farmers, 1973

farmer money and some other inputs during the growing period. This type of sale is called, in some areas, the "green rice sale," since it was sold when the rice plant is still green.

In this study, rice is treated as a single homogeneous crop and the second rice crop is not included because of lack of disaggregate time series data.

Corn

Corn is one of the dominant upland food crops in Thailand, both in terms of planted area and export value. The planted area of corn has expanded steadily from about 0.2 million rai in 1950 to 1.8 million rai in 1960 (30). In 1978, the planted area rose to about 8.7 million rai and ranks second, trailing only rice (Table 3.3). The average yield per rai also increased from 127 kilograms in 1950 to 306 kilograms in 1960 (30). However, since the late sixties, the average yield is relatively stable, except for 1972 and 1977 when the yield reached its minimum. The introduction of new Guatamala variety was probably the reason for the increase in the average yield in the fifties.

A strong export demand has been a key factor in the rapid expansion of corn production in Thailand. Exports have increased from 0.03 million tons of corn in 1953 to 0.5 and 2.0 million tons in 1960 and 1978, respectively (30, 35). However, the percentage of exports has decreased from 95 percent of the total production in 1960 to about 70 percent in 1978 due to the increase in the domestic demand for feed industry. Nevertheless, the value of corn exports is still important. In fact, in 1978, corn export value exceeded 4 billion baht and ranked fifth among the agricultural exports (Table 3.2).

There are two kinds of corn that grow in Thailand. The first is for direct human consumption varieties such as sweet corn and the other is for animal feed. Human consumption varieties are mostly domestically consumed and do not play a major role either in terms of planted area or export earning. In this study, therefore, we consider only the corn used for animal feed.

Unlike rice, corn is an upland crop and the producing area is not scattered around the country. Instead, it is concentrated in zones 5 to 7. These three zones together, averaging over a five-year period, accounted for almost 70 percent of the total corn planted area in the country. The other important zones in terms of planted area are zones 1, 4, 8, and 9 (Table 3.4).

Even though in most areas corn will not compete for land with rice, it may compete with other field crops since they can grow on the same type of soil and under the same weather conditions. However, during the planting season, all crops may compete for labor with one another because most crops are sown in the beginning of the rainy season. In growing corn, land usually will be plowed by either buffalo or tractor about two times before the seed is sown. The method of planting is similar to that of upland rice, that is, the hole is made with a sharp stick, three to five seeds are dropped into the hole and then covering these seeds with soil around them. The planting time for the first crop is around April or May and the harvesting time is around August or September. For the second crop, the seed is planted in August to September and harvested in January to February (Figure 3.4). Unlike rice, the corn crop is mostly grown only once in each field in one year. After it has been harvested, corn is either threshed by a small machine at the field or hauled from the field and threshed at the farmer's house. Corn is mostly sold in the spot market immediately after it has been harvested. The relatively high percentage of corn sold in the months of October to January can be seen from Table 3.5 and Figure 3.5. The corn markets, both domestic and export, unlike rice, are mostly free from government intervention. However, in some areas, the problem may arise due to a lack of adequate storage and transportation from the local market to the Bangkok market where the grain is exported or sold to the feed industry. For instance, damage may be caused by rain when the corn is packed in the gunny bag and is waiting for a train to transport it at the railway station without any additional protection. Nevertheless, the problem may be less severe now because the other means of transportation such as trucks are more available and more convenient.

Cassava

Cassava or tapioca is a root crop and is called by various common names in different parts of the world. It is called "manioc" by French-speaking people, "madioca" or "macaheira" in Brazil or "yuca" in Spanish-speaking areas. But all these refer to one species, Manihot esculenta Crantz. Among the leading producing countries are Brazil, Indonesia, Nigeria, Zaire, Thailand, and India (37). Tapioca products can be used either for human consumption or for animal feed or industrial uses such as adhesives, textiles, and the paper industry.

In Thailand, cassava is one of the most rapidly expanding crops during the last decade. The planted area for the kingdom was only 0.4 million rai in 1960, becoming 1.4 million rai and 6.3 million rai in 1970 and 1978, respectively. However, the average yield per rai has fluctuated from year-to-year and no definite trend is evident (30, 35).

Only a very small amount of tapioca is used in the domestic animal feed industry which has just begun utilizing tapioca products. Another domestic use such as human consumption is also very small compared to total production. Therefore, a strong export demand has been a key factor in the rapid expansion of cassava production in Thailand. Export value of processed cassava (chips, flour, pellets, and waste) has increased from 747 million baht in 1968 to 10.89 billion baht in 1978 and ranks first in terms of export value of all agricultural commodities and above rice for the first time in history (Table 3.2). Recently, tapioca products have been mostly exported in the form of pellets.

The interesting point to note regarding the expansion of the planted area is that in the very first expansion period from the mid fifties to the late sixties, cassava was primarily limited only to two changwads, Chonburi and Rayong, in zone 15. In this period, demand for tapioca products was mostly for human consumption and industrial uses. However, after that period, the export demand for animal feed industry became very strong and cassava production has been expanded to other zones, mostly in the Northeast. The planted area in each zone and its percentage of total planted area are shown in Table 3.4. From this table, we see that the cassava planted area is concentrated in zones 3, 5 and 15. These three zones together accounted for about 60 percent of total cassava planted area in the country.

Cassava is an upland crop and is usually planted on loam or sandy loam soil. The major competing crop for land utilization may differ from zone-to-zone. In zone 15, sugarcane may compete for land with cassava, while in zones 3 and 5, kenaf may be an alternative crop for cassava. Cassava can be planted either in the dry or rainy season. However, most cassava is planted in the wet season. The planting period starts from March to June and can be harvested after ten to twelve months of growing (Table 3.4). To plant the crop, sticks are cut from the mature plant and buried in the ground at a depth around 3 to 5 centimeters. The length of the stick is about 5 to 10 centimeters or have two to three buds on it. The plant is grown in rows. The space between plants is about 1 meter and between rows is about 1.5 meters. After ten months of growing, the farmer can harvest the crop any time that is convenient to him; timing is not so crucial as for other crops such as rice or kenaf. However, if plants are uprooted too early, they may be immature or give a small root weight, and if uprooted too late, the roots may contain too much fiber. Another requirement is that the field should not be so dry that the farmers may not be able to uproot the plant, especially when it is pulled by hand. In some areas, instead of pulling it by hand, the plants are cut and a tractor is used to plow up the root. Then the root is collected by farmers. However, in using this harvesting method, the roots lost due to soil cover may be more than by the pulling method.

Fresh tapioca roots are inputs of tapioca factories, which produce flour, sago, chips[1], and pellets[2]. Most farmers sell their cassava in the form of fresh roots either to local assemblers or to factories which produce either chips, pellets, flour, or sago. Most chip factories sell their product to nearby pellet factories which in turn sell the pellets to the exporters. In the sixties, most of the tapioca exports were in the form of chips or flour. However, since 1969, most of the cassava exports have been in the form of pellets. The cassava market, generally, is free from government intervention, except in recent years when the quality of the export product has been checked carefully by the government. This problem arises from dishonest exporters who try to mix other unwanted materials, e.g., sand, with the tapioca product.

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[1]Chips are made by cutting a fresh cassava root into small pieces (about 1/2") and drying in the sun for 2-3 days.

[2]A pellet is a granular form of cassava product and is made from chips. Although this is not a necessary step, the pellets made from chips are, in general, cheaper and better quality than if made directly from fresh cassava roots.

Sugarcane

Sugarcane, a tropical upland crop, is grown primarily for the manufacture of cane sugar. However, it has also been widely used in manufacturing other sweetening products as well. A directly consumed variety is also produced in Thailand, but the area devoted to the production of this type is almost negligible.

Sugarcane is one of the leading crops in Thailand both in terms of planted area and export earnings. Planted area was only 0.3 million rai in 1950 and increased to about one million rai and three million rai in 1960 and 1978, respectively (30, 35). In 1978, it was ranked fourth among all crops, excluding tree crops such as rubber and coconuts. There was also a positive trend of average yield per rai in the fifties and sixties. However, since the 1970s, the average yield per rai has been relatively stable. In 1978, the average yield was 6.4 tons per rai.

Again, like many other important crops, the increase in export demand for cane sugar has played an important role in the expansion of sugar industry in Thailand. In 1950, Thailand exported approximately 3,745 tons of sugar with a value of 5.6 million baht. In 1978, however, it increased to 1.78 million tons, mostly in the form of raw sugar, with an export value of 4.5 billion baht and ranked fourth among the agricultural commodities, trailing only cassava, rice, and rubber. However, unlike corn, cassava, and kenaf, the government has intervened in both the domestic market and export markets in the form of putting a ceiling price on domestic sugar, guaranteeing the price for the cane growers, and imposing export taxes and quota.

Sugarcane in Thailand is planted mostly in the early rainy season, starting from March to May when there is still sufficient soil moisture for buds and roots to germinate. However, in some areas, it can also be planted as early as January, but this practice is very rare. Sugarcane is not, however, propagated from seed but, instead, from a section of stalk containing buds or eyes. The length of the stalk for propagation is approximately 20 to 30 centimeters which has two or three buds on it, and half of its stalk should be inserted into the soil at about a 45° angle. Spacing between stalks is about 50 to 75 centimeters and between rows is about 1 meter. The first crop is cut about 8-12 months after planting and thereafter at 10-12 month intervals. These succeeding crops are called ratoons and grow from the original roots after the cane has been cut. Yield from ratoons can be either larger or smaller than the first crop depending on the fertilities of the soil and weather conditions. In fact, unlike other sugarcane growing countries where the first crop will be harvested only after 12 to 18 months of growing, the second crop from ratoons usually has a higher yield than the first crop because of the longer period of growing of the second crop. The number of times it can be cut from one growing varies from 2 to 4 times. Most of the cane growers in Thailand prefer to cut about three times before the roots are plowed up and new plants are grown. Therefore, strictly speaking, sugarcane is not an annual crop in the sense that it can be harvested more than once from one growing and the last harvesting time occurs about three years after planting. However, it is not a perennial crop in the sense that it can be harvested within the first year of planting. So, the advantage of sugarcane over the other crops is that it is labor saving especially in terms of soil preparation. However, this advantage may be offset by the lower yield of its ratoons in the later year.

Most of the cane growers are scattered around the sugarcane factory area where the canes are cut and directly transported to the factory immediately after it has been cut. However, the sale of the sugarcane may not be done directly between the sugarcane growers and the factories. Instead, in most cases, it is done through the local middlemen who in turn have a selling quota from the factories which is, of course, a reduction in market efficiency. The middleman is called a "quota man," and he may or may not grow sugarcane himself.

Kenaf

Kenaf is a fiber crop and probably the closest substitute of jute, though it has lower quality. Its major use is to manufacture gunny bags, rope and paper. Kenaf can be grown in almost all tropical countries in the world. However, it is only in a limited number of countries that production is commercially important; for example, India, Thailand, Vietnam, Brazil, and the Congo (15). Although not a dominant crop in Thailand's agriculture, kenaf is nevertheless important. In 1955, the area planted to kenaf was only 0.05 million rai, but in 1960, the planted area has increased to almost one million rai (30). However, since its peak in 1966 when the planted area was about

3.3 million rai, the planted area has fluctuated from year-to-year with a declining trend. In 1978, the kenaf planted area was 2 million rai (Table 3.3) and ranked sixth among all crops, excluding rubber and coconut trees.

Most of Thailand's kenaf production is either processed in domestic mills or exported as raw baled kenaf. An insignificant amount may be locally utilized in the local villages. Unlike corn, where only the export demand has been a key factor in rapid expansion of corn production, both domestic mill consumption and export demand are attributable to the expansion of kenaf production. In fact, mill consumption in Thailand has tended to grow more rapidly than export demand (5). In 1950, the export value of baled kenaf was about one million baht and no gunny bags were exported. However, since 1956, both baled kenaf and gunny bags have been exported. In 1978, the export values were 443 million baht for baled kenaf and 425 million baht for gunny bags.

Historically, unlike rice, Thailand's kenaf export business has been in the hands of private traders and there has been little government involvement except for a small export tax. Nevertheless, the future demand for kenaf may not be as good as it has been because of the introduction of low-cost synthetic fiber which can be used to make products traditionally made from jute and kenaf. Another factor that may have a negative effect on kenaf expansion is the shift toward bulk handling of agricultural products in the developed countries. However, these phenomena may not yet pose a serious problem in the developing countries like Thailand, where gunny bag demand is still great. In any event, kenaf planted area in recent years has fluctuated greatly and the tendency toward further expansion is less apparent. Similarly, changes in yield have been irregular, and no clear trend is evident (Table 3.3).

Kenaf is primarily grown in the Northeast on soil having low fertility. Unlike other crops, the planted area in each zone from zone 1 to zone 5 is distributed almost evenly (Table 3.4). In growing kenaf, soil preparation is done mostly with animal power (buffalo) and usually after the first spring rains and before the rice planting season begins. The seeds are sown in April either by broadcasting or in hills or dropping seeds into the holes like upland rice. Other activities such as applying fertilizer or weed control are very limited. Harvesting may begin at about the time the plants are flowering or a little before, around September or October. Too early or too late harvesting will have an effect upon the quality of the fiber. If the plant is cut too early, the top stem will be immature and therefore, decay in the retting[1] process. If the plant is cut too late, the stems become too woody, thus, lowering the quality of the fiber. The harvesting process begins by cutting the kenaf stock with a hand knife and then leaving it on the field for about a week to permit its dying and the subsequent removal of leaves. The stalks are later transported to retting sites which may be wherever water is available. Retting decomposes the outer vegetative matter leaving the fiber open for

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[1]The retting process consists of the immersion of bundles of plants in ponds or streams for 10 to 30 days in order that the skin and pulp decay and thereby free the fibers.

stripping. The farmers then wash and dry it for two or three days. The fiber is then packed into bales and is ready for transport to the market place. The retting process usually takes about two to four weeks and is also an important factor affecting the quality of fiber. Clean and moving water is preferred to dirty or still water. Inadequate supplies of clean water during the retting time is still a problem facing farmers in most kenaf growing areas.

CHAPTER IV. THEORETICAL CONSIDERATIONS

Several approaches may be used to study the supply response of agricultural products which can be categorized broadly into two groups as positive and normative approaches. Positive analysis describes structures as it actually exists, and hence, can be used to predict the magnitude of one variable from the magnitude of the other. This method involves the statistical analysis of time series data which may be aggregated over some regional or national level. In contrast, normative analysis attempts to show how much a farmer ought to produce under certain assumptions, to maximize profit, for example. This approach deals with the derivation of supply functions from production functions, budgeting and linear programming, usually on a farm basis. Regression analysis, on the other hand, is very useful and quite accurate for prediction of aggregate output especially in the short-run where the relationships among the variables still hold during the forecasting period. Because it is related to the past, the regression model cannot be used to analyze the possible effects of new variables as compared to the normative approach. Another advantage of the normative approach is that it provides estimates of output supplies and factor demands for individual commodities in one analysis. However, the limitation of the normative approach is that estimated coefficients based on a representative farm analysis may not be appropriate to use in the national or regional model. Even though the individual farm programming model can be derived, the computational and financial burden would be great for the aggregate at the national level. Nevertheless, both approaches have been employed in supply analyses and many researchers consider them as complements rather than rivals. The approach one should follow depends on the purpose and the information available. Our purpose is to study the relationship between the acreage of each crop and prices and other variables. Therefore, the regression analysis of time series data is used in this study and the model specification is of a form similar to the Nerlove supply model, which we will discuss in detail in the next section.

The Nerlove Supply Models

Tne Nerlove supply model has been widely used because of its relative success in empirical works in supply analysis in both developed and less developed countries. However, it has been extensively revised and modified by numerous later researchers in order to satisfy their purposes. The general form of the model is:

$$A_t^* = \alpha_0 + \alpha_1 P_t^* + \alpha_2 Z_t + U_t \qquad (4.1)$$

where A_t^* is the desired output,

P_t^* is the expected price variable(s),

Z_t is the nonprice variable(s) or supply shifter variable(s),

U_t is the random disturbance term.

Since both A_t^* and P_t^* are unobservable variables, additional assumptions are needed. The general assumptions are:

a) $A_t - A_{t-1} = \lambda(A_t^* - A_{t-1}), \qquad 0 < \lambda \leq 1$

where A_t is the actual output.

This model is called the partial adjustment or the habit persistence hypothesis and λ is called the coefficient of adjustment. This hypothesis states that the change in actual output is proportional to the difference between desired and actual output. In the agricultural supply context, this means that farmers increase their output of a crop in any year only to the extent of a fraction λ of the difference between the output in the preceding year. This assumption reflects the traditional, technological and/or institutional constraints which permit only a fraction of the intended levels to be realized during a given short period. In the short-run, some of the factors of production are fixed and may be very difficult to shift from one production activity to another. Furthermore, farmers may be reluctant to adopt the new technology until they are convinced by observing other people practice it for a period of time.

b) $P^*_t - P^*_{t-1} = \delta[P_{t-1} - P^*_{t-1}], \qquad 0 < \delta \leq 1.$

This is called the adaptive expectations model and δ is called the coefficient of expectation. This hypothesis postulates that each year farmers revise the price expected to prevail in the coming year in proportion to the error they have made in predicting price this period.

Using either assumption (a) or (b) or both, we are able to get the reduced form which contains only the observable variables.

Substitute (4.1) in (a) and rearranging terms,

$$A_t = (1 - \lambda)A_{t-1} + \lambda A_t^*$$

$$= (1 - \lambda)A_{t-1} + \lambda\alpha_0 + \lambda\alpha_1 P_t^* + \lambda\alpha_2 Z_t + \lambda U_t \quad (4.2)$$

Lagging (4.2) one period and multiplying by $(1 - \delta)$,

$$(1 - \delta)A_{t-1} = (1 - \delta)A_{t-2} + (1 - \delta)\lambda\alpha_0 + (1 - \delta)\lambda\alpha_1 P^*_{t-1}$$

$$+ (1 - \delta)\lambda\alpha_2 Z_{t-1} + (1 - \delta)\lambda U_{t-1} \quad (4.3)$$

Subtract (4.3) from (4.2) and rearranging term,

$$A_t = \delta\lambda\alpha_0 + \lambda\alpha_1[P_t^* - (1 - \lambda)P_{t-1}^*] + [(1 - \lambda) + (1 - \delta)]A_{t-1}$$

$$- (1 - \delta)(1 - \lambda)A_{t-2} + \lambda\alpha_2 Z_t - (1 - \delta)\lambda\alpha_2 Z_{t-1} + \lambda U_t$$

$$- (1 - \delta)\lambda U_{t-1}$$

But, from (b)

$$P_t^* - (1 - \delta)P_{t-1}^* = \delta P_{t-1}$$

This gives,

$$A_t = \delta\lambda\alpha_0 + \delta\lambda\alpha_1 P_{t-1} + [(1 - \lambda) + (1 - \delta)]A_{t-1}$$

$$- (1 - \delta)(1 - \lambda)A_{t-2} + \lambda\alpha_2 Z_t - (1 - \delta)\lambda\alpha_2 Z_{t-1}$$

$$+ \lambda U_t - (1 - \delta)\lambda U_{t-1} \quad (4.4)$$

or in the reduced form of the observable variables,

$$A_t = \beta_0 + \beta_1 P_{t-1} + \beta_2 A_{t-1} + \beta_3 A_{t-2} + \beta_4 Z_t + \beta_5 Z_{t-1} + V_t$$

(4.5)

where $\beta_0 = \delta\lambda\alpha_0$ $\beta_3 = -(1-\delta)(1-\lambda)$

$\beta_1 = \delta\lambda\alpha_1$ $\beta_4 = \lambda\alpha_2$

$\beta_2 = (1-\lambda) + (1-\delta)$ $\beta_5 = -(1-\delta)\lambda\alpha_2$

$V_t = \lambda U_t - (1-\delta)\lambda U_{t-1}$.

If only the partial adjustment hypothesis is assumed (i.e., $\delta = 1$), Equation (4.4) reduces to

$$A_t = \lambda\alpha_0 + \lambda\alpha_1 P_{t-1} + (1-\lambda)A_{t-1} + \lambda\alpha_2 Z_t + \lambda U_t \qquad (4.6)$$

On the other hand, if only the adaptive expectation hypothesis is assumed (i.e., $\lambda = 1$), Equation (4.4) reduces to

$$A_t = \delta\alpha_0 + \delta\alpha_1 P_{t-1} + (1-\delta)A_{t-1} + \alpha_2 Z_t - (1-\delta)\alpha_2 Z_{t-1} + U_t - (1-\delta)U_{t-1}. \qquad (4.7)$$

The differences between (4.6) and (4.7) are the disturbance terms and that Equation (4.7) contains the variable Z_{t-1} where its coefficient is equal to the negative of the product of the coefficients of A_{t-1} and Z_t. Furthermore, Equation (4.6) is just identified while Equation (4.7) is overidentified. In addition, if we change the specification of the model in (4.1) by assuming that there is no other regressor variable Z_t (i.e., $\alpha_2 = 0$), then both (4.6) and (4.7) are reduced to a similar form and we cannot distinguish between the two hypotheses. That is, we do not know empirically that our estimation equation comes from either partial adjustment or adaptive expectation hypothesis.

For $\alpha_2 = 0$, Equation (4.6) reduces to

$$A_t = \lambda\alpha_0 + \lambda\alpha_1 P_{t-1} + (1 - \lambda)A_{t-1} + \lambda U_t, \tag{4.8}$$

and Equation (4.7) reduces to

$$A_t = \delta\alpha_0 + \delta\alpha_1 P_{t-1} + (1 - \delta)A_{t-1} + U_t + (1 - \delta)U_{t-1}. \tag{4.9}$$

Both (4.8) and (4.9) are of the form

$$A_t = \gamma_0 + \gamma_1 P_{t-1} + \gamma_2 A_{t-1} + W_t \tag{4.10}$$

Equation (4.10) with the trend variable added is the form that Nerlove (25) used in his earlier studies to estimate the elasticities of supply of U.S. agricultural commodities.

The interesting point to make here is that when the Nerlovian type model is applied in empirical studies, we must state explicitly what are the hypotheses of the model, either the partial adjustment or the adaptive expectations or both hypotheses are assumed. If one assumes either $\delta = 1$ or $\lambda = 1$ while the true model, neither δ nor λ equal to unity, this may introduce bias into the estimation of the parameters (39).

However, one need not assume either the partial adjustment or the adaptive expectation hypothesis. For example, we might specify that A_t is a distributed lag function of P_t, instead of P_t^*, plus some other variable, Z_t, i.e.,

$$A_t = a_0 + a_1 \sum_{i=0}^{\infty} W(i)P_{t-1-i} + a_2 Z_t + e_t \tag{4.11}$$

where W(i) is a weight assigned to each lagged variable and its value depends, again, on the assumption used. If, for example, a Koyck or a geometric lag is assumed, then W(i) is of the form $\delta(1 - \delta)^i$. It can be shown that the reduced form under this assumption is equivalent to the adaptive expectation model.

Substitute $W(i) = \delta(1 - \delta)^i$ into (4.11)

$$A_t = a_0 + a_1\delta \sum_{i=0}^{\infty} (1 - \delta)^i P_{t-1-i} + a_2 Z_t + e_t \qquad (4.12)$$

Lag (4.12) one period and multiply by $(1 - \delta)$,

$$(1 - \delta)A_{t-1} = (1 - \delta)a_0 + a_1\delta \sum_{i=0}^{\infty} (1 - \delta)^{i+1} P_{t-2-i}$$

$$+ a_2(1 - \delta)Z_{t-1} + (1 - \delta)e_{t-1} \qquad (4.13)$$

Subtract (4.13) from (4.12) and rearranging terms, we get

$$A_t = \delta a_0 + a_1\delta \sum_{i=0}^{\infty} (1 - \delta)^i P_{t-1-i} - a_1\delta \sum_{i=0}^{\infty} (1 - \delta)^{i+1} P_{t-2-i}$$

$$+ (1 - \delta)A_{t-1} + a_2 Z_t - (1 - \delta)a_2 Z_{t-1} + e_t - (1 - \delta)e_{t-1}$$

$$= \delta a_0 + a_1\delta P_{t-1} + a_1\delta \sum_{i=1}^{\infty} (1 - \delta)^i P_{t-1-i}$$

$$- a_1\delta \sum_{i=1}^{\infty} (1 - \delta)^i P_{t-1-i} + (1 - \delta)A_{t-1}$$

$$+ a_2 Z_t - (1 - \delta)a_2 Z_{t-1} + e_t - (1 - \delta)e_{t-1}$$

$$= \delta a_0 + a_1\delta P_{t-1} + (1 - \delta)A_{t-1} + a_2 Z_t - (1 - \delta)a_2 Z_{t-1}$$

$$+ e_t - (1 - \delta)e_{t-1}, \qquad (4.14)$$

which is the same as (4.6).

Very often, one assumes W(i) = 1 for i = 0 and W(i) = 0 for all

$i \neq 0$. With the naive assumption, (4.11) reduces to

$$A_t = a_0 + a_1 P_{t-1} + a_2 Z_t + e_t \tag{4.15}$$

which is a traditional static supply model where the explanatory variables contain no lagged dependent variable. The form of the weight depends on the assumption one makes which in turn depends on the nature of the problem studied. For example, in a study of supply analysis of livestock, a polynomial or Almon lag may be more appropriate than a geometric or Koyck lag, e.g., Meilke, Zwart, and Martin (21). A survey on distributed lag models was given and discussed by Griliches (10).

Estimation Problems

Consider the general linear model

$$Y = Z\beta + U$$

where Y is an n x 1 vector of the dependent variable,
Z is an n x k matrix of the explanatory variables,
β is an k x 1 vector of the coefficients,
U is an n x 1 vector of the disturbance term,
n is the number of observations, and
k is the number of explanatory variables.

The assumptions are:

(1) $(Z'Z)^{-1}$ exist

(2) Z is fixed

(3) $E(U) = 0$

(4) $E(UU') = \sigma^2 I_n$

If all the above assumptions hold, then the ordinary least squares

(OLS) estimates give the Best Linear Unbiased Estimator (BLUE) of βs (Gaussian-Markov theorem).

Assumption (1) implies that the rank of Z must be equal to k or one of the variables in Z is not a linear combination of the other variable(s). In practice, we may not have perfect correlation among these variables but, instead, we may have a partial or high correlation which is called a multicollinearity problem. As a result, the estimates of the coefficients may not be reliable due to large standard errors. This problem may arise in an equation that contains the lagged independent variable.

Assumptions (2) and (3) guarantee the unbiasedness of the OLS estimator. Assumption (4) means that the disturbance term is independently distributed with homogeneous variance. This assumption implies that OLS estimator will yield a minimum variance. Furthermore, if U is also normally distributed, i.e., $U \sim NID(0, \sigma^2 I_n)$, then the OLS estimator is equivalent to the maximum likelihood estimator (MLE). If Z is stochastic and correlated with U, the OLS estimator is biased and inconsistent. This case may not be difficult to find in econometric problems such as demand or supply analysis where price and quantity simultaneously determine each other, i.e., if one of the explanatory variables is an endogenous variable. In other situations such as where the explanatory variable is a lagged dependent variable which is not independent of the disturbance term, then, if assumptions (3) and (4) hold, OLS estimator will give consistent estimates, though they are biased. There are several cases when assumption (4) is violated, and this is called a heteroscedasticity problem. OLS will not yield the minimum variance estimates, even though, in some cases, may give an unbiased estimator. If we know the distribution of U and its parameters, we may be able to utilize this information by transforming the original data, then applying OLS which is called the Generalized Least Squares (GLS) procedure. In general, we do not know the distribution of the disturbance term. There are an infinite number of assumptions that can be made about the disturbance term. Different assumptions will lead to a different method of estimation. In this section, however, only the four most relevant and often uses will be discussed briefly. For simplicity, let us consider the linear regression of the form

$$A_t = \beta_0 + \beta_1 A_{t-1} + \beta_2 X_t + V_t$$

The four assumptions are as follows:

(1) $V_t \sim NID(0, \sigma_v^2)$

(2) i) $V_t = U_t - (1 - \delta)U_{t-1}, \; 0 < \delta < 1$

ii) $U_t \sim NID(0, \sigma_u^2)$

(3) i) $V_t = U_t - (1 - \delta)U_{t-1}, \; 0 < \delta < 1$

ii) $U_t = \rho U_{t-1} + e_t, \; |\rho| < 1$

iii) $e_t \sim NID(0, \sigma_e^2)$

(4) i) $V_t = \rho V_{t-1} + e_t, \; |\rho| < 1$

ii) $e_t \sim NID(0, \sigma_e^2)$

Although only assumption (1) will be employed in the present study, it is worth a discussion about the consequences of each assumption briefly, at least, to remind us that the interpretation of the statistical results must be made very cautiously before jumping to any conclusion. For further detail regarding different methods of estimation, information can be found in any standard econometric textbook, e.g., Johnston (14) and Kmenta (16).

Assumption (1) is the simplest assumption, and it is a possible assumption when the partial adjustment model is assumed together with the assumption that U_t in Equation (4.1) is also NID(0, σ_u^2). Since $V_t = \lambda U_t$ (see (4.2)) and λ is a constant, therefore, $V_t \sim$ NID(0, $\lambda^2\sigma_u^2$). OLS will yield consistent but biased estimates of the βs because of the presence of the lagged dependent variable (A_{t-1}) on the right-hand side of the equation. Furthermore, in this case, MLE is identical with OLS.

Assumption (2) is an assumption candidate when an adaptive expectation model is assumed (see Equation (4.4)). There is not much problem in estimation if δ is known since GLS can be applied. Under this assumption, it follows that

$$E(V_t) = 0$$

$$E(V_t V_{t+s}) = \begin{cases} [1 + (1 - \delta)^2]\sigma_u^2, & s = 0 \\ -(1 - \delta)\sigma_u^2, & s = \pm 1 \\ 0, & \text{otherwise} \end{cases}$$

Thus, the covariance matrix (Ω) = E($\underline{VV}'$) is known and is of the form

$$\Omega = \sigma_u^2 \begin{bmatrix} [1 + (1 - \delta)^2] & - (1 - \delta) & 0 & \ldots 0 \\ - (1 - \delta) & [1 + (1 - \delta)^2] & - (1 - \delta) & 0 \\ & & & \\ & & & [1 + (1 - \delta)^2] \end{bmatrix}$$

The GLS estimator of βs is given by

$$(\underline{X}'\Omega^{-1}\underline{X})^{-1}\underline{X}'\Omega'\underline{A}$$

where $\underline{A}$ is a vector of the dependent variable,

$\underline{X}$ is a matrix in which the tth row contains the following elements $[1, A_{t-1}, X_t]$, and

$\underline{V}$ is a vector of the disturbance terms, V_t.

In practice, however, δ is generally unknown, therefore, GLS cannot apply directly. Nevertheless, there are several procedures, such as the method of instrumental variable and maximum likelihood that give consistent estimators of the βs, though it is still biased in the small sample case. Most procedures deal with searching for the optimum value of δ which gives the minimum mean square error and the procedure may be iterative in nature.

There is no problem in assumption (3) if both δ and ρ are known, since GLS can be applied directly. In general, δ and ρ are unknown, and the search and iterative procedure may be needed. The models with assumptions (2) and (3) are computationally burdensome and are worth doing only if one is very convinced about the specification above. Since we will not apply this procedure here, therefore, we will not discuss it further.

Assumption (4) is an autocorrelation assumption of the disturbance term and is not tied with either the adaptive expectations or the partial adjustment hypothesis. If ρ is known, then GLS is applicable since we can compute the covariance matrix (Ω) similarly to the method used making assumption (1), and Ω is of the form

$$\begin{bmatrix} 1 & \rho & \rho^2 & \rho^3 \ldots & \rho^{n-1} \\ \rho & 1 & \rho & \rho^2 \ldots & \rho^{n-2} \\ & & & & \\ \rho^{n-1} & \rho^{n-2} & \ldots\ldots & \ldots & 1 \end{bmatrix}$$

where n is the number of observations. If ρ is unknown, one has to estimate ρ or use a search and/or iterative procedure similar to those in the models using assumptions (2) and (3). Again, we will not discuss it here further.

The assumption regarding the disturbance term is, in fact, crucial. The unbiasedness and consistency properties of the estimators depend on the assumption made about the disturbance term and consequently, the method of estimation employed.

The Variable Problems

The dependent variable

In studying the supply analysis of any crop, one of the main objectives is the empirical estimation of the elasticity of supply or output with respect to price. The choice of the dependent variable lies between the production or output and the planting or harvesting acreage. If our objective is to estimate the elasticity of production, then the relevant dependent variable is the production. Under certain assumptions, however, the acreage response may give a better approximation of production elasticity. Consider the fact that production is the product of area and yield per unit area; if we assume that the elasticity of yield with respect to price is very small or close to zero which is not unrealistic for the less developed countries, then the production response and the area response are approximately equal. Let Q be production, Y be yield per unit area and A be the planted area; then the relationship between the elasticities of Q, A, and Y with respect to P are

$$e_{QP} = e_{AP} + e_{YP},$$

where e_{QP} = elasticity of Q with respect to P,

e_{AP} = elasticity of A with respect to P, and

e_{YP} = elasticity of Y with respect to P.

If e_{YP} is very small, then $e_{QP} \cong e_{AP}$. However, as pointed out by Behrman (4), the realized agricultural output often differs considerably from planned output because of important environmental factors which remain beyond farmers' control. The frequent large discrepancies between planned and actual agricultural production have led most econometric investigators of agricultural supply response to approximate planned output not by actual output, but by area. The area actually planted in a particular crop is, to a much greater degree, under the farmers' control than output is, and thus, presumably a much better index of planned production. By contrast, the actual output is dependent on the harvested, not the planted, area which in turn depends on the harvesting cost relative to the price of output and the actual yield which, to some extent, depends on weather conditions. These factors are not under the control of the farmers. The farmer may be able to adjust, to some extent, his output by shifting his land from low to high fertility by increasing the utilization of fertilizer, water, etc., or expand to low fertility land. As a result, the response of yield with respect to price may not be small and cannot be ignored.

The price variable

In the simple Nerlove supply model, only P_t^* is used. If one or more prices of competing crops are used, then the following problem may arise. What are the relevant competing crops? Because of the heterogeneous nature of land, the higher the level of aggregation, the more alternative crops we will have. Furthermore, using more than one price, we may encounter a multicollinearity problem among the price variables. However, even if we use single price variable in the model, the problem still remains. That is, the following choices must be considered:

a) the absolute price of the crop actually received by farmers;

b) the relative price, i.e., the price of the crop under consideration deflated by some deflator.

If the relative price is used, then the question becomes, what is the appropriate deflator? In order to be able to answer this question, we must know why the farmer wants to alter his production.

If he increases his production because he wants to consume more, then no price variable is relevant, i.e., any price will not yield a significant effect. On the other hand, if the profit maximization is his goal, then the relative price may be appropriate. The deflator should be the index of the price of the alternative crops. What is the appropriate weight, the acreage, the total output or the marketed output? If the crop under consideration is a subsistence crop as opposed to a cash crop, then the marketed output is a better weight than the total output. However, the availability of data may force one to use other variables as proxy variables.

The supply shifter variable

These are non-price variable(s). In general, the reason for including these variables is to avoid the problem of identification in the estimation of the structural parameters. The most common variable is a time trend which is used as a proxy for a technological change or to pick up some autonomous trend or for the purpose of correcting the serial correlation among the disturbance terms. The weather variables such as rainfall, temperature and/or some measure of the weather index are also often used. This is because weather conditions are one of the constraints that prevent a farmer from planting a crop as much as he wants to. The selection of the shift variables may depend on the objective of the investigator. Many times, this variable cannot be quantified, so dummy variables are used instead. For example, the effect of transportation, disease, insect attacks, regional or geographical differences. However, including too many variables in the model may cause a multicollinearity problem and loss of degrees of freedom which may cause hypothesis testing to be unreliable. Some authors include the risk variable such as the standard deviation of price and/or yield (4). The most common goal is to increase the value of the coefficient of determination (R^2) of the model and to achieve estimated coefficients that have the expected signs.

CHAPTER V. EMPIRICAL ANALYSIS

The Estimation Models

Because the period under study is very short and in order to conserve the degrees of freedom in statistical analysis, the relatively simple version of the Nerlove (25) supply model is applied in this study. Therefore, very limited hypotheses can be tested. The emphasis will be focused on the question of what form of the models and price variables are relevant to the decision-making of Thai farmers in considering what crop will be produced each year. The basic model is of the form

$$A_t = \alpha_0 + \alpha_1 P_t^* + U_t \tag{5.1}$$

where A_t = the actual planted area of crop under study,

P_t^* = the expected price of the crop under study,

U_t = the random disturbance term.

Since P_t^* is unobservable, therefore, additional assumptions are necessary in order to be able to estimate the parameter αs of the model. For this study, three models are assumed and tested. The three models are:

a. The naive model, where

$$P_t^* = P_{t-1}. \tag{5.2}$$

b. The intermediate model, where

$$P_t^* = \lambda P_{t-1} + (1 - \lambda)P_{t-2}. \tag{5.3}$$

c. The adaptive expectation or the geometric lag model, where

$$P^*_t = P^*_{t-1} + \delta[P_{t-1} - P^*_{t-1}],\ 0 < \delta \leq 1. \tag{5.4}$$

The first model states that the expected price of current year is equal to last year's price. Substituting (5.2) into (5.1), we obtain the equation of the form

$$A_t = \alpha_0 + \alpha_1 P_{t-1} + U_t \tag{5.5}$$

which is estimable because it contains all observable variables.

Instead of the expected price equal to last year's price, the weighted average of the price lagged one and two years is used in model (b). For this model, the value of λ need not be restricted to the value between zero and one. Since several values of λ which lie outside this interval can be meaningfully interpreted, Equation (5.3) can be rewritten as

$$P^*_t = P_{t-1} + (\lambda - 1)[P_{t-1} - P_{t-2}]. \tag{5.6}$$

For $\lambda = 2$,

$$P^*_t = P_{t-1} + [P_{t-1} - P_{t-2}] \tag{5.7}$$

Equation (5.7) is equivalent to saying that the expected price is last year's price plus the difference between last year's price and the price in the preceding year. If $\lambda = \frac{1}{2}$, P^*_t is an unweighted average of price lagged one and two years. If $\lambda = 0$, P^*_t is equal to the price lagged two years. Finally, when $\lambda = 1$, models (a) and (b) are the same. Substituting (5.3) into (5.1), we obtain the equation:

$$A_t = \beta_0 + \beta_1 P_{t-1} + \beta_2 P_{t-2} + U_t \tag{5.8}$$

where $\beta_0 = \alpha_0$

$\beta_1 = \alpha_1 \lambda$

$\beta_2 = \alpha_1(1 - \lambda)$

The value of the structural parameters can be uniquely obtained from the reduced form parameters, i.e.,

$$\lambda = \frac{\beta_1}{\beta_1 + \beta_2}$$

$$\alpha_1 = \beta_1 + \beta_2$$

Noting that if λ is greater than one which implies that the farmer over-adjusts his price expectation and if α_1 is positive, this will lead to a negative value of the coefficient of the price lagged two years (β_2).

Model (c) states that the expected price of this year is equal to last year's expected price plus some portion of the error made last year in forming the price expectation. However, another interpretation of this model is also possible if we rewrite (5.4) as

$$P_t^* = \sum_{j=0}^{\infty} \delta(1 - \delta)^j P_{t-1-j} \tag{5.9}$$

This form implies that the farmers have a much longer memory than the first two models when only price lagged one or two years is used in forming the price expectation. However, under this interpretation, we must restrict the value of δ to lie between zero and one. Otherwise, the model is unstable in the long-run. Theoretically, under this formulation, all the previous prices must be included. In practice, however, if the value of δ is big (but less than one, of course), or $(1 - \delta)$ is very small, we can safely ignore prices in the very distant past. Substituting (5.4) in (5.1) and after some manipulation as shown in Chapter IV, the reduced form is obtained as

$$A_t = \beta_0 + \beta_1 P_{t-1} + \beta_2 A_{t-1} + V_t \tag{5.10}$$

where
$$\beta_0 = \alpha_0 \delta$$
$$\beta_1 = \alpha_1 \delta$$
$$\beta_2 = (1 - \delta)$$
$$V_t = U_t - (1 - \delta) U_{t-1}$$

The structural parameters can be estimated from the reduced form coefficients as

$$\delta = 1 - \beta_2$$
$$\alpha_0 = \frac{\beta_0}{1 - \beta_2}$$
$$\alpha_1 = \frac{\beta_1}{1 - \beta_2}$$

It is also felt that many relevant variables may have been left out of the above model and also some variables may be very difficult to quantify. Therefore, a trend variable is added to the model. Even though it is a very crude representation of these variables, at least it may be able to absorb all effect on area response not attributable to price changes. However, many variables, such as prices, are correlated with the trend variable. Therefore, it may cause some problems, rather than helping, both in terms of bias in model specification and hypothesis testing.

In this study, we also want to see the effect of changing the price variable on the magnitude of price elasticities. Therefore, at least two price variables are used, i.e., the absolute price of the crop under study and the price deflated by the wholesale price index of agricultural products (WPIA). The additional price variables are also tests for some crops in some zones. That is, the price ratio of the crop under study to the price of a selected competitive crop is used instead of the absolute price or the deflated price. This formulation will allow us to test the hypothesis that a certain crop is, in fact, a competitive crop for the crop under study. The purposes of using a deflated price are to remove the effect of changing the general price level and as a proxy for the price received by farmers from alternative activities. However, using the WPIA as a deflator may introduce some bias in the estimation process since this index includes livestock, livestock products, and other crops which may not be competitive activities to the production of the crop concern. Furthermore, the WPIA is available at the national aggregate level which is higher than the level of the supply function where the zone level is estimated. However, if the price movements in each zone are fixed at the same proportion each year during the study period, the bias will be less. The bias is also increased when the price of the crop used is the average crop year price which starts from April to March of the following year while the available indices are using the calendar year. Therefore, the interpretation and conclusion deriving from this study are subject to this limitation.

To summarize, for each crop in each zone, there are basically six equations to be estimated. These include two equations, the absolute price and the deflated price, for each model (the naive, the intermediate, and the adaptive expectation models). Furthermore, these six equations for each crop are also estimated at the national aggregate level. In some zones, the additional equations using the price ratio of the crop under study to the price of selected competitive crop are also estimated. The estimation procedure employed in this study is the OLS method. The potential bias resulting from using this method of estimation have been already discussed in Chapter IV.

Statistical Results

In this section, the estimated coefficients of all equations for each crop in each zone and the national model are presented and discussed. However, if either the contribution of the trend variable (T) is not significant or alters the sign of the price variable which is expected to be positive, or increases the level of significance of the price coefficient considerably, the model will be reestimated by dropping the trend variable from the equation. Only the most reasonable results from one of the two equations will be reported. Together with its coefficients of determination (R^2), the standard error (SE) of the coefficient, the level of significance ($Pr > |t|$), and the Durbin-Watson (DW) statistic are also reported. We will not, in general, discuss the value of the DW statistics obtained from each model since the sample size is too small and its test is also biased when the lag dependent variable is included as one of the explanatory variables.

The estimated elasticities with respect to price lagged one year (E_{t-1}) and with respect to the expected price (E*) are calculated and reported. However, if any coefficient (excluding the intercept term) in any equation is not significant at the 0.30 level or better, the elasticity will not be computed. The 0.30 level is arbitrary; however, it is higher than conventional 0.01 or 0.05 levels. Nevertheless, when taking the small sample size into consideration, this level is justified as a criterion as to whether or not the model is acceptable. These estimated elasticities are calculated at the sample mean. The elasticity with respect to price lagged one year (E_{t-1}) can be interpreted as a short-run (SR) elasticity while the elasticity with respect to the expected price (E*) can be interpreted as a long-run (LR) elasticity (25). The LR elasticity can be obtained by dividing the SR elasticity by the adaptive expectation coefficient (δ) for the adaptive expectation model or by the weight coefficient (λ) for the intermediate model. However, if δ or λ is greater than one, the LR elasticity will be smaller than the SR elasticity. This result is unacceptable for those who believe that the LR elasticity of supply for an individual firm (including agricultural production firm) is always greater than or equal to the SR elasticity. This argument is based on the definition that LR is the period when all inputs are considered as variables, i.e., no input is a fixed input, and, therefore, more flexible than the SR where some of the inputs are fixed. Thus, when the estimated value of λ or δ is outside the zero-one interval, E* will not be computed.

The data period used in this study is from 1967 to 1977. Since some of the models have the price lagged two years as the explanatory variable, only nine observations are used in the regression analysis. The data sources and descriptions are given in Appendix A. The statistical results for each crop in each zone and the national aggregate model are presented below.

Rice

Zones 1-6, 8, and 11 were chosen for analysis. These eight zones together account for about 66 percent of the five years average of total rice planted area in the country. The results for each zone are given in Tables 5.1-5.8.

For zone 1 (Table 5.1), all models fit the data quite well, especially the adaptive expectation model. All the price coefficients are significant at most the 0.06 level. The estimated elasticities range from 0.27 to 0.54. Comparing the models, the naive model gives the lowest elasticity while the intermediate model gives the highest value. Comparing the deflated and undeflated price, the deflated price gives a higher elasticity than the undeflated price for all three models. In terms of explanatory power, the deflated price equations tend to give a higher R^2 for both the naive and adaptive expectation models but lower for the intermediate model. Even though high values of R^2 are obtained for the adaptive expectation model, the estimated values of the adaptive expectation coefficient (δ) from the two equations are both greater than one. Therefore, it is unstable and E* is not computed. Similarly, for the intermediate model, the estimated values of the weight coefficient (λ) from the two equations are greater than one and again, E* is not computed. In general, we may conclude that the response of the rice farmers in zone 1, though positive, is very low. However, when comparing this result to Behrman (4), for which five provinces in this zone were estimated, his estimated elasticities for the period of 1940 to 1963 were even lower and ranged from 0.04 to 0.15 with one province (Loei) showing an insignificant effect of the price variable.

For zone 2 (Table 5.2), very poor results are obtained. The value of R^2 is very low and the price coefficients are not significant at the conventional level. Only in the undeflated price equation of the naive model is the price coefficient significant at the 0.22 level, but the value of R^2 is very low. These results imply that the year-to-year variation in rice planted area cannot be explained by price movements. The only estimated elasticity from this equation is 0.11 which is very low. The small elasticity indicates that the price responsiveness of rice growers in zone 2, if any, is very small. Adding the trend variable in the model, the sign of the price coefficient becomes negative but not significant. The small elasticity (0.22) of a province in this zone was also found by Behrman (4) for the period of 1940-1963.

The results for zone 3 (Table 5.3), like zone 2, are poor. The value of R^2 range from 0.13 to 0.65. Even though the price coefficient still has a positive sign and R^2 is also increased when the trend variable is added, the price coefficient remains insignificant. The only acceptable equation is the undeflated price equation of the naive model. The estimated elasticity derived from this equation is equal to 0.22. The estimated elasticities for the four provinces in zone 3 during the period of 1940 to 1963 were found by Behrman (4) to range from 0.08 to 0.57.

Since about 90 percent of the rice planted area in zones 1-3, are glutinous rice, the glutinous paddy price is considered appropriate for these three zones. However, the local farm price at the zone level is not available. Therefore, the price of glutinous paddy first grade average over the whole country is used as a proxy variable for the local farm price of all grades of paddy. The difficulties of applying the models for zones 2 and 3, therefore, can partially be blamed on the inappropriate use of this proxy variable.

For zones 4 and 5, the unweighted average of glutinous and non-glutinous is used because the farmers in these zones grow both glutinous and nonglutinous rice. Like zones 1-3, the local farm price is not available; thus, the average over the whole country price is used in the analysis. For zone 4, only the undeflated price equation of the naive model is acceptable in terms of the level of significance of the price coefficient. If the trend variable is added into the model (not shown here), the coefficient of price lagged one year becomes negative but not significant. The only estimated elasticity is equal to 0.14. The elasticities estimated by Behrman (4) for the three provinces in zone 4 were found to range from 0.16 to 0.36. For zone 5, the intermediate model is rejected because the price coefficient is not significant at the 0.30 level, the values of R^2 are very low. Comparing the two models, the estimated elasticities are about the same. The value of R^2 of the model adaptive expectation model is higher than the naive model. The estimated values of the adaptive expectation coefficients are, again, greater than one. The estimated elasticities range from 0.25 to 0.66 and are comparable to Behrman's (4) results where the elasticities of the two provinces in zone 5 were found to be 0.34 and 0.55. When the trend variable is included in the model, the sign of the price coefficient is still positive but it becomes insignificant. Similar results to those in zone 1 are obtained when comparison between the deflated and undeflated price is made. That is, the deflated price equation gives the higher elasticity than the undeflated price equation in both models.

For zones 6, 8, and 11, the price datum used in the analysis is the first grade nonglutinous paddy price and is available at the zone level. For zone 6, both equations of the intermediate model are rejected while only the undeflated price equations of the naive and adaptive expectation model are acceptable in terms of the significance level of the price coefficient. The explanatory power of the models is very low. The estimated elasticities are equal to 0.12 and 0.22 for the naive and adaptive expection model, respectively. Two provinces, Nakhonsawan and Uthaithani in zone 6, were found by Behrman (4) to have elasticities equal to 0.28 and 0.13, respectively. The price coefficient of Petchabun province was not significant. For zone 8, two equations of the naive model and one equation of the adaptive expectation model are acceptable while both equations of the intermediate model are rejected. If the trend variable is added into the model, the coefficient of the price lagged one year is still positive but becomes insignificant. The estimated elasticities derived from the naive model are 0.16 and 0.40 for the undeflated and deflated price, respectively. The only estimated elasticity derived from the adaptive expectation model is 0.25. Four provinces in zone 8 were studied by Behrman (4) and the elasticities were found to range from 0.07 to 0.50. For zone 11, the explanatory power is very low and ranges from 0.34 to 0.68. The signs of the coefficients of price lagged one year obtained from these equations are mixed, positive and negative. The only significant coefficient is found in the undeflated price equation of the naive model. The estimated elasticity is equal to - 0.08. If the trend variable is included in this equation, the sign of the price coefficient is still negative but becomes insignificant. All provinces in this zone were also studied by Behrman (4) for the period of 1940-1963. He found elasticities ranging from 0.02 to 0.62. Six out of eleven elasticities estimated were less than or equal to 0.12 and only one province was above 0.24. The relatively unresponsiveness to the price in this zone is due to the limited alternative crops for rice. Since rice is the first crop which grows in the wet season on mostly flooded area, other crops cannot be grown. However, the possibility of substitution may occur for dry season rice when other crops such as mungbean and soybean can be grown on the same parcel of land because of the ability to control water level. Therefore, the unresponsiveness to the price is not a surprising result.

For the national aggregate model, the intermediate model is rejected. Two equations of the naive model are acceptable but the deflated price equation has a very low R^2. For the adaptive expectation model, the deflated price equation is rejected because the price coefficient is not significant. The estimated elasticities deriving from the national aggregate model range from 0.07 to 0.12. These results are comparable with Behrman (4). He found the elasticity to be 0.18 for the national aggregate model.

In general, it can be concluded that no model seems to fit the data well. The difficulties can partially be blamed on the price data which in many cases are not available at the zone level. Comparing the three models, the intermediate model gives the poorest results, since almost all equations estimated are rejected. The adaptive expectation model seems to fit data better than the naive model, but the estimated value of δs are all greater than one. Comparing the deflated price and undeflated price equations, the deflated price equation tends to give higher estimated elasticities but lower R^2s than the undeflated price equation. In terms of price responsiveness, very low response, if any, was found at both the zone and national aggregate level. However, this is not a surprising result for rice.

Corn

Zones 1, 5, 6, and 7 were chosen to analyze. These four zones together account for almost 80 percent of the five years average of total corn planted area in the country. The results for each zone are shown in Tables 5.10-5.14.

In general, for zone 1, the results are quite satisfactory in terms of the explanatory power of the model and level of significance

Table 5.1. Alternative regressions explaining rice planted area, zone 1, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	3899.18	2819.97	4047.57	3699.45	6653.30	4829.98
SE[c]	(374.14)	(635.60)	(379.76)	(1081.19)	(1587.53)	(957.84)
Pr > |t|[d]	(0.0001)	(0.05)	(0.0001)	(0.01)	(0.01)	(0.004)
P_{t-1}	1.05	1.66	1.54	3.18	1.38	2.72
SE	(0.27)	(0.69)	(0.48)	(1.37)	(0.51)	(0.68)
Pr > |t|	(0.006)	(0.05)	(0.02)	(0.06)	(0.04)	(0.01)
P_{t-2}	–	–	-0.65	-1.48	–	–
SE	–	–	(0.53)	(1.30)	–	–
Pr > |t|	–	–	(0.26)	(0.30)	–	–
A_{t-1}	–	–	–	–	-0.76	-0.71
SE	–	–	–	–	(0.42)	(0.29)
Pr > |t|	–	–	–	–	(0.13)	(0.06)
T	–	178.75	–	–	122.78	288.78
SE	–	(50.74)	–	–	(76.54)	(59.20)
Pr > |t|	–	(0.01)	–	–	(0.17)	(0.005)
R^2	0.68	0.79	0.74	0.48	0.84	0.90
DW	2.08	2.62	2.37	1.21	1.90	2.61
λ	–	–	1.73	1.87	–	–
δ	–	–	–	–	1.76	1.71
E_{t-1}	0.27	0.28	0.40	0.54	0.36	0.46
E*	0.27	0.28	NC[e]	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.2. Alternative regressions explaining rice planted area, zone 2, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	3071.82	3244.85	3094.73	3316.12	3261.77	2871.63
SE[c]	(269.30)	(581.43)	(305.00)	(678.91)	(933.36)	(1155.14)
Pr > |t|[d]	(0.0001)	(0.0008)	(0.0001)	(0.003)	(0.01)	(0.05)
P_{t-1}	0.27	0.18	0.34	0.32	0.29	0.17
SE	(0.20)	(0.63)	(0.38)	(0.86)	(0.24)	(0.67)
Pr > |t|	(0.22)	(0.78)	(0.41)	(0.72)	(0.28)	(0.81)
P_{t-2}	–	–	-0.10	-0.22	–	–
SE	–	–	(0.42)	(0.82)	–	–
Pr > |t|	–	–	(0.81)	(0.80)	–	–
A_{t-1}	–	–	–	–	-0.07	0.12
SE	–	–	–	–	(0.31)	(0.30)
Pr > |t|	–	–	–	–	(0.84)	(0.71)
T	–	–	–	–	–	–
SE	–	–	–	–	–	–
Pr > |t|	–	–	–	–	–	–
R^2	0.21	0.01	0.21	0.02	0.21	0.04
DW	2.79	3.41	2.90	2.36	2.61	0.62
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	NC	NC
E_{t-1}	0.11	NC	NC	NC	NC	NC
E*	0.11	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.3. Alternative regressions explaining rice planted area, zone 3, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	4304.54	4076.85	4433.32	4452.52	6815.27	6203.88
SE[c]	(613.13)	(1409.31)	(677.41)	(1608.65)	(1565.73)	(1953.20)
Pr > |t|[d]	(0.0002)	(0.02)	(0.0006)	(0.03)	(0.0007)	(0.02)
P_{t-1}	0.93	1.55	1.36	2.30	0.61	0.88
SE	(0.45)	(1.52)	(0.85)	(2.04)	(0.61)	(1.22)
Pr > |t|	(0.08)	(0.34)	(0.16)	(0.30)	(0.37)	(0.50)
P_{t-2}	—	—	-0.57	-1.15	—	—
SE	—	—	(0.94)	(1.94)	—	—
Pr > |t|	—	—	(0.57)	(0.57)	—	—
A_{t-1}	—	—	—	—	-0.59	-0.55
SE	—	—	—	—	(0.34)	(0.35)
Pr > |t|	—	—	—	—	(0.14)	(0.18)
T	—	—	—	—	215.06	289.84
SE	—	—	—	—	(142.49)	(113.80)
Pr > |t|	—	—	—	—	(0.19)	(0.05)
R^2	0.38	0.13	0.42	0.18	0.65	0.62
DW	2.77	1.97	2.74	1.89	2.38	2.3
λ	—	—	NC[e]	NC	—	—
δ	—	—	—	—	NC	NC
E_{t-1}	0.22	NC	NC	NC	NC	NC
E*	0.22	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.4. Alternative regressions explaining rice planted area, zone 4, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	4216.31	4259.91	4116.78	3861.16	3815.29	2518.11
SE[c]	(317.36)	(867.66)	(335.80)	(959.09)	(1091.89)	(1716.57)
Pr > |t|[d]	(0.0001)	(0.002)	(0.0001)	(0.01)	(0.01)	(0.19)
P_{t-1}	0.53	0.68	0.21	0.04	0.49	0.91
SE	(0.22)	(0.88)	(0.40)	(1.10)	(0.25)	(0.89)
Pr > |t|	(0.05)	(0.47)	(0.62)	(0.97)	(0.10)	(0.35)
P_{t-2}	–	–	0.42	1.04	–	–
SE	–	–	(0.44)	(1.05)	–	–
Pr > |t|	–	–	(0.38)	(0.36)	–	–
A_{t-1}	–	–	–	–	0.09	0.32
SE	–	–	–	–	(0.24)	(0.28)
Pr > |t|	–	–	–	–	(0.71)	(0.29)
T	–	–	–	–	–	–
SE	–	–	–	–	–	–
Pr > |t|	–	–	–	–	–	–
R^2	0.45	0.08	0.52	0.21	0.46	0.25
DW	2.47	1.72	2.67	1.63	2.68	2.66
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	NC	NC
E_{t-1}	0.14	NC	NC	NC	NC	NC
E*	0.14	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.5. Alternative regressions explaining rice planted area, zone 5, 1969-1977

Explanatory variable	The naive model		The intermediate model		expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	2123.68	1087.75	2038.34	839.42	3439.12	2341.08
SE[c]	(665.52)	(1379.68)	(747.60)	(1626.13)	(1150.40)	(1556.29)
Pr > |t|[d]	(0.02)	(0.46)	(0.03)	(0.62)	(0.02)	(0.18)
P_{t-1}	0.53	1.80	0.25	1.40	0.57	1.95
SE	(0.46)	(1.41)	(0.89)	(1.87)	(0.44)	(1.32)
Pr > |t|	(0.29)	(0.24)	(0.78)	(0.48)	(0.24)	(0.19)
P_{t-2}	–	–	0.36	0.65	–	–
SE	–	–	(0.98)	(1.78)	–	–
Pr > |t|	–	–	(0.73)	(0.73)	–	–
A_{t-1}	–	–	–	–	-0.51	-0.52
SE	–	–	–	–	(0.38)	(0.36)
Pr > |t|	–	–	–	–	(0.22)	(0.20)
T	–	–	–	–	–	–
SE	–	–	–	–	–	–
Pr > |t|	–	–	–	–	–	–
R^2	0.16	0.19	0.17	0.21	0.36	0.40
DW	2.85	2.93	3.04	3.14	1.87	1.93
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	1.51	1.52
E_{t-1}	0.25	0.61	NC	NC	0.27	0.66
E*	0.25	0.61	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.6. Alternative regressions explaining rice planted area, zone 6, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	2550.14	2665.32	2507.47	2400.01	4335.62	3170.27
SE[c]	(226.78)	(443.49)	(242.44)	(509.67)	(954.94)	(1207.42)
Pr > |t|[d]	(0.0001)	(0.0005)	(0.0001)	(0.003)	(0.004)	(0.04)
P_{t-1}	0.24	0.22	0.08	-0.04	0.43	0.32
SE	(0.14)	(0.41)	(0.27)	(0.47)	(0.16)	(0.49)
Pr > |t|	(0.15)	(0.61)	(0.78)	(0.94)	(0.04)	(0.54)
P_{t-2}	—	—	0.20	0.49	—	—
SE	—	—	(0.28)	(0.47)	—	—
Pr > |t|	—	—	(0.50)	(0.34)	—	—
A_{t-1}	—	—	—	—	-0.73	-0.22
SE	—	—	—	—	(0.38)	(0.48)
Pr > |t|	—	—	—	—	(0.10)	(0.67)
T	—	—	—	—	—	—
SE	—	—	—	—	—	—
Pr > |t|	—	—	—	—	—	—
R^2	0.28	0.04	0.33	0.19	0.55	0.07
DW	3.17	2.34	2.91	2.17	2.41	1.89
λ	—	—	NC[e]	NC	—	—
δ	—	—	—	—	1.73	NC
E_{t-1}	0.12	NC	NC	NC	0.22	NC
E*	0.12	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.7. Alternative regressions explaining rice planted area, zone 8, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	2903.79	2459.03	2942.07	2303.88	4345.95	3097.01
SE[c]	(316.19)	(495.33)	(344.87)	(590.62)	(929.37)	(1019.87)
Pr > |t|[d]	(0.0001)	(0.002)	(0.0001)	(0.008)	(0.003)	(0.02)
P_{t-1}	0.42	1.03	0.59	0.83	0.63	1.13
SE	(0.22)	(0.49)	(0.44)	(0.62)	(0.23)	(0.53)
Pr > |t|	(0.09)	(0.07)	(0.22)	(0.23)	(0.04)	(0.08)
P_{t-2}	–	–	-0.22	0.35	–	–
SE	–	–	(0.46)	(0.62)	–	–
Pr > |t|	–	–	(0.65)	(0.60)	–	–
A_{t-1}	–	–	–	–	-0.51	-0.22
SE	–	–	–	–	(0.31)	(0.30)
Pr > |t|	–	–	–	–	(0.15)	(0.50)
T	–	–	–	–	–	–
SE	–	–	–	–	–	–
Pr > |t|	–	–	–	–	–	–
R^2	0.35	0.39	0.37	0.42	0.55	0.44
DW	3.05	3.15	3.11	3.33	2.66	2.67
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	1.51	NC
E_{t-1}	0.16	0.40	NC	NC	0.25	NC
E^*	0.16	0.40	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.8. Alternative regressions explaining rice planted area, zone 11, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	7339.41	7203.51	7460.41	7665.32	9407.18	9610.25
SE[c]	(248.04)	(541.20)	(236.16)	(538.70)	(2935.60)	(3244.99)
Pr > |t|[d]	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.02)	(0.03)
P_{t-1}	-0.35	-0.06	0.01	0.33	-0.32	0.09
SE	(0.15)	(0.52)	(0.32)	(0.50)	(0.33)	(0.57)
Pr > |t|	(0.05)	(0.92)	(0.97)	(0.54)	(0.38)	(0.88)
P_{t-2}	—	—	-0.51	-0.84	—	—
SE	—	—	(0.27)	(0.49)	—	—
Pr > |t|	—	—	(0.12)	(0.14)	—	—
A_{t-1}	—	—	—	—	-0.29	-0.35
SE	—	—	—	—	(0.40)	(0.46)
Pr > |t|	—	—	—	—	(0.51)	(0.49)
T	—	-69.46	10.70	-55.82	-28.49	-98.63
SE	—	(45.21)	(60.74)	(39.91)	(82.73)	(60.86)
Pr > |t|	—	(0.18)	(0.87)	(0.22)	(0.74)	(0.17)
R^2	0.44	0.34	0.68	0.59	0.50	0.40
DW	1.66	1.41	2.40	1.90	1.12	0.94
λ	—	—	NC[e]	NC	—	—
δ	—	—	—	—	NC	NC
E_{t-1}	-0.08	NC	NC	NC	NC	NC
E*	-0.08	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.9. Alternative regressions explaining rice planted area, Thailand, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	43483.50	43910.37	43042.53	41008.48	64216.89	62426.74
SE[c]	(1721.95)	(4149.77)	(1729.50)	(4268.80)	(15873.35)	(19419.84)
Pr > |t|[d]	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.01)	(0.02)
P_{t-1}	3.98	5.05	1.97	0.81	2.48	0.46
SE	(1.14)	(3.96)	(2.08)	(4.59)	(2.05)	(3.34)
Pr > |t|	(0.01)	(0.24)	(0.38)	(0.87)	(0.28)	(0.90)
P_{t-2}	–	–	2.47	6.97	–	–
SE	–	–	(2.16)	(4.60)	–	–
Pr > |t|	–	–	(0.29)	(0.18)	–	–
A_{t-1}	–	–	–	–	-0.47	-0.45
SE	–	–	–	–	(0.36)	(0.41)
Pr > |t|	–	–	–	–	(0.25)	(0.33)
T	–	–	–	–	768.62	1204.41
SE	–	–	–	–	(537.84)	(481.95)
Pr > |t|	–	–	–	–	(0.21)	(0.05)
R^2	0.64	0.18	0.70	0.41	0.76	0.69
DW	2.90	1.47	3.45	1.92	1.78	1.60
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	1.47	NC
E_{t-1}	0.12	0.10	NC	NC	0.07	NC
E*	0.12	0.10	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

of the estimated coefficients. Almost all equations give a reasonable value of the estimated parameters. The estimated elasticities with respect to price lagged one year are very high and range from 1.43 to 2.70. Comparing the three models, the intermediate model tends to give the highest elasticity while the naive models give the lowest elasticity. Comparison between the deflated price and undeflated price equations, the deflated price equations yield higher elasticities than the undeflated price equation for all three models. The estimated value of the weight coefficient of price lagged one year (λ) is greater than one for the undeflated price equation and equal to 0.50 for the deflated price equation. Similarly, the adaptive expectation coefficient is also greater than one for the undeflated price equation and equal to 0.33 for the deflated price equation.

There are several other upland crops which are grown in this zone. These include cassava, kenaf, and sugarcane. The price ratio of corn to the prices of these crops are formulated and tested in all three models. Only the corn/kenaf and corn/cassava show a significant effect on the corn planted area. The equations that show significant effect are given below.

Using corn/cassava price ratio (zone 1):

$$A_t = -\ 299.14 + 87.63P_{t-1} + 59.48T$$

SE	(46.45)	(17.26)	(11.72)
$Pr > \|t\|$	(0.003)	(0.002)	(0.002)

$R^2 = 0.97$ DW = 2.03 $E_{t-1} = 0.81$

$$A_t = -216.59 + 71.88P_{t-1} + 47.49P_{t-2} + 38.22T$$

SE	(25.07)	(10.04)	(11.98)	(8.23)
Pr > |t|	(0.003)	(0.0008)	(0.01)	(0.006)

$R^2 = 0.99$ DW = 3.35 $\lambda = 0.60$ $E_{t-1} = 0.66$

$$A_t = -179.74 + 85.40P_{t-1} + 0.23A_{t-1} + 37.34T$$

SE	(53.66)	(15.78)	(0.15)	(18.25)
Pr > |t|	(0.02)	(0.003)	(0.20)	(0.10)

$R^2 = 0.98$ DW = 2.90 $\delta = 0.77$ $E_{t-1} = 0.79$

Using corn/kenaf price ratio (zone 1):

$$A_t = -294.55 + 550.13P_{t-1} + 61.18T$$

SE	(49.81)	(103.65)	(11.02)
Pr > |t|	(0.001)	(0.002)	(0.001)

$R^2 = 0.97$ DW = 2.62 $E_{t-1} = 0.97$

$$A_t = -380.59 + 657.10P_{t-1} - 0.29A_{t-1} + 82.10T$$

SE	(68.52)	(112.47)	(0.18)	(16.06)
Pr > |t|	(0.003)	(0.002)	(0.16)	(0.004)

$R^2 = 0.98$ DW = 3.26 $\delta = 1.29$ $E_{t-1} = 1.15$

The price ratio coefficients are positive and significantly different from zero, implying that the prices of cassava and kenaf do have some influence on the farmers' decision on how many rai will be devoted to corn each year. Because zone 1 is considered as a relatively new area for growing corn as compared to zones 5-7, Behrman (4) did not include any province in this zone in his analysis.

For zone 5, in general, the results are not as good as those in zone 1 both in terms of the explanatory power and the level of significance of the price coefficient. The estimated elasticities obtaining from this study range from 0.81 to 1.21. Comparing the intermediate model and the adaptive expectation model, there is no clearcut evidence to conclude that one model is superior to the other. Both models, however, give a higher elasticity than the naive model. Comparing the deflated price and undeflated price equations, the deflated price equation seems to fit the data better than the undeflated price equation. This is because for the undeflated price equation, two models are rejected as compared to no model being rejected when the deflated price is used. Furthermore, the estimated value of λ and δ are also in the acceptable interval.

Cassava, kenaf, groundnut, and cotton[1] are the possible alternative crops for corn growing in zone 5. The price ratio of corn to the prices of these crops are also tested in the models. All crops, except cassava, were found, in at least one equation, to show a significant effect of these price ratios. Only the accepted equations are shown below.

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[1]Since the price of cotton is not available at the zone level, the price average over the whole country is used as a proxy for the zone's prices.

Using corn/kenaf price ratio (zone 5):

$$A_t = 189.01 + 628.96P_{t-1} + 70.96T$$

SE	(203.77)	(399.27)	(37.58)
Pr > |t|	(0.39)	(0.17)	(0.11)

$R^2 = 0.74$ DW = 2.35 $E_{t-1} = 0.41$

Using corn/groundnut price ratio (zone 5):

$$A_t = -373.81 + 1668.04P_{t-1} + 100.23T$$

SE	(40.57)	(827.12)	(26.87)
Pr > |t|	(0.39)	(0.09)	(0.01)

$R^2 = 0.77$ DW = 2.57 $E_{t-1} = 0.86$

$$A_t = -598.43 + 2185.54P_{t-1} + 0.55A_{t-1}$$

SE	(562.16)	(1073.12)	(0.23)
Pr > |t|	(0.33)	(0.09)	(0.06)

$R^2 = 0.61$ DW = 2.76 $\delta = 0.43$ $E_{t-1} = 1.13$

Using corn/cotton price ratio (zone 5):

$$A_t = -312.84 + 4602.11P_{t-1}$$

SE	(434.76)	(1579.45)
Pr > |t|	(0.50)	(0.02)

$R^2 = 0.55$ DW = 2.64 $E_{t-1} = 1.34$

These results suggest that kenaf, groundnuts, and cotton are, in fact, possible substitute crops for corn in zone 5. Cotton and groundnuts may be more likely than kenaf because a higher estimated elasticity was obtained from the equations using the corn/cotton and corn/groundnut price ratios than using the corn/kenaf price ratio.

Using the data period of 1949 to 1963, Behrman (4) found an elasticity equal to 0.27 for Nakhonratchasima (in zone 5). This is smaller than the estimated elasticities derived from the present study.

In zone 6, the biggest zone for corn growing, the results are very impressive in terms of the explanatory power and the level of significance of the price coefficients. The estimated elasticities range from 0.39 to 0.58 which is smaller than zone 1 and zone 5. Comparing the three models, the intermediate model gives the highest elasticity, followed by the adaptive expectation model and the naive model, respectively. Comparing the deflated price and undeflated price equations, the deflated price equation yields a higher elasticity than the undeflated price equation in all three models. The estimated value of δs are both greater than one while one of the estimated values of λ is less than one.

Mungbeans, soybeans, and cotton[1] are considered as the possible competing crops for corn in this zone. The corn/mungbean, corn/soybean, and corn/cotton price ratios are formulated and used in all three models. All crops are found to show a significant effect on the corn planted area. The regression results are shown below.

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[1]Using the whole country average price because zone's price is not available.

Using corn/mungbean price ratio (zone 6):

$$A_t = 751.96 + 1087.64P_{t-1} + 168.12T$$

SE	(154.32)	(300.55)	(21.89)
Pr > |t|	(0.003)	(0.01)	(0.0003)

$R^2 = 0.94$ DW = 2.63 $E_{t-1} = 0.22$

$$A_t = 1040.82 + 1226.83P_{t-1} - 0.39A_{t-1} + 245.69T$$

SE	(225.85)	(280.82)	(0.24)	(51.96)
Pr > |t|	(0.006)	(0.007)	(0.17)	(0.005)

$R^2 = 0.96$ DW = 2.27 $\delta = 1.39$ $E_{t-1} = 0.25$

Using corn/soybean price ratio (zone 6):

$$A_t = 186.76 + 2825P_{t-1} + 165.41T$$

SE	(426.62)	(1219.59)	(29.20)
Pr > |t|	(0.68)	(0.06)	(0.001)

$R^2 = 0.90$ DW = 1.83 $E_{t-1} = 0.51$

$$A_t = 353.36 + 3756.14P_{t-1} - 0.54A_{t-1} + 270.38T$$

SE	(391.40)	(1221.77)	(0.33)	(69.46)
Pr > |t|	(0.41)	(0.03)	(0.16)	(0.01)

$R^2 = 0.94$ DW = 1.08 $\delta = 1.54$ $E_{t-1} = 0.68$

Using corn/cotton price ratio (zone 6):

$$A_t = 279.77 + 4746.62P_{t-1} + 84.12T$$

SE	(197.95)	(990.06)	(27.81)
$Pr > \|t\|$	(0.21)	(0.003)	(0.02)

$R^2 = 0.96$ DW = 2.15 $E_{t-1} = 0.67$

$$A_t = 538.05 + 4975.03P_{t-1} - 1642.92P_{t-2} + 112.44T$$

SE	(177.57)	(728.43)	(656.60)	(23.24)
$Pr > \|t\|$	(0.03)	(0.001)	(0.05)	(0.005)

$R^2 = 0.98$ DW = 2.57 $\lambda = 1.49$ $E_{t-1} = 0.70$

$$A_t = 478.54 + 5035.88P_{t-1} - 0.29A_{t-1} + 137.53T$$

SE	(225.51)	(925.94)	(0.20)	(44.21)
$Pr > \|t\|$	(0.09)	(0.003)	(0.20)	(0.03)

$R^2 = 0.96$ DW = 2.27 $\delta = 1.29$ $E_{t-1} = 0.71$

It can be concluded from these results that the price of mungbeans, soybeans, and cotton do have some influence on farmers' decision on corn planted area. The magnitude of the elasticities obtained from using price ratios are about the same as those obtained from the other forms of the price variable.

Behrman (4) found the elasticities of corn planted area with respect to price to be 1.92 and 4.47 for Nakhonsawan and Petchabun provinces (in zone 6), respectively. This study finds much lower elasticities as compared to Behrman's study. However, when comparing these results with Nerlove's study of the corn planted area response for the United States during 1909-1932 in which he found the elasticities range from 0.09 to 0.49, the present study, in many cases, finds elasticities higher than Nerlove's study.

In zone 7 (Table 5.13), in general, the results are not as good as in zone 1 and 6, both in terms of explanatory power of the model and the level of significance of its estimated coefficients. Only three equations out of six equations estimated are acceptable. The estimated elasticities range from 0.15 to 0.19 which is very small as compared to other zones. For the acceptable equations, the intermediate model gives the highest R^2 value while the naive model gives the lowest value. Comparing the undeflated and deflated price equations, the price coefficients in the undeflated price equation of both naive and intermediate models are found to be not significant while the reverse is true for the adaptive expectation model. The estimated values of λ and δ are in the acceptable range.

The corn/mungbean, corn/soybean, and corn/cotton price ratios are also attempted in this zone. Only the corn/mungbean price ratio shows a significant effect on corn planted area. The results are given below.

<u>Using corn/mungbean price ratio (zone 7)</u>:

$$A_t = 1719.09 + 549.61P_{t-1} - 49.80T$$

SE	(116.69)	(247.97)	(14.91)
$Pr > \|t\|$	(0.0001)	(0.07)	(0.02)

$R^2 = 0.67$ DW = 2.20 $E_{t-1} = 0.15$

$$A_t = 934.39 + 535.32P_{t-1} + 0.46A_{t-1} - 52.51T$$

SE	(527.48)	(224.91)	(0.30)	(13.63)
Pr > |t|	(0.14)	(0.06)	(0.19)	(0.01)

$R^2 = 0.77$ DW = 3.55 $\delta = 0.54$ $E_{t-1} = 0.15$

The price ratio equation does not seem to be superior to the other forms of the price variable in terms of explanatory power. The estimated elasticities are about the same as for the other equations.

For the national aggregate model (Table 5.14), every equation, except the undeflated price equation of the adaptive expectation model, is acceptable. All models seem to fit the data well. The estimated elasticities range from 0.19 to 0.37. These results are consistent with the estimates in zone 6, the biggest zone for corn. Comparing the models, unlike most of the results obtaining from the zone level, the adaptive expectation model and the intermediate model do not give a bigger estimate of the elasticity than the naive model. Comparing the deflated price and undeflated price equations, the results are similar to the zone results, that is, the deflated price equations tend to give higher elasticity estimates than the undeflated price equations.

Overall, for corn, it can be concluded that all models seem to fit the data equally well and much better than for rice. The price responsiveness, in general, is very high. The intermediate model and the adaptive expectation model tend to give a higher elasticity than the naive model. The deflated price equation seems to give a higher elasticity than the undeflated price equation. There are many crops that may be considered as competitive crops for corn. These include cassava, kenaf, groundnuts, cotton, mungbeans, and soybeans.

<u>Cassava</u>

Zones 1, 3, 5, and 15 were chosen for analysis. These four zones together account for about 70 percent of the five years average of total cassava planted area in the country.

For zone 1, both equations of the intermediate model are rejected because some of its coefficients are not significant. The deflated price equation of the naive model is also rejected for the same reason. Two equations of the adaptive expectation model are acceptable. However, the estimated value of the adaptive expectation coefficients are negative and greater than one in absolute value. Therefore, the LR elasticities are not computed. The estimated SR elasticities range from 1.65 to 1.80, which is very high. The naive model gives a smaller elasticity than the adaptive expectation model. For the adaptive expectation model, the deflated price equation gives a slightly higher elasticity than the undeflated price equation.

Three price ratios are also attempted. It was found that the coefficients of the cassava/corn and cassava/sugarcane price ratios are significant while the coefficient of the cassava/kenaf price ratio is not significant. The results for the cassava/corn and cassava/sugarcane price ratio equations are given below.

Table 5.10. Alternative regressions explaining corn planted area, zone 1, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-337.93	-817.71	-318.30	-1550.75	-465.32	-656.08
SE[c]	(64.45)	(186.42)	(58.21)	(360.68)	(91.98)	(277.88)
Pr > |t|[d]	(0.002)	(0.005)	(0.003)	(0.005)	(0.004)	(0.06)
P_{t-1}	440.01	917.02	517.48	1142.22	565.29	961.46
SE	(100.56)	(247.42)	(100.62)	(455.70)	(112.84)	(351.31)
Pr > |t|	(0.005)	(0.01)	(0.004)	(0.05)	(0.004)	(0.03)
P_{t-2}	–	–	-161.76	1145.24	–	–
SE	–	–	(98.66)	(391.12)	–	–
Pr > |t|	–	–	(0.16)	(0.03)	–	–
A_{t-1}	–	–	–	–	-0.37	0.67
SE	–	–	–	–	(0.21)	(0.15)
Pr > |t|	–	–	–	–	(0.14)	(0.004)
T	36.92	80.07	49.03	–	55.29	–
SE	(17.61)	(11.83)	(17.22)	–	(18.52)	–
Pr > |t|	(0.08)	(0.0005)	(0.04)	–	(0.03)	–
R^2	0.96	0.95	0.98	0.83	0.98	0.91
DW	1.49	2.53	2.64	1.34	2.29	2.06
λ	–	–	1.45	0.50	–	–
δ	–	–	–	–	1.37	0.33
E_{t-1}	1.43	2.16	1.68	2.70	2.24	2.27
E*	1.43	2.16	NC[e]	5.40	NC	6.88

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.11. Alternative regressions explaining corn planted area, zone 5, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	172.93	-303.15	154.48	-1640.26	173.24	-575.47
SE[c]	(257.23)	(545.14)	(284.54)	(742.94)	(278.12)	(677.80)
Pr > |t|[d]	(0.52)	(0.60)	(0.61)	(0.08)	(0.56)	(0.43)
P_{t-1}	598.24	834.43	525.17	1201.88	604.45	1213.52
SE	(192.23)	(630.44)	(340.89)	(649.74)	(331.71)	(747.38)
Pr > |t|	(0.02)	(0.23)	(0.17)	(0.11)	(0.12)	(0.16)
P_{t-2}	–	–	93.58	1557.84	–	–
SE	–	–	(347.45)	(672.33)	–	–
Pr > |t|	–	–	(0.80)	(0.06)	–	–
A_{t-1}	–	–	–	–	-0.01	0.43
SE	–	–	–	–	(0.39)	(0.26)
Pr > |t|	–	–	–	–	(0.98)	(0.15)
T	–	91.37	–	–	–	–
SE	–	(32.98)	–	–	–	–
Pr > |t|	–	(0.03)	–	–	–	–
R^2	0.58	0.71	0.59	0.65	0.58	0.55
DW	2.22	3.02	2.07	2.23	2.21	2.89
λ	–	–	NC[e]	0.44	–	–
δ	–	–	–	–	NC	0.57
E_{t-1}	0.81	0.83	NC	1.20	NC	1.21
E*	0.81	0.83	NC	2.73	NC	2.12

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.12. Alternative regressions explaining corn planted area, zone 6, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	829.30	199.86	936.19	-491.80	1131.59	393.19
SE[c]	(191.17)	(251.89)	(155.58)	(698.93)	(309.82)	(283.47)
Pr > |t|[d]	(0.005)	(0.46)	(0.002)	(0.51)	(0.01)	(0.22)
P_{t-1}	594.57	1136.76	729.31	1437.24	710.64	1217.38
SE	(248.25)	(283.22)	(201.48)	(700.87)	(257.48)	(276.73)
Pr > |t|	(0.05)	(0.007)	(0.02)	(0.09)	(0.04)	(0.007)
P_{t-2}	–	–	-459.28	1156.25	–	–
SE	–	–	(205.34)	(705.30)	–	–
Pr > |t|	–	–	(0.08)	(0.15)	–	–
A_{t-1}	–	–	–	–	-0.41	-0.30
SE	–	–	–	–	(0.34)	(0.23)
Pr > |t|	–	–	–	–	(0.28)	(0.26)
T	85.53	147.92	143.24	–	150.92	206.85
SE	(50.96)	(22.14)	(47.16)	–	(72.90)	(50.74)
Pr > |t|	(0.14)	(0.0005)	(0.03)	–	(0.09)	(0.01)
R^2	0.90	0.95	0.95	0.70	0.92	0.96
DW	1.88	3.07	2.62	1.49	1.25	2.57
λ	–	–	2.70	0.55	–	–
δ	–	–	–	–	1.41	1.30
E_{t-1}	0.39	0.54	0.48	0.67	0.46	0.58
E*	0.39	0.54	NC[e]	1.22	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.13. Alternative regressions explaining corn planted area, zone 7, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	1846.61	1625.37	1839.28	1224.00	707.52	922.41
SE[c]	(133.74)	(250.11)	(161.92)	(297.31)	(725.73)	(701.35)
Pr > |t|[d]	(0.0001)	(0.0006)	(0.0001)	(0.0009)	(0.37)	(0.25)
P_{t-1}	117.60	318.97	114.69	328.32	187.04	280.85
SE	(158.16)	(257.59)	(175.23)	(215.22)	(147.75)	(256.97)
Pr > |t|	(0.49)	(0.26)	(0.54)	(0.19)	(0.26)	(0.32)
P_{t-2}	–	–	18.02	478.65	–	–
SE	–	–	(170.42)	(252.28)	–	–
Pr > |t|	–	–	(0.92)	(0.12)	–	–
A_{t-1}	–	–	–	–	0.64	0.43
SE	–	–	–	–	(0.40)	(0.40)
Pr > |t|	–	–	–	–	(0.17)	(0.33)
T	-56.16	-44.22	-58.54	-63.30	-71.74	-46.19
SE	(31.33)	(17.54)	(40.99)	(17.77)	(29.63)	(17.43)
Pr > |t|	(0.12)	(0.05)	(0.21)	(0.02)	(0.06)	(0.05)
R^2	0.45	0.52	0.45	0.72	0.63	0.61
DW	1.77	2.39	1.69	1.90	3.06	2.96
λ	–	–	NC[e]	0.41	–	–
δ	–	–	–	–	0.36	NC
E_{t-1}	NC	0.19	NC	0.19	0.15	NC
E*	NC	0.19	NC	0.46	0.41	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.14. Alternative regressions explaining corn planted area, Thailand, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	4387.75	2685.94	4786.60	3717.35	1720.00	519.55
SE[c]	(662.64)	(877.82)	(374.06)	(982.04)	(1292.54)	(987.88)
Pr > |t|[d]	(0.0003)	(0.02)	(0.0001)	(0.01)	(0.23)	(0.62)
P_{t-1}	1988.54	2862.67	1080.22	3114.53	337.28	2527.48
SE	(508.31)	(1207.70)	(589.85)	(1067.08)	(834.80)	(1478.26)
Pr > |t|	(0.006)	(0.06)	(0.13)	(0.03)	(0.70)	(0.14)
P_{t-2}	–	–	-1392.72	-1725.50	–	–
SE	–	–	(501.65)	(1023.99)	–	–
Pr > |t|	–	–	(0.04)	(0.15)	–	–
A_{t-1}	–	–	–	–	0.72	0.63
SE	–	–	–	–	(0.32)	(0.17)
Pr > |t|	–	–	–	–	(0.06)	(0.01)
T	–	321.84	450.82	374.44	–	–
SE	–	(73.72)	(111.03)	(71.65)	–	–
Pr > |t|	–	(0.005)	(0.01)	(0.003)	–	–
R^2	0.69	0.91	0.94	0.94	0.83	0.88
DW	0.70	0.95	2.48	1.92	1.50	1.54
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	0.28	0.37
E_{t-1}	0.36	0.37	0.19	0.37	NC	0.33
E*	0.36	0.37	NC	NC	NC	0.89

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Using cassava/corn price ratio (zone 1):

$$A_t = -402.71 + 401.38P_{t-1} + 78.70T$$

SE	(253.28)	(343.39)	(25.25)
$Pr > \lvert t \rvert$	(0.16)	(0.29)	(0.02)

$R^2 = 0.72$ DW = 1.46 $E_{t-1} = 1.07$

$$A_t = -437.47 + 696.99P_{t-1} + 3.72A_{t-1}$$

SE	(108.85)	(179.37)	(0.48)
$Pr > \lvert t \rvert$	(0.01)	(0.01)	(0.0002)

$R^2 = 0.93$ DW = 2.60 $\delta = -2.72$ $E_{t-1} = 1.86$

Using cassava/sugarcane price ratio (zone 1):

$$A_t = -225.46 + 43734.19P_{t-1} + 2.93A_{t-1}$$

SE	(140.51)	(29599.03)	(0.67)
$Pr > \lvert t \rvert$	(0.16)	(0.19)	(0.005)

$R^2 = 0.83$ DW = 1.81 $\delta = -1.93$ $E_{t-1} = 2.87$

These results suggest that corn and sugarcane may be considered as competing crops for cassava in zone 1. The significance of the coefficient of the cassava/corn price ratio is consistent with the result obtained from the corn response model when corn/cassava price ratio is used.

In zone 3, only the naive model is acceptable. The other two models are rejected because the coefficients of the price variable are not significant. For the naive model, the estimated elasticity derived from the undeflated price equation is about the same as derived from the deflated price equation and is approximately equal to 0.28. Only the cassava/kenaf price ratio was attempted in this zone. The result is given below.

Using corn/kenaf price ratio (zone 3):

$$A_t = - 637.74 + 5735.23P_{t-1}$$

SE (377.44) (2244.66)

$Pr > |t|$ (0.13) (0.04)

$R^2 = 0.48$ DW = 1.77 $E_{t-1} = 3.18$

Even though a positive coefficient is obtained as expected, the explanatory power is too low as compared to when other forms of the price variable are used. Nevertheless, the estimated elasticity is very large implying that the degree of substibility of cassava and kenaf is very strong.

The results for zone 5 are shown in Table 5.17. The signs of the estimated coefficients of the price variable are mixed, both positive and negative. The negative coefficients are obtained from the deflated price equation while the positive coefficients are obtained from the undeflated price equation. However, no equation with negative sign is found significant. The estimated elasticities derived from the undeflated price equations are 1.88 and 1.33 for the naive and the adaptive expectation models, respectively.

The cassava/kenaf, cassava/corn, cassava/groundnut, and cassava/cotton price ratios were formed and tested in all models above. Only the cassava/kenaf price ratio was found to be significant and the result is given below.

Using cassava/kenaf price ratio (zone 5):

$$A_t = -\ 603.78 + 7119.96P_{t-1}$$

SE (317.64) (1958.58)

Pr > |t| (0.10) (0.01)

$R^2 = 0.65$ DW = 1.89 $E_{t-1} = 2.22$

$$A_t = -\ 993.86 + 5646.83P_{t-1} + 3948.15P_{t-2}$$

SE (287.83) (1596.85) (1585.02)

Pr > |t| (0.01) (0.01) (0.05)

$R^2 = 0.83$ DW = 1.94 $\lambda = 0.59$ $E_{t-1} = 1.76$

$$A_t = -\ 45.30 + 895.99P_{t-1} + 1.07A_{t-1}$$

SE (91.75) (741.66) (0.10)

Pr > |t| (0.64) (0.27) (0.0001)

$R^2 = 0.98$ DW = 2.70 $\delta = -\ 0.07$ $E_{t-1} = 0.28$

When using the price ratio, the naive model gives the highest elasticity while the adaptive expectation model gives the lowest value. This result is reversed from the estimate derived from other forms of the price variable. Even though the adaptive expectation model gives the highest R^2 value, the significant level of the price coefficient is much higher than the other two models. Therefore, the estimated elasticities derived from the first two models are more reliable than from the last model. The large elasticity implies that the price of kenaf has a strong influence on the cassava planting decision in zone 5.

Zone 15 is the oldest zone in terms of cassava growing. In general, the results are satisfactory, since only two equations are rejected. The estimated elasticities range from 0.58 to 1.92. Every model seems to fit the data equally well except one deflated price equation of the naive model. The deflated price equation tends to give a higher elasticity than the undeflated price equation, but with a slightly smaller R^2. The estimated values of λ and δ derived from the two models are in the acceptable range.

The cassava/rice and cassava/sugarcane price ratios were also tested. Even though the positive signs of the price coefficients are obtained, the level of significance is rather high. This does not necessarily imply that either rice or sugarcane is a competing crop for cassava. The problems of the insignificance of the price ratio coefficient may arise from the fact that there are several other agriculturally related activities beyond just growing these three crops. These activities include fisheries and fruit trees which are also the major sources of income for the farmers in this zone. The above activities may compete, at least for labor, with cassava growing. Therefore, instead of using the price ratio of cassava to a price of selected crop, the price ratio of cassava to the weighted average price of several agricultural products (or activities), may be more appropriate for this zone.

The national aggregate model for cassava is shown in Table 5.19. In general, the results are not as good as for the national corn supply function. The problems for cassava can partially be explained by the planting and harvesting nature of this crop. Cassava can be grown and harvested any time of the year and the period of growing also varies from eight to twelve months. These variations occur not only between zones but also within the zones as well. Therefore, the data regarding planting area and the price received by farmers are very difficult to define in terms of crop year. The question is what is the relevant crop year for this crop, i.e., from and to what month of the year? Nevertheless, the estimated elasticities derived from the aggregate model are very small as compared to the estimate from the zone models. The only two estimates derived from the adaptive expectation model are 0.28 and 0.23 for the undeflated and deflated price equations, respectively.

Only two provinces, Chonburi and Rayong in zone 15, were studied by Behrman (4). The price coefficient was not found significantly different from zero for Chonburi province. For Rayong province, however, the price coefficient was found to be significantly different from zero at the 0.25 level and the estimated elasticity was 1.09 which is comparable with the results of zone 15 in the present study.

It can be concluded that, in general, the results are satisfactory even though it is not as good as for corn function. The estimated elasticities are mostly greater than one for the zone's functions. The naive model tends to fit the data better than for other models in most zones, at least in terms of the significance of the price coefficient. Even though high values of R^2 are obtained from the adaptive expectation model or the intermediate model, in many cases, they are rejected due to insignificance of the price coefficients. The major competitive crop for cassava in the northeast region is kenaf. The other alternative crops are corn and sugarcane.

Table 5.15. Alternative regressions explaining cassava planted area, zone 1, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-416.45	-376.99	-603.71	-385.94	-323.94	-408.65
SE[c]	(202.79)	(288.05)	(296.67)	(403.30)	(129.19)	(156.82)
Pr > |t|[d]	(0.09)	(0.24)	(0.10)	(0.38)	(0.05)	(0.04)
P_{t-1}	642.19	484.51	488.23	476.14	686.76	849.36
SE	(410.58)	(524.03)	(453.62)	(620.26)	(287.56)	(340.84)
Pr > |t|	(0.17)	(0.39)	(0.33)	(0.48)	(0.05)	(0.05)
P_{t-2}	—	—	489.03	23.41	—	—
SE	—	—	(555.72)	(657.50)	—	—
Pr > |t|	—	—	(0.42)	(0.97)	—	—
A_{t-1}	—	—	—	—	2.49	3.45
SE	—	—	—	—	(0.37)	(0.63)
Pr > |t|	—	—	—	—	(0.0006)	(0.002)
T	63.64	74.64	74.57	75.34	—	—
SE	(14.70)	(26.44)	(19.46)	(34.99)	—	—
Pr > |t|	(0.005)	(0.03)	(0.01)	(0.08)	—	—
R^2	0.76	0.70	0.79	0.70	0.88	0.89
DW	1.80	1.45	1.59	1.44	2.07	2.18
λ	—	—	NC[e]	NC	—	—
δ	—	—	—	—	-1.49	-2.45
E_{t-1}	1.65	NC	NC	NC	1.77	1.80
E*	1.65	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.16. Alternative regressions explaining cassava planted area, zone 3, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-756.04	-1199.31	-917.81	-1460.81	-83.96	-221.14
SE[c]	(188.20)	(531.78)	(213.18)	(586.43)	(403.09)	(470.51)
Pr > |t|[d]	(0.007)	(0.07)	(0.008)	(0.06)	(0.85)	(0.66)
P_{t-1}	2505.49	3355.92	961.85	2239.68	413.32	849.36
SE	(839.77)	(1960.92)	(1386.92)	(2230.01)	(1370.54)	(1512.44)
Pr > |t|	(0.02)	(0.14)	(0.52)	(0.36)	(0.78)	(0.60)
P_{t-2}	–	–	1430.60	1543.08	–	–
SE	–	–	(1058.23)	(1494.85)	–	–
Pr > |t|	–	–	(0.23)	(0.35)	–	–
A_{t-1}	–	–	–	–	2.03	2.11
SE	–	–	–	–	(1.13)	(0.69)
Pr > |t|	–	–	–	–	(0.13)	(0.03)
T	49.94	137.46	91.48	163.23	-11.68	-0.90
SE	(33.02)	(29.31)	(43.62)	(38.38)	(44.48)	(49.16)
Pr > |t|	(0.18)	(0.003)	(0.09)	(0.01)	(0.80)	(0.99)
R^2	0.87	0.79	0.91	0.82	0.92	0.93
DW	2.33	1.59	2.10	1.60	2.99	3.11
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	NC	NC
E_{t-1}	2.78	2.79	NC	NC	NC	NC
E*	2.78	2.79	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.17. Alternative regressions explaining cassava planted area, zone 5, 1969-1977

Explanatory variable	The naive model ABSL[a]	The naive model WPIA[b]	The intermediate model ABSL[a]	The intermediate model WPIA[b]	The adaptive expectation model ABSL[a]	The adaptive expectation model WPIA[b]
Intercept	-452.56	-44.30	-561.39	-9520.70	-31.89	4.10
SE[c]	(230.27)	(150.87)	(244.65)	(917.69)	(87.26)	(86.97)
Pr > |t|[d]	(0.09)	(0.78)	(0.06)	(0.0001)	(0.73)	(0.96)
P_{t-1}	2874.18	-520.02	2030.30	-291.02	66.90	-112.01
SE	(652.28)	(530.80)	(975.87)	(547.49)	(341.56)	(322.23)
Pr > |t|	(0.003)	(0.37)	(0.08)	(0.62)	(0.86)	(0.74)
P_{t-2}	—	—	1316.58	-629.06	—	—
SE	—	—	(1151.50)	(526.53)	—	—
Pr > |t|	—	—	(0.30)	(0.29)	—	—
A_{t-1}	—	—	—	—	0.83	0.81
SE	—	—	—	—	(0.22)	(0.22)
Pr > |t|	—	—	—	—	(0.01)	(0.01)
T	—	137.82	—	140.57	40.06	44.11
SE	—	(12.89)	—	(12.66)	(25.57)	(26.56)
Pr > |t|	—	(0.0001)	—	(0.0001)	(0.18)	(0.16)
R^2	0.74	0.95	0.78	0.96	0.99	0.99
DW	1.11	0.91	1.03	1.32	2.38	2.57
λ	—	—	0.61	NC[e]	—	—
δ	—	—	—	—	NC	NC
E_{t-1}	1.88	NC	1.33	NC	NC	NC
E*	1.88	NC	2.18	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.18. Alternative regressions explaining cassava planted area, zone 15, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	400.78	-874.11	436.17	-1237.92	392.94	-683.68
SE[c]	(116.86)	(604.43)	(130.72)	(542.70)	(209.45)	(496.87)
Pr > |t|[d]	(0.01)	(0.19)	(0.02)	(0.06)	(0.11)	(0.22)
P_{t-1}	1573.38	7106.83	2475.72	3783.68	1543.99	4408.55
SE	(318.23)	(2348.63)	(1297.02	(2608.67)	(714.65)	(2272.01)
Pr > |t|	(0.002)	(0.02)	(0.10)	(0.20)	(0.07)	(0.10)
P_{t-2}	—	—	-1116.96	4851.14	—	—
SE	—	—	(1552.75)	(2608.67)	—	—
Pr > |t|	—	—	(0.50)	(0.10)	—	—
A_{t-1}	—	—	—	—	0.02	0.57
SE	—	—	—	—	(0.44)	(0.26)
Pr > |t|	—	—	—	—	(0.96)	(0.07)
T	—	—	—	—	—	—
SE	—	—	—	—	—	—
Pr > |t|	—	—	—	—	—	—
R^2	0.78	0.57	0.80	0.74	0.78	0.76
DW	1.85	1.40	2.02	1.69	3.13	3.09
λ	—	—	NC[e]	0.44	—	—
δ	—	—	—	—	NC	0.43
E_{t-1}	0.58	1.92	NC	1.02	NC	1.19
E*	0.58	1.92	NC	2.33	NC	2.77

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.19. Alternative regressions explaining cassava planted area, Thailand, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-183.97	499.45	462.70	1058.42	-1069.16	-1274.36
SE[c]	(1075.12)	(1072.72	(1422.32)	(1121.45)	(660.10)	(758.66)
Pr > |t|[d]	(0.87)	(0.66)	(0.76)	(0.86)	(0.16)	(0.14)
P_{t-1}	537.07	-824.65	855.13	375.39	1853.14	1915.73
SE	(2190.24)	(1896.61)	(2319.54)	(2057.08)	(1307.64)	(1282.15)
Pr > |t|	(0.81)	(.68)	(0.73)	(0.86)	(0.21)	(0.19)
P_{t-2}	–	–	-1732.70	-2347.96	–	–
SE	–	–	(2353.61)	(1890.03)	–	–
Pr > |t|	–	–	(0.49)	(0.27)	–	–
A_{t-1}	–	–	–	–	1.36	1.50
SE	–	–	–	–	(0.09)	(0.15)
Pr > |t|	–	–	–	–	(0.0001)	(0.0001)
T	565.67	532.50	554.75	509.03	–	–
SE	(69.03)	(95.54)	(73.34)	(93.42)	–	–
Pr > |t|	(0.0002)	(0.001)	(0.001)	(0.003)	–	–
R^2	0.92	0.92	0.93	0.94	0.97	0.97
DW	1.03	1.15	1.38	1.64	2.75	2.24
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	-0.36	-0.50
E_{t-1}	NC	NC	NC	NC	0.28	0.23
E*	NC	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Sugarcane

Zones 1, 11, 12, and 15 were chosen for analysis. These four zones together account for about 85 percent of five years average of total sugarcane planted area in the country.

In zone 1 (Table 5.20), all models fit the data well, High values of R^2 are obtained from all equations. Only one deflated price equation of the naive model is rejected because the price coefficient is not significant. The estimated elasticities with respect to price lagged one year range from 0.64 to 1.05. The adaptive expectation model gives the highest elasticity while the intermediate model gives the smallest elasticity. Comparing the deflated price and undeflated price equations, the deflated price equation tends to give a higher elasticity but smaller R^2 than the undeflated price equation. The estimated value of λ and δ all have a reasonable magnitude and range from 0.22 to 0.70. In general, there is no clearcut evidence that one model is superior to the others. The sugarcane/corn, sugarcane/kenaf, and sugarcane/cassava price ratios were also tested in the models. Only the coefficient of the sugarcane/corn price ratio was found not significantly different from zero. The results that show a significant effect of the coefficient of these ratios are given below.

Using sugarcane/cassava price ratio (zone 1):

$$A_t = -\ 15.37 + 0.089P_{t-1} + 18.08T$$

SE	(19.91)	(0.06)	(5.74)
$Pr > \|t\|$	(0.47)	(0.20)	(0.02)

$R^2 = 0.90$ DW = 1.86 $E_{t-1} = 0.35$

$$A_t = -9.18 + 0.08P_{t-1} + 0.21P_{t-2}$$

SE	(12.50)	(0.04)	(0.04)
Pr > |t|	(0.49)	(0.07)	(0.001)

$R^2 = 0.96$ DW = 2.13 $\lambda = 0.28$ $E_{t-1} = 0.31$

$$A_t = -7.04 + 0.14P_{t-1} + 0.61A_{t-1}$$

SE	(8.07)	(0.05)	(0.18)
Pr > |t|	(0.71)	(0.03)	(0.01)

$R^2 = 0.92$ DW = 3.25 $\delta = 0.39$ $E_{t-1} = 0.55$

<u>Using sugarcane/kenaf price ratio (zone 1)</u>:

$$A_t = -28.37 + 0.79P_{t-1} + 15.17T$$

SE	(13.64)	(0.22)	(3.43)
Pr > |t|	(0.08)	(0.01)	(0.004)

$R^2 = 0.96$ DW = 2.23 $E_{t-1} = 0.59$

$$A_t = -36.66 + 0.65P_{t-1} + 0.29P_{t-2} + 14.14T$$

SE	(12.18)	(0.19)	(0.15)	(2.91)
Pr > |t|	(0.03)	(0.02)	(0.12)	(0.004)

$R^2 = 0.98$ DW = 3.01 $\lambda = 0.24$ $E_{t-1} = 0.48$

$$A_t = -16.01 + 0.93P_{t-1} + 0.52A_{t-1}$$

SE	(17.29)	(0.27)	(0.17)
Pr > |t|	(0.39)	(0.01)	(0.02)

$R^2 = 0.93$ DW = 1.97 $\delta = 0.48$ $E_{t-1} = 0.69$

All models fit the data well. Similar results as when other forms of the price variable are used, were obtained. That is, the adaptive expectation model gives the highest elasticity but lowest R^2 while the intermediate model gives the smallest elasticity but highest R^2. In general, the estimated elasticities are smaller for the case when the price ratios are used than when the absolute or deflated price is used. The elasticities derived from sugarcane/kenaf price ratio equations have a higher value than those derived from sugarcane/cassava price ratio equations. This suggests that the price of kenaf may influence the farmers' decision regarding sugarcane planting more than the price of cassava. The significance of the coefficient of the sugarcane/cassava is consistent with the significance of the coefficient of the cassava/sugarcane price ratio in the cassava supply function. Similarly, the insignificance of the coefficient of the sugarcane/corn price ratio in sugarcane supply function is consistent with the insignificance of the coefficient of the corn/sugarcane price ratio in the corn supply function.

For zone 11, unlike zone 1, only one undeflated price equation of the naive model seems to fit the data satisfactorily while for the other models, very poor results were obtained. The estimated elasticities derived from the naive model are 0.87 and 1.82 for the undeflated price and deflated price, respectively. However, the estimated elasticity from the deflated price equation may be less reliable than the one derived from the undeflated price equation because the explanatory power of the deflated price equation is very low and the level of significance of the price coefficient is much higher than for the undeflated price equation.

The sugarcane/rice price ratio was also tested in the model but it was not found significant. Another attempt was made by substituting a relative revenue (R_t) variable for the price variable. Defining $R_t = P_t^S * Y_t^S / P_t^R * Y_t^R$, where P_t^S is the price of sugarcane, P^R is the price of rice, Y_t^S is the yield per rai of sugarcane, and Y_t^R is the yield per rai of rice. Using this formulation in all three models, we found two models that show some significant effect of this variable. The results are shown below.

Using the relative revenue of sugarcane to rice (zone 11):

$$A_t = 74.58 + 15.67R_{t-1} + 51.30T$$

SE	(42.10)	(11.83)	(3.54)
Pr > |t|	(0.13)	(0.23)	(0.0001)

$R^2 = 0.97$ DW = 2.50 $E_{t-1} = 0.14$

$$A_t = - 38.63 + 23.76R_{t-1} + 1.05A_{t-1}$$

SE	(64.84)	(16.85)	(0.11)
Pr > |t|	(0.57)	(0.21)	(0.0001)

$R^2 = 0.95$ DW = 2.77 $E_{t-1} = 0.21$

The small value of elasticities (0.14 and 0.21) and the high level of significance of R_{t-1} (0.21 and 0.23) indicate that the degree of substitution between rice and sugarcane, if any, is very small. It is also interesting to note that the trend variable alone explains almost 97 percent of the variation of sugarcane planted area in this zone. However, the trend variable cannot tell us what the factor(s) are that introduce the change in the sugarcane planted area. Furthermore, when a trend variable is included in the model with the price variable (deflated or undeflated), the coefficient of the price variable becomes negative. A similar problem is also found when the rice supply function is estimated. This problem may arise from the fact that the price data used in this study are the zone price data which are derived from the simple average of all provinces in the zone instead of weighted average. Furthermore, zone 11 is the biggest zone in terms of the number of provinces within the zone and, of course, the planted area of crop under study vary from province-to-province. The bias in the simple average price of all provinces is, therefore, increased. In fact, sugarcane is concentrated in only two of the ten provinces in the zone. Thus, for future research, the weighted price should be used and further disaggregation of the supply functions within this zone is recommended.

In zone 12 (Table 5.22), the biggest zone for sugarcane in the country, all models fit the data well. The explanatory power of all models is very high and all coefficients of the price variable are significant at better than the 0.15 level. The estimated elasticities with respect to price lagged one year range from 0.37 to 1.19. The naive model yields a higher elasticity than both intermediate and adaptive expectation models. Comparing the deflated price and undeflated price equations, similar results as for other crops are obtained; that is, the deflated price equation gives a higher elasticity than the undeflated price equations. The estimated value of λ and δ all have reasonable magnitudes and range from 0.38 to 0.54.

When the price ratio of sugarcane to rice is used in the model, only the naive model shows satisfactory results. The result is given below.

Using sugarcane/rice price ratio (zone 12):

$$A_t = -\ 646.64 + 3227.30P_{t-1} + 199.68T$$

SE	(339.09)	(2100.39)	(21.65)
$Pr > \|t\|$	(0.11)	(0.18)	(0.0001)

$R^2 = 0.94$ DW = 0.98 $E_{t-1} = 0.55$

This result implies that rice may compete for land with sugarcane.

Because the price received by farmers is not available in zone 15, the average sugarcane price for the whole country is used as a proxy for the local price. No satisfactory result is obtained from most of the models. The only acceptable result is the naive model. The estimated elasticities derived from this model are 0.53 and 0.94 for the undeflated price and deflated price equations, respectively. However, the deflated price equation has a very low R^2 and the level of significance of the price coefficient is very high as compared to the undeflated price equation. The elasticity derived from the intermediate model is not calculated even though the coefficient of the price variable is significant at the 0.18 level. This is because the other variable (P_{t-2}) is not significant. The difficulty for zone 15 can be explained by the mixed agricultural activities as previously discussed when the cassava supply function is estimated. Furthermore, the price average over the whole country may not be a good proxy for the local zone's price. The sugarcane/rice and sugarcane/cassava price ratios are also attempted. The signs of the price coefficient obtained from these attempts are mixed, positive and negative, but none show a significant effect. Noting that when only the trend variable is used in the model, the value of R^2 obtained is 0.90. Again, like zone 11, we cannot identify what the specific factor(s) are that influence the sugarcane planted area.

The national aggregate models are given in Table 5.24. Both the naive model and the intermediate model are acceptable. Even though high R^2 is obtained from the adaptive expectation model, but some of its coefficients are not significant, and, therefore, it was rejected. Comparing the naive and the intermediate models, the naive model may fit the data better than the intermediate model in terms of R^2 and level of significance of its coefficients. The estimated elasticities derived from the intermediate model are higher than the one obtained from the naive model. Comparing the undeflated price and deflated price equations, the deflated price equation gives a higher elasticity but lower R^2 (as in zone 1 and zone 12) than the undeflated price equation.

Since no other estimate of sugarcane elasticity for Thailand is available, no comparison is made. However, in general, we may conclude that all models fit the data well. The intermediate model seems to fit the sugarcane data better, both in terms of its explanatory power and the level of significance of its coefficient as compared to when it is applied to other crops. This is not a surprising result, however, since the sugarcane production period from planting time to the last harvesting time lasts more than one year. In terms of price responsiveness, sugarcane is, in fact, very responsive to price. The deflated price equation tends to give a higher elasticity than the undeflated price. However, there is no model that gives an elasticity coefficient uniformly higher than the other models for all zones.

Kenaf

Zones 1 to 5 were chosen for analysis. These five zones together account for almost all of the kenaf planted area in the country.

In zone 1 (Table 5.25), the models do not fit the data as well as other crops such as corn and sugarcane. Two equations, all from the intermediate model, are not acceptable since some of its coefficients are not significant. For the deflated price equation of the naive model, it is also rejected. While the adaptive expectation model seems to give the best fit and its price coefficient is significant, the estimated value of δs are all greater than one which lies outside our assumed interval. The elasticities range from 0.79 to 1.58. The deflated price equation tends to give a smaller elasticity than the undeflated price equation which is contradictory to the results generally obtained from other crops. The value of R^2 is smaller for the deflated price than the undeflated price. This result agrees with the other crop analyses.

When the kenaf/corn, kenaf/cassava, and kenaf/sugarcane price ratios are used in the model, all equations were found to have a positive coefficient for the price variable, although some of them

Table 5.20. Alternative regressions explaining sugarcane planted area, zone 1, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-31.85	-59.48	-38.24	-140.63	-25.95	-83.24
SE[c]	(16.84)	(54.29)	(17.14)	(70.62)	(21.17)	(56.52)
Pr > |t|[d]	(0.11)	(0.32)	(0.08)	(0.10)	(0.27)	(0.19)
P_{t-1}	0.56	0.57	0.46	0.70	0.70	1.05
SE	(0.20)	(0.56)	(0.21)	(0.51)	(0.23)	(0.54)
Pr > |t|	(0.03)	(0.35)	(0.08)	(0.23)	(0.02)	(0.10)
P_{t-2}	—	—	0.21	0.75	—	—
SE	—	—	(0.18)	(0.47)	—	—
Pr > |t|	—	—	(0.29)	(0.17)	—	—
A_{t-1}	—	—	—	—	0.30	0.78
SE	—	—	—	—	(0.24)	(0.18)
Pr > |t|	—	—	—	—	(0.27)	(0.01)
T	11.53	21.74	9.90	17.74	—	—
SE	(5.33)	(4.67)	(5.33)	(4.88)	—	—
Pr > |t|	(0.07)	(0.004)	(0.12)	(0.02)	—	—
R^2	0.94	0.89	0.96	0.92	0.92	0.87
DW	2.76	1.62	2.70	2.06	2.60	2.54
λ	—	—	0.69	0.49	—	—
δ	—	—	—	—	0.70	0.22
E_{t-1}	0.78	NC[e]	0.64	0.70	0.97	1.05
E^*	0.78	NC	0.93	1.44	1.39	4.77

[a]ABSL is the equation using absolute price.

[b]WIPA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.21. Alternative regressions explaining sugarcane planted area, zone 11, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	48.50	-313.36	68.41	-150.92	24.78	35.38
SE[c]	(75.37)	(499.90)	(88.99)	(560.84)	(43.04)	(170.77)
Pr > |t|[d]	(0.54)	(0.55)	(0.47)	(0.80)	(0.59)	(0.84)
P_{t-1}	1.77	5.01	2.09	5.73	0.33	0.01
SE	(0.38)	(3.58)	(0.76)	(3.83)	(0.42)	(1.35)
Pr > |t|	(0.002)	(0.20)	(0.03)	(0.19)	(0.46)	(0.99)
P_{t-2}	–	–	-0.46	-1.83	–	–
SE	–	–	(0.91)	(2.46)	–	–
Pr > |t|	–	–	(0.63)	(0.48)	–	–
A_{t-1}	–	–	–	–	0.90	1.06
SE	–	–	–	–	(0.23)	(0.14)
Pr > |t|	–	–	–	–	(0.01)	(0.0003)
T	–	–	–	–	–	–
SE	–	–	–	–	–	–
Pr > |t|	–	–	–	–	–	–
R^2	0.76	0.22	0.77	0.28	0.93	0.93
DW	1.28	0.85	1.63	1.20	2.65	2.51
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	NC	NC
E_{t-1}	0.87	1.82	NC	NC	NC	NC
E*	0.87	1.82	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.22. Alternative regressions explaining sugarcane planted area, zone 12, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-424.92	-1092.58	-487.07	-1321.09	-232.94	-515.19
SE[c]	(88.72)	(298.57)	(70.23)	(300.92)	(93.48)	(287.06)
Pr > |t|[d]	(0.003)	(0.01)	(0.0001)	(0.01)	(0.06)	(0.13)
P_{t-1}	2.88	6.38	1.47	4.17	1.62	3.04
SE	(0.67)	(1.96)	(0.76)	(2.22)	(0.66)	(1.78)
Pr > |t|	(0.01)	(0.02)	(0.11)	(0.12)	(0.06)	(0.15)
P_{t-2}	—	—	1.73	3.54	—	—
SE	—	—	(0.71)	(2.20)	—	—
Pr > |t|	—	—	(0.06)	(0.17)	—	—
A_{t-1}	—	—	—	—	0.53	0.12
SE	—	—	—	—	(0.20)	(0.22)
Pr > |t|	—	—	—	—	(0.04)	(0.04)
T	126.35	188.98	130.83	195.31	72.68	94.19
SE	(17.14)	(13.38)	(12.78)	(12.53)	(22.98)	(34.62)
Pr > |t|	(0.0003)	(0.0001)	(0.0002)	(0.0001)	(0.03)	(0.04)
R^2	0.98	0.97	0.99	0.98	0.99	0.99
DW	1.48	1.47	2.17	1.91	2.86	2.83
λ	—	—	0.46	0.54	—	—
δ	—	—	—	—	0.47	0.38
E_{t-1}	0.73	1.19	0.37	0.78	0.41	0.57
E*	0.73	1.19	0.80	1.45	0.87	1.50

[a] ABSL is the equation using absolute price.

[b] WPIA is the equation using price deflated by WPIA.

[c] SE is the standard error of the coefficient.

[d] Pr > |t| is the probability of the t-statistic greater than the calculated t.

Table 5.23. Alternative regressions explaining sugarcane planted area, zone 15, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	162.09	21.29	208.97	246.74	34.38	103.07
SE[c]	(58.86)	(268.99)	(76.55)	(364.89)	(74.49)	(143.94)
Pr > |t|[d]	(0.03)	(0.94)	(0.03)	(0.52)	(0.66)	(0.50)
P_{t-1}	1.18	2.88	2.02	4.29	0.02	-0.83
SE	(0.35)	(2.36)	(0.93)	(2.84)	(0.60)	(1.52)
Pr > |t|	(0.01)	(0.26)	(0.07)	(0.18)	(0.98)	(0.61)
P_{t-2}	–	–	-1.28	-3.47	–	–
SE	–	–	(1.32)	(3.74)	–	–
Pr > |t|	–	–	(0.37)	(0.39)	–	–
A_{t-1}	–	–	–	–	0.97	1.06
SE	–	–	–	–	(0.44)	(0.24)
Pr > |t|	–	–	–	–	(0.07)	(0.01)
T	–	–	–	–	–	–
SE	–	–	–	–	–	–
Pr > |t|	–	–	–	–	–	–
R^2	0.62	0.17	0.67	0.28	0.79	0.80
DW	0.99	0.57	1.61	1.11	2.46	2.58
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	NC	NC
E_{t-1}	0.53	0.94	NC	NC	NC	NC
E*	0.53	0.94	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.24. Alternative regressions explaining sugarcane planted area, Thailand, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-313.64	-1466.42	-72.15	-1175.81	-243.10	-105.50
SE[c]	(86.60)	(552.50)	(378.04	(2761.82)	(153.01)	(641.32)
Pr > |t|[d]	(0.01)	(0.04)	(0.85)	(0.69)	0.17	(0.88)
P_{t-1}	6.61	15.11	19.81	61.93	5.11	1.07
SE	(0.98)	(5.46)	(4.61)	(21.47)	(2.81)	(6.52)
Pr > |t|	(0.001)	(0.03)	(0.01)	(0.03)	(0.13)	(0.88)
P_{t-2}	–	–	-8.57	-36.01	–	–
SE	–	–	(6.54)	(28.37)	–	–
Pr > |t|	–	–	(0.24)	(0.25)	–	–
A_{t-1}	–	–	–	–	0.22	0.82
SE	–	–	–	–	(0.38)	(0.31)
Pr > |t|	–	–	–	–	(0.59)	(0.04)
T	221.57	316.25	–	–	188.74	116.25
SE	(24.38)	(29.63)	–	–	(62.54)	(77.80)
Pr > |t|	(0.0001)	(0.0001)	–	–	(0.03)	(0.19)
R^2	0.99	0.97	0.92	0.58	0.99	0.99
DW	1.68	1.12	1.16	1.04	1.87	2.39
λ	–	–	1.76	2.39	NC[e]	NC
δ	–	–	–	–	–	–
E_{t-1}	0.56	0.94	1.68	3.84	NC	NC
E*	0.56	0.94	NC	NC	NC	NC

[a]ABSL is the equation using absolute prices.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

are not significant. The equations that show significant effects are shown below.

Using kenaf/corn price ratio (zone 1):

$$A_t = 209.60 + 62.42P_{t-1} - 0.48A_{t-1}$$

SE	(62.13)	(25.35)	(0.27)
Pr > |t|	(0.02)	(0.05)	(0.13)

$R^2 = 0.54$ DW = 2.47 $\delta = 1.48$ $E_{t-1} = 0.52$

Using kenaf/sugarcane price ratio (zone 1):

$$A_t = 206.16 + 7694.16P_{t-1} - 0.42A_{t-1}$$

SE	(72.73)	(4046.39)	(0.30)
Pr > |t|	(0.03)	(0.10)	(0.21)

$R^2 = 0.42$ DW = 2.55 $\delta = 1.42$ $E_{t-1} = 0.34$

Using kenaf/cassava price ratio (zone 1):

$$A_t = 249.60 + 32.70P_{t-1} - 39.23P_{t-2}$$

SE	(74.69)	(17.04)	(14.00)
Pr > |t|	(0.02)	(0.10)	(0.03)

$R^2 = 0.57$ DW = 2.70 λ = negative $E_{t-1} = 0.74$

The first two equations are consistent with results when either corn or sugarcane supply functions are estimated. However, when the cassava/kenaf price ratio is used in the cassava supply function, no equation was found to have a significant price coefficient. This contradiction result implies that the price of cassava may have some influence on the farmers' decision on kenaf planting area while the price of kenaf has little, if any, influence on the farmers' decision to grow cassava.

The results of zone 2 are given in Table 5.26. No equation is acceptable since all price coefficients are not significant and some of them are negative. The kenaf/cassava price ratio is the only other price formulation which is tested. Only one equation is acceptable and is shown below. For other equations, the price coefficient is either negative or not significant or both.

Using the kenaf/cassava price ratio (zone 2):

$$A_t = 604.40 + 39.69P_{t-1} - 0.68A_{t-1} - 57.77T$$

SE	(80.06)	(14.19)	(0.18)	(9.79)
$Pr > \|t\|$	(0.001)	(0.04)	(0.01)	(0.002)

$R^2 = 0.89$ DW = 1.21 $\delta = 1.68$ $E_{t-1} = 0.64$

The insignificance of the price coefficient in this zone is possibly due to the limited number of possible substitute crops. However, Behrman (4) found the elasticities of kenaf planted area was 5.50 for Ubonratchathani province during the period of 1954 to 1963. The reason for the higher elasticity during the earlier period can be explained by the fact that the kenaf crop by that time was relatively new to the farmers. They responded to price mostly by opening up new land. However, in the later period, the availability of new land is limited together with few suitable substitute crops because of the poor quality of land. Therefore, the price responsiveness is lower in the later period. The only possible substitute crop is cassava which was just introduced into this zone about a decade ago.

The results for zone 3 are given in Table 5.27. The adaptive expectation model seems to fit the data best followed by the intermediate model. The estimated value of both the λs and δs all have a reasonable magnitude. In all deflated price equations, the trend variable is dropped out of the model because it is not significant. The deflated price equation is superior to the undeflated price equation both in terms of high R^2 and highly significant of the price coefcients. The estimated elasticities range from 0.82 to 1.59. Comparing the values of elasticities derived from the three models, the results are mixed since it also depends on the form of the price variable used. For the undeflated price equation, the adaptive expectation model gives the highest value of elasticity and follow by the intermediate model. For the deflated price equation, the naive model gives the highest elasticity while the intermediate model gives the smallest elasticity.

The kenaf/cassava price ratio is the only other formulation attempted for this zone. Positive price coefficients are obtained from all equations. Only one equation, however, shows a significant effect and the result is given below.

Using kenaf/cassava price ratio (zone 3):

	$A_t =$	$- 127.39$	$+ 131.51P_{t-1}$
SE		(183.93)	(26.96)
Pr > |t|		(0.51)	(0.002)

$R^2 = 0.77$ DW = 2.10 $E_{t-1} = 1.17$

Even though the explanatory power is not as high as most of the other equations when other forms of the price variable are used, the highly significant coefficient of the price variable and the high value of the elasticity coefficient is obtained. Furthermore, this result is consistent with the significance of the cassava/kenaf price ratio in the cassava supply function. This result implies that kenaf and cassava are competitive crops in zone 3.

The estimated elasticities in this zone are, in general, comparable with Behrman's study in which he found the elasticities range from 1.67 to 3.31 for three provinces within the zone (Khonkaen, Mahasarakham, and Roi-et).

For zone 4 (Table 5.28), all equations, except the deflated price equation of the adaptive expectation model, are acceptable. Even though the values of R^2 of all equations are a little too low as compared to other crops or other zones, the levels of significance of the price coefficients are acceptable. The estimated elasticities with respect to price lagged one year range from 0.39 to 1.40. Similar results to those in zone 3 were obtained. That is, the trend variable is not significant when the deflated price is used. Comparing the deflated price and undeflated price equations, the deflated price equations tend to give smaller elasticities than the undeflated price equations, which is generally contradictory to other crop analyses. Comparing the three models, the intermediate model seems to fit data better than the other two models, both in terms of R^2 and the level of significance of its coefficients.

The kenaf/corn and kenaf/cassava price ratio were also attempted for this zone. For the kenaf/cassava price ratio equation, no model is found to have a significant price coefficient, though it is positive. For the kenaf/corn price ratio, only one equation is found to have a significant price coefficient. The result is given below.

Using kenaf/corn price ratio (zone 4):

$$A_t = 108.03 + 68.99P_{t-1} + 0.45A_{t-1}$$

SE	(170.54)	(44.39)	(0.29)
Pr > |t|	(0.55)	(0.17)	(0.17)

$R^2 = 0.41$ DW = 2.68 $\delta = 0.55$ $E_{t-1} = 0.31$

This result implies that corn is considered as a substitute crop for kenaf in zone 4, although the degree of substitution is very low.

Two provinces in this zone, Buriram and Sisaket, were found by Behrman (4) to have SR elasticities equal to 1.92 and 3.30, respectively. His result was a little higher than the present study.

For zone 5 (Table 5.29), no model is acceptable because some of the price coefficients are negative, but not significant. Therefore, no estimated elasticity is derived from these models. The difficulties for this zone probably are due to the fact that there are many crops which may be considered as substitute crops for kenaf. Several price ratios have been formulated and tested in the model, including cassava, corn, groundnut, and cotton. The kenaf/corn and kenaf/cotton price ratios are not found to have any significant effect on kenaf planted area. However, when the corn/kenaf price ratio was used in the model in the corn supply function, its coefficient was found significant.

This result implies that the price of kenaf may have some influence on farmers' decision regarding corn planting area while the corn price may have little, if any, influence on kenaf planting area. This phenomenon can be explained by the fact that kenaf can always be grown on the soil that is suitable for corn while the area which kenaf can be grown on may not be suitable for corn. The reason is that kenaf can be grown on almost any type of soil and its yield may be not affected very much by the level of fertility of the soil. For corn, however, high fertility of the soil is necessary in order to give the minimum yield to cover the cost of production. And unlike kenaf, the yield of corn is very sensitive to the level of soil fertility. In fact, in some areas, corn cannot be produced at all. Therefore, changing from corn growing to kenaf may be more possible than changing from kenaf to corn.

The kenaf/cassava and kenaf/groundnut price ratios were found to have a significant effect on kenaf planted area. The results are given below.

Using kenaf/cassava price ratio (zone 5):

$$A_t = - 353.43 + 32.08P_{t-1} + 102.54P_{t-2}$$

SE	(180.35)	(25.58)	(25.38)
Pr > $\lvert t \rvert$	(0.10)	(0.26)	(0.007)

$R^2 = 0.83$ DW = 2.56 $\lambda = 0.24$ $E_{t-1} = 0.39$

$$A_t = -343.58 + 88.32P_{t-1} + 0.54A_{t-1}$$

SE	(275.93)	(32.51)	(0.25)
Pr > |t|	(0.26)	(0.03)	(0.07)

$R^2 = 0.65$ DW = 3.26 $\delta = 0.46$ $E_{t-1} = 1.07$

Using kenaf/groundnut price ratio (zone 5):

$$A_t = -3.41 + 407.43P_{t-1} + 0.43A_{t-1}$$

SE	(242.99)	(229.85)	(0.30)
Pr > |t|	(0.99)	(0.13)	(0.19)

$R^2 = 0.49$ DW = 2.50 $\delta = 0.57$ $E_{t-1} = 0.64$

The significance of the coefficient of the kenaf/cassava price ratio is consistent with the significance of the cassava/kenaf price ratio in the cassava supply function. This result implies that cassava and kenaf in zone 5 are competitive crops.

The national aggregate model is given in Table 5.30. Both equations of the intermediate model are rejected. One equation of the naive model is also rejected while both equations of the adaptive expectation model are acceptable. The estimated elasticities with respect to price lagged one year range from 0.35 to 0.56 which is quite low as compared to the zone's elasticities. The low elasticity of the aggregate model is probably due to the inappropriate average price data used in the model.

The estimated elasticities of all crops and all zones are summarized in Tables 5.31-5.34. The ranges, means and medians of the estimated elasticities derived from different models for all estimated

Table 5.25. Alternative regressions explaining kenaf planted area, zone 1, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-59.25	50.70	-20.95	59.31	7.80	156.90
SE[c]	(144.07)	(145.16)	(170.30)	(149.85)	(141.56)	(63.47)
Pr > |t|[d]	(0.70)	(0.74)	(0.91)	(0.71)	(0.96)	(0.05)
P_{t-1}	183.52	102.24	196.27	143.82	189.97	117.29
SE	(77.57)	(64.59)	(86.27)	(83.96)	(71.96)	(38.63)
Pr > |t|	(0.06)	(0.16)	(0.07)	(0.15)	(0.05)	(0.02)
P_{t-2}	–	–	-38.55	-52.87	–	–
SE	–	–	(73.85)	(65.15)	–	–
Pr > |t|	–	–	(0.62)	(0.45)	–	–
A_{t-1}	–	–	–	–	-0.34	-0.52
SE	–	–	–	–	(0.24)	(0.24)
Pr > |t|	–	–	–	–	(0.22)	(0.08)
T	-12.11	4.17	-10.91	5.91	-13.90	–
SE	(7.20)	(11.31)	(8.02)	(11.84)	(6.79)	–
Pr > |t|	(0.14)	(0.72)	(0.23)	(0.64)	(0.10)	–
R^2	0.54	0.37	0.56	0.44	0.67	0.63
DW	2.83	2.70	2.73	2.67	2.34	2.47
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	1.34	1.52
E_{t-1}	1.52	NC	NC	NC	1.58	0.79
E*	1.52	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.26. Alternative regressions explaining kenaf planted area, zone 2, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	293.43	502.22	544.98	524.92	748.03	838.33
SE[c]	(269.04)	(240.40)	(362.94)	(255.42)	(328.54)	(238.15)
Pr > |t|[d]	(0.32)	(0.08)	(0.19)	(0.10)	(0.07)	(0.02)
P_{t-1}	77.33	-28.93	51.12	9.80	-38.94	-70.42
SE	(140.84)	(102.86)	(142.51)	(123.73)	(132.66)	(81.51)
Pr > |t|	(0.60)	(0.79)	(0.73)	(0.94)	(0.78)	(0.43)
P_{t-2}	—	—	-123.45	-56.74	—	—
SE	—	—	(120.21)	(87.82)	—	—
Pr > |t|	—	—	(0.35)	(0.55)	—	—
A_{t-1}	—	—	—	—	-0.60	-0.61
SE	—	—	—	—	(0.32)	(0.27)
Pr > |t|	—	—	—	—	(0.12)	(0.07)
T	-30.78	-30.80	-22.57	-29.49	-37.14	-47.41
SE	(12.80)	(16.70)	(15.04)	(17.69)	(11.20)	(14.85)
Pr > |t|	(0.05)	(0.11)	(0.19)	(0.16)	(0.02)	(0.02)
R^2	0.51	0.49	0.60	0.53	0.72	0.75
DW	2.48	2.75	2.28	2.52	2.20	2.30
λ	—	—	NC[e]	NC	—	—
δ	—	—	—	—	NC	NC
E_{t-1}	NC	NC	NC	NC	NC	NC
E*	NC	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.27. Alternative regressions explaining kenaf planted area, zone 3, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	381.69	-29.00	-274.68	-155.66	-648.87	-210.86
SE[c]	(498.28)	(139.82)	(433.36)	(110.11)	(227.53)	(103.72)
Pr > |t|[d]	(0.47)	(0.84)	(0.55)	(0.21)	(0.04)	(0.09)
P_{t-1}	371.24	491.68	395.70	387.99	603.10	430.51
SE	(263.78)	(85.55)	(187.61)	(71.83)	(96.25)	(57.19)
Pr > |t|	(0.21)	(0.001)	(0.09)	(0.002)	(0.002)	(0.0003)
P_{t-2}	–	–	391.12	187.28	–	–
SE	–	–	(149.00)	(67.72)	–	–
Pr > |t|	–	–	(0.05)	(0.03)	–	–
A_{t-1}	–	–	–	–	0.69	0.37
SE	–	–	–	–	(0.10)	(0.11)
Pr > |t|	–	–	–	–	(0.001)	(0.01)
T	-73.00	–	-92.46	–	-62.43	–
SE	(24.79)	–	(19.11)	–	(8.60)	–
Pr > |t|	(0.03)	–	(0.01)	–	(0.001)	–
R^2	0.60	0.83	0.83	0.92	0.96	0.94
DW	0.59	1.13	1.66	2.02	2.61	2.74
λ	–	–	0.50	0.67	–	–
δ	–	–	–	–	0.31	0.63
E_{t-1}	0.98	1.04	1.04	0.82	1.59	0.91
E*	0.98	1.04	2.08	1.22	5.13	1.44

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

Table 5.28. Alternative regressions explaining kenaf planted area, zone 4, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	-49.80	146.86	-437.88	54.35	-265.88	69.70
SE[c]	(348.97)	(117.51)	(257.62)	(106.84)	(329.09)	(145.11)
Pr > |t|[d]	(0.89)	(0.25)	(0.15)	(0.63)	(0.46)	(0.65)
P_{t-1}	287.66	179.38	300.36	103.67	304.91	163.51
SE	(164.63)	(68.44)	(106.07)	(67.33)	(143.67)	(71.51)
Pr > |t|	(0.13)	(0.03)	(0.04)	(0.17)	(0.09)	(0.06)
P_{t-2}	–	–	212.82	133.52	–	–
SE	–	–	(69.13)	(64.60)	–	–
Pr > |t|	–	–	(0.03)	(0.08)	–	–
A_{t-1}	–	–	–	–	0.42	0.24
SE	–	–	–	–	(0.24)	(0.26)
Pr > |t|	–	–	–	–	(0.15)	(0.39)
T	-18.19	–	-25.85	–	-18.02	–
SE	(14.86)	–	(9.89)	–	(12.94)	–
Pr > |t|	(0.27)	–	(0.05)	–	(0.22)	–
R^2	0.45	0.50	0.81	0.71	0.65	0.56
DW	1.42	1.97	2.71	3.05	2.71	2.74
λ	–	–	0.59	0.44	–	–
δ	–	–	–	–	0.58	NC[e]
E_{t-1}	1.32	0.67	1.38	0.39	1.40	NC
E*	1.32	0.67	2.34	0.89	2.41	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.29. Alternative regressions explaining kenaf planted area, zone 5, 1969-1977

Explanatory variable	The naive model ABSL[a]	The naive model WPIA[b]	The intermediate model ABSL[a]	The intermediate model WPIA[b]	The adaptive expectation model ABSL[a]	The adaptive expectation model WPIA[b]
Intercept	923.94	578.08	306.08	441.43	701.00	627.82
SE[c]	(408.10)	(448.54)	(367.23)	(341.53)	(395.74)	(418.40)
Pr > |t|[d]	(0.06)	(0.24)	(0.68)	(0.25)	(0.14)	(0.19)
P_{t-1}	-71.58	95.49	-63.25	-71.72	-95.44	-53.87
SE	(208.55)	(187.29)	(146.25)	(157.19)	(188.83)	(204.36)
Pr > |t|	(0.74)	(0.63)	(0.68)	(0.67)	(0.63)	(0.80)
P_{t-2}	–	–	379.96	273.19	–	–
SE	–	–	(141.55)	(114.93)	–	–
Pr > |t|	–	–	(0.04)	(0.06)	–	–
A_{t-1}	–	–	–	–	0.46	0.50
SE	–	–	–	–	(0.30)	(0.36)
Pr > |t|	–	–	–	–	(0.18)	(0.22)
T	-43.00	-36.60	-68.26	-42.19	-40.16	-52.01
SE	(29.69)	(33.92)	(22.85)	(25.56)	(26.86)	(33.40)
Pr > |t|	(0.20)	(0.32)	(0.03)	(0.16)	(0.20)	(0.18)
R^2	0.35	0.37	0.73	0.70	0.56	0.54
DW	1.51	1.81	2.19	2.05	2.74	2.83
λ	–	–	NC[e]	NC	–	–
δ	–	–	–	–	NC	NC
E_{t-1}	NC	NC	NC	NC	NC	NC
E*	NC	NC	NC	NC	NC	NC

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

Table 5.30. Alternative regressions explaining kenaf planted area, Thailand, 1969-1977

Explanatory variable	The naive model		The intermediate model		The adaptive expectation model	
	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]	ABSL[a]	WPIA[b]
Intercept	2901.09	2063.00	3117.15	1770.01	825.26	1272.74
SE[c]	(671.65)	(714.41)	(1059.11)	(918.55)	(836.58)	(727.94
Pr > |t|[d]	(0.01)	(0.03)	(0.03)	(0.11)	(0.37)	(0.14)
P_{t-1}	189.64	583.76	215.24	511.07	561.33	447.07
SE	(447.40)	(348.52)	(494.69)	(391.79)	(323.03)	(299.96)
Pr > |t|	(0.69)	(0.15)	(0.68)	(0.25)	(0.14)	(0.20)
P_{t-2}	—	—	-164.58	224.09	—	—
SE	—	—	(584.48)	(396.05)	—	—
Pr > |t|	—	—	(0.79)	(0.60)	—	—
A_{t-1}	—	—	—	—	0.62	0.40
SE	—	—	—	—	(0.21)	(0.21)
Pr > |t|	—	—	—	—	(0.03)	(0.12)
T	-210.12	-164.11	-194.15	-160.16	-257.04	140.43
SE	(121.82)	(56.01)	(144.05)	(59.89)	(82.47)	(48.43)
Pr > |t|	(0.14)	(0.03)	(0.24)	(0.04)	(0.03)	(0.03)
R^2	0.52	0.66	0.52	0.68	0.82	0.80
DW	1.06	1.64	1.12	1.62	2.50	2.56
λ	—	—	NC[e]	NC	—	—
δ	—	—	—	—	0.38	0.60
E_{t-1}	NC	0.46	NC	NC	0.56	0.35
E*	NC	0.46	NC	NC	1.47	0.58

[a]ABSL is the equation using absolute price.

[b]WPIA is the equation using price deflated by WPIA.

[c]SE is the standard error of the coefficient.

[d]Pr > |t| is the probability of the t-statistic greater than the calculated t.

[e]NC indicates not calculated.

zones are presented in Table 5.31. The means and medians of estimated elasticities derived from different forms of the price variables were compared for each model and each crop and the results are given in Table 5.32. Comparing means and medians of the estimated elasticities derived from different models for each crop and each form of the price variable used are shown in Table 5.33. Finally, the ranges, means, and medians of estimated elasticities for each crop in each zone and the national aggregate are given in Table 5.34.

From Table 5.32. for rice, corn and sugarcane, it was found that the means of the elasticities derived from the deflated price equation is always greater than the one derived from the absolute price equation regardless of the model used. By contrast, for kenaf, the result is the opposite. That is, the mean of the elasticities derived from the absolute price equation is always greater than the one derived from the deflated price equation. For cassava, the results are mixed. For the intermediate model and the adaptive expectation model, the results are the same as for kenaf. For the naive model, the result is similar to rice, corn, and sugarcane. The elasticities derived from the price ratio equations, in many cases, are smallest. The conclusion may alter slightly if one uses the median to compare these results.

From Table 5.33, using either mean or median in comparison, one arrives at the same conclusion in almost all cases, with the exception of the absolute price equation of cassava crop. In general, the comparisons between the model for each crop are not all independent of the form of the price variable used. For rice, the adaptive expectation model always gives a higher elasticity than the naive model. For corn, the naive model gives a higher elasticity than the adaptive expectation model if the absolute price is used. For cassava, sugarcane, and kenaf, the results are also mixed. For the intermediate model, in most cases, the elasticities are smallest.

From Table 5.34, in general, the national aggregate model has a smaller elasticity than the zone models. Comparing zones, the elasticities for a given crop vary considerably from zone-to-zone. One striking result prevails; that is, the farmers in the northeastern region (zones 1-5) are far more response to price than the farmers in the central region (zones 7, 11, 12, and 15) in almost all crops. This is despite the fact that the central region is much closer to Bangkok, the country's capital, where all markets, domestic and export, are located. Furthermore, the biggest zones, in terms of planted area, do not necessarily have the highest elasticity, e.g., rice in zone 11, corn in zone 6, cassava in zones 5 and 15, and sugarcane in zone 12. These zones have, in fact, smaller elasticities than the smaller zones. However, the specified models tend to fit the data for the biggest zone better than other zones. This evidence can be seen from the corn function in zone 6, sugarcane function in zone 12, and kenaf function in zone 3. Any model seems to fit the data in these zones very well and the price coefficients are highly significant in most cases.

It is also clear from Table 5.34 that all crops, except rice, have very high elasticities. The crop that has the highest elasticities is cassava and the second highest is kenaf. The very high responsiveness to price for these two crops can be explained by the fact that these two crops can be grown on almost any type of soil. Therefore, it is very easy to substitute for other crops. Furthermore, in some areas like the northeastern region, cassava and kenaf are competitive crops. When the relative price of the two crops changes, the allocation of land devoted to these crops is also changed. Thus, the high elasticity was found for these crops.

For corn and sugarcane, even though the estimated elasticities are smaller than for kenaf and cassava, it is still considered as a high elasticity as compared to other developed countries such as the United States.

The very low elasticity for rice is not a surprising result. As mentioned earlier, rice is the only staple food for the Thai people, most of the farmers, whenever they can, will always grow rice at least enough for their own consumption, regardless of what its price will be. By doing this, they feel more secure than growing other crops where the price fluctuates considerably from year-to-year. Furthermore, since most of the main (first) rice crop is grown on low land which is flooded in the rainy season, the only suitable crop is rice. This does not mean, however, that the second rice crop which grows in the dry season will not respond to price. In the dry season when the water level is very low or can be controlled, there are many other crops that can be grown on the paddy field. Thus, the responsiveness to the price may be very high. The second rice crop, however, was not analyzed in this study.

Table 5.31. Ranges, means, and medians of estimated elasticities derived from different models

Model	Statistics	Rice	Corn	Cassava	Sugarcane	Kenaf
Naive	Range[a]	-0.08/0.61	0.15/2.16	0.58/3.18	0.35/1.82	0.67/1.52
	Mean[a]/median[a]	0.23/0.22	0.77/0.79	2.01/1.92	0.84/0.76	1.12/1.11
ABSL[b]	Range	-0.08/0.27	0.39/1.43	0.58/2.78	0.53/0.87	0.98/1.52
	Mean/median	0.16/0.15	0.88/0/81	1.72/1.77	0.73/0.76	1.27/1.32
WPIA[c]	Range	0.28/0.61	0.19/2.16	1.92/2.79	0.94/1.82	0.67/1.04
	Mean/median	0.43/0.40	0.93/0.69	2.35/2.35	1.32/1.19	0.86/0.86
RATIO[d]	Range	—	0.15/1.34	1.07/3.18	0.35/0.59	1.17/1.17
	Mean/median	—	0.66/0.67	2.16/2.22	0.50/0.55	1.17/1.17
Intermediate	Range[a]	0.40/0.54	0.19/2.70	1.02/1.76	0.31/0.78	0.39/1.38
	Mean[a]/median[a]	0.47/0.47	1.04/0.69	1.37/1.33	0.55/0.56	0.79/0.78
ABSL	Range	0.40/0.40	0.48/1.68	1.33/1.33	0.37/0.64	1.04/1.38
	Mean/median	0.40/0.40	1.08/1.08	1.33/1.33	0.51/0.51	1.21/1.21
WPIA	Range	0.54/0.54	0.19/2.70	1.02/1.02	0.70/0.78	0.39/0.82
	Mean/median	0.54/0.54	1.19/0.94	1.02/1.02	0.74/0.74	0.61 0.61
RATIO	Range	—	0.66/0.70	1.76/1.76	0.31/0.48	0.39/0.74
	Mean/median	—	0.68/0.68	1.76/1.76	0.40/0.40	0.57/0.57
Adaptive	Range[a]	0.22/0.66	0.15/2.27	0.28/1.86	0.41/1.05	0.31/1.59
	Mean[a]/median[a]	0.35/0.32	0.87/0.71	1.30/1.48	0.71/0.63	0.93/0.85
ABSL	Range	0.22/0.36	0.15/1.83	1.77/1.77	0.41/0.97	1.40/1.59
	Mean/median	0.28/0.26	0.81/0.46	1.77/1.77	0.69/0.69	1.50/1.58
WPIA	Range	0.46/0.66	0.58/2.27	1.19/1.80	0.57/1.05	0.79/0.91
	Mean/median	0.56/0.56	1.35/1.21	1.50/1.50	0.81/0.81	0.85/0.85
RATIO	Range	—	0.15/1.15	0.28/1.86	0.55/0.69	0.31/1.07
	Mean/median	—	0.69/0.71	1.00/0.87	0.62/0.62	0.59/0.58

[a]Combine all equations of the model.

[b]ABSL is the equation using absolute price.

[c]WPIA is the equation using price deflated by WPIA.

[d]RATIO is the equation using price ratio.

Table 5.32. Comparison among means and medians of estimated elasticities derived from different forms of price variable for each model and each crop

Crop	The naive model	The intermediate model	The adaptive expectation model
Rice			
Mean	W > A	W > A	W > A
Median	W > A	W > A	W > A
Corn			
Mean	W > A > R	W > A > R	W > A > R
Median	A > W > R	A > W > R	W > R > A
Cassava			
Mean	W > R > A	R > A > W	A > W > R
Median	W > R > A	R > A > W	W > A > R
Sugarcane			
Mean	W > A > R	W > A > R	W > A > R
Median	W > A > R	W > A > R	W > A > R
Kenaf			
Mean	A > R > W	A > W > R	A > W > R
Median	A > R > W	A > W > R	A > W > R

W is the mean (median) of the elasticities derived from the equation using price deflated by WPIA.
A is the mean (median) of the elasticities derived from the equation using absolute price.
R is the mean (median) of the elasticities derived from the equation using price ratio.

Table 5.33. Comparison among means and medians of estimated elasticities derived from different models for each crop and each form of price variable used

Crop	Absolute price equation (ABSL)	Deflated price equation (WPIA)	Price ratio equation (RATIO)
Rice			
Mean	I > A > N	A > I > N	–
Median	I > A > N	A > I > N	–
Corn			
Mean	I > N > A	A > I > N	A > I > N
Median	I > N > A	A > I > N	A > I > N
Cassava			
Mean	A > N > I	N > A > I	N > I > A
Median	N > A > I	N > A > I	N > I > A
Sugarcane			
Mean	N > A > I	N > A > I	A > N > I
Median	N > A > I	N > A > I	A > N > I
Kenaf			
Mean	A > N > I	N > A > I	N > A > I
Median	A > N > I	N > A > I	N > A > I

N is the mean (median) of the elasticities derived from the naive model.
I is the mean (median) of the elasticities derived from the intermediate model.
A is the mean (median) of the elasticities derived from the adaptive expectation model.

Table 5.34. Ranges, means, and medians of estimated elasticities for each crop in each zone and national aggregate (1969-1977)

Zone	Statistics	Rice	Corn	Cassava	Sugarcane	Kenaf
1	Range	0.27/0.54	0.66/2.70	0.87/1.86	0.31/1.05	0.34/1.58
	Mean/median	0.39/0.38	1.50/1.43	1.50/1.71	0.65/0.64	0.92/0.77
2	Range	0.11/0.11	–	–	–	0.64/0.64
	Mean/median	0.11/0.11	–	–	–	0.64/0.64
3	Range	0.22/0.22	–	2.78/3.18	–	0.82/1.59
	Mean/median	0.22/0.22	–	2.92/2.79	–	1.08/1.04
4	Range	0.14/0.14	–	–	–	0.31/1.40
	Mean/median	0.14/0.14	–	–	–	0.91/1.00
5	Range	0.25/0.66	0.41/1.34	0.28/2.22	–	0.39/1.07
	Mean/median	0.45/0.44	0.97/1.00	1.49/1.76	–	0.70/0.64
6	Range	0.12/0.22	0.22/0.71	–	–	–
	Mean/median	0.17/0.17	0.53/0.54	–	–	–
7	Range	–	0.15/0.19	–	–	–
	Mean/median	–	0.17/0.15	–	–	–
8	Range	0.16/0.40	–	–	–	–
	Mean/median	0.27/0.25	–	–	–	–
11	Range	-0.08/-0.08	–	–	0.14/1.82	–
	Mean/median	-0.08/-0.08	–	–	0.76/0.54	–
12	Range	–	–	–	0.37/1.19	–
	Mean/median	–	–	–	0.66/0.57	–
15	Range	–	–	0.58/1.92	0.53/0.94	–
	Mean/median	–	–	1.18/1.11	0.74/0.74	–
All zones	Range	-0.08/0.66	0.15/2.70	0.28/3.18	0.14/1.82	0.31/1.59
	Mean/median	0.30/0.27	0.86/0.70	1.66/1.77	0.68/0.62	0.91/0.87
National aggregate	Range	0.07/0.12	0.19/0.37	0.23/0.28	0.56/3.84	0.35/0.56
	Mean/median	0.10/0.10	0.32/0.36	0.26/0.26	1.76/1.31	0.46/0.46

CHAPTER VI. SUMMARY AND CONCLUSIONS

Summary

The analysis of the price responsiveness of agricultural supply, particularly in countries such as Thailand where agriculture dominates the economy, is very important for making suitable policy for the country. If the study shows that the farmers are responsive to price, changes in production can be accomplished by using price as an incentive for farmers. On the other hand, if supply is not price responsive, the increase in production must be achieved by other means such as changing the underlying technological or social conditions under which the crops are produced. Policy recommendations are implied by _a priori_ hypotheses about the responsiveness of a supply function, which is an empirical question. Despite the relative importance of information on supply, research studies on Thailand's agricultural supply seem to be inadequate. Most of the research has concentrated heavily on the demand side and very often at a very aggregated level, except for one study by Behrman (4). Therefore, this study, in general, attempts to contribute to the knowledge of the influence of price on the supply of agricultural production in Thailand. This goal, however, can be achieved by several methods of analyses such as linear programming and the budgeting approach. In this study, the statistical analysis of time series data was employed. The period under study was between 1969 to 1977 and the crops included were rice, corn, cassava, sugarcane, and kenaf. For agricultural development and planning purposes, the seventy-two provinces (changwads) in the country have been grouped by the Ministry of Agriculture and Cooperatives into nineteen agro-economic zones. Each zone is considered to be homogeneous in terms of climatic and agronomic conditions, and agricultural activities. The statistical analysis of the supply of crops is primarily at the zone level of aggregation. However, the aggregate model for the whole country was also estimated.

Since the period under study is relatively short and in order to conserve degrees of freedom in statistical analysis, the very simple Nerlovian supply function was applied in this study. The basic model is of the form $A_t = \alpha_0 + \alpha_1 P^*_t + U_t$, where A_t is the actual planted area of crop of concern, P^*_t is the expected price, and U_t is the random disturbance term.

Because P^*_t is unobservable, three models regarding the formulation of farmers' price expectations were tested and compared. The three models are:

I. The naive model, where

$$P^*_t = P_{t-1},$$

that is, the expected price for this year is equal to the actual price which prevailed in the last year.

II. The intermediate model, where

$$P^*_t = \lambda P_{t-1} + (1 - \lambda)P_{t-2},$$

that is, the expected price for this year is the weighted average of the price lagged one and two years.

III. The adaptive expectation model, where

$$P_t = P^*_{t-1} + \delta[P_{t-1} - P^*_{t-1}], \qquad 0 < \delta \leq 1,$$

that is, the expected price of this year is equal to the last year's expected price plus some error adjustment made last year in forming price expectation. A trend variable was also added into all models in order to pick up whatever variation of the planted area of the crop under study that cannot be explained by price alone. For each model, at least two equations were estimated using two different price variables. For one equation, the absolute price was used and for the other equation, the price deflated by the wholesale price index of agricultural products was used. The reduced form equation derived from the original behavioral equation and the different assumptions regarding price expectations were then estimated by the OLS method. Furthermore, for some crops in some zones, the price ratio of the crop under study to a single selected crop was also used in all three models. In general, therefore, for each crop in each zone there were at least six equations to be estimated. However, the trend variable may be dropped out from the reported model if either the trend variable itself does not show any significant effect at the 0.30 level or lower or it increases the level of significance of the price and/or other variables to higher than the 0.30 level. The discussion and comparison among the models were based upon the explanatory power of the model, the level of significance of the price and other variables, and the magnitude of the estimated elasticities. However, the elasticity was computed only when all the coefficients (except the intercept term) were significant at the 0.30 level or lower.

From this study, it was found that, in general, all crops are price responsive. However, the price responsiveness for rice is very low and even negative for some zones. The estimated elasticities of rice planted area with respect to price lagged one year range from - 0.08 to 0.66 with mean and median equal to 0.30 and 0.27, respectively.

For corn, the estimated elasticities range from 0.15 to 2.70 with the mean and median equal to 0.86 and 0.70, respectively. Comparing zones, zone 1 and zone 5 in the northeast tend to have higher elasticities than zones 6 and 7.

For cassava, the estimated elasticities range from 0.28 to 3.18 with mean and median equal to 1.66 and 1.77, respectively. Very high elasticities were also obtained for kenaf which range from 0.31 to 1.59 with mean and median equal to 0.91 and 0.87, respectively. In the case of sugarcane, the estimated elasticities range from 0.14 to 1.82 with mean and median equal to 0.68 and 0.62, respectively. The elasticities are about the same magnitude for kenaf in all zones.

Cassava and kenaf were found to be the competitive crops for corn in zone 1, while groundnut and cotton prices were found to have an influence on corn planted area in zone 5. Soybeans and cotton were found to be the competitive crops for corn in zone 6, while mungbean was a competitive crop for corn in zone 6 and zone 7.

It was found that corn and sugarcane were the competitive crops for cassava in zone 1. In zone 3 and zone 5, kenaf price was found to have an influence on cassava planted area. No competitive crop was found to have a significant influence on cassava planted area in zone 15.

Cassava and kenaf were found to be the competitive crops for sugarcane in zone 1. In zone 11 and zone 12, rice was found to be a competitive crop for sugarcane. In zone 15, no alternative crop was found to have a significant effect on sugarcane planted area.

Comparing the three models, the adaptive expectation model did not show uniformly better results than the naive model. And, in many cases, the estimated value of the adaptive expectation coefficient (δ) was either greater than one or less than zero which was outside the assumed interval. The intermediate model did not fit the data well except for sugarcane crop. The better fit for sugarcane is not a surprising result, however, because sugarcane, unlike other crops, can be harvested more than once and last more than one year for one planting.

Comparing the absolute price and the deflated price equations, in most cases, but not always, the deflated price equation tends to give higher elasticities than the undeflated price equation. However, deflated price equations tend to reduce the explanatory power of the model.

Conclusion and Policy Implications

The general conclusions which can be made from this study are as follows:

1. When the period under study is very short, the relatively simple naive model does not show any inferiority, if not superiority, to either the intermediate model or the adaptive expectation model.

This result implies that the farmers do, in fact, use the current price as the expected price that will prevail in the next year. The planting decision on how much acreage they are willing to devote to a certain crop is based on this expected price.

2. The estimated price elasticities derived from the equations using the deflated price tend to give a higher value than the undeflated price equations. This result implies that the farmers do take the rise in general price level into account when making decisions regarding land allocation to each crop.

3. In many cases, when there is no equation which is acceptable from all three models, the equation using the price ratio of the crop under study to a price of the selected competing crop seems to give a more reasonable result than other forms of the price variable used. Therefore, the price ratio may be considered as more appropriate than using either the absolute price or the deflated price.

4. In general, the Thai farmers are very price responsive, based on the evidence from the studies of corn, cassava, sugarcane and kenaf. These results suggest that if the government wants to increase the production of these crops at least in terms of area expansion, it can do so by using price as an incentive. However, the increase in area of these crops may cause a reduction in area planted to other crops, especially in zones where the possibility of opening up the new cultivated land is impossible. The latter implication is derived from the significant effect of the price ratio variable when it was used in the model.

5. The price responsiveness of rice, if any, is very low as

compared to other crops. This is not a surprising result, however. The rice crop covered in this study is the wet season crop and the possibility of alternative crops is very limited because of the flooded nature of the paddy field. Furthermore, there is always an incentive to grow rice, at least enough for on-farm consumption. By doing this, farmers feel more secure than growing other crops. Nevertheless, this does not imply that the production of rice cannot increase by using price as an incentive, since, given the planted area, the production can be increased by increasing yield per unit area. If yield is responsive to price, for example, applying more fertilizer, the production will increase. Another possibility is that if the relative price is favorable to rice, in certain irrigated areas, second rice (dry season) is also an alternative to other crops, thus, increasing the rice planted area.

Suggestions for Further Research

There are several potential improvements of the model used in this study especially when longer time series become available. These suggestions are as follows:

1. Instead of using price deflated by the wholesale price index or the price ratio of the crop of concern to a selected single competitive crop, the special price index should be constructed from several competitive crops which may vary from zone-to-zone. The weights used could be either quantity marketed (if available) or planted area.

2. Yield per unit area may be incorporated into the model either

explicitly or implicitly by multiplying by its price which is a gross revenue per unit area. Ideally, the relative net revenue to the alternative crops may be more appropriate than the gross revenue. But the time series of cost data for each crop is, generally, not available.

3. The crop year price used in the model may be inappropriate for some crops such as cassava which can be grown or harvested in any month of the year. The weighted average of selected monthly price such as the post-harvest or pre-planting months should be tested.

4. For sugarcane, if possible, the separate model for newly planted and the ratoon may be more accurate than the combined model.

5. For rice, different models should be respecified. The other variables may include a weather index and/or farm population. The optimum amount of water level at the right time may play a major role in determining the actual planted area. The consideration of adding the farm population into the model is based on the fact that rice is the only staple food in Thailand.

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I also would like to dedicate the benefit, if any, from this research to the Thai farmers, the backbone of the country's economy. Any errors which may appear in this thesis, of course, are my sole responsibility.

APPENDIX A. DATA SOURCES AND DESCRIPTIONS

The most important sources of data were annual issues of Agricultural Statistic of Thailand, published by the Thailand Ministry of Agriculture and Cooperatives, Office of Agricultural Economics (OAE) (formerly Division of Agricultural Economics), Center for Agricultural Statistics, Bangkok, Thailand. The additional unpublished data were also obtained from personal correspondence with the staff of the above office. Notations, definitions, and sources of data used in the model are as follows:

t = time period, when used as a subscript and in all cases, except for the wholesale price index, referred to crop year which start from April to March.

T = trend variable, 1969 = 1, ..., 1977 = 9.

$WPIA_t$ = wholesale price index of agricultural product and t' is referred to a calendar year (1968 = 100).

Sources: Bank of Thailand Monthly Bulletin, Vol. 17, No. 4 (April 1977) and Vol. 20, No. 1 (January 1980).

A_t = the planted area of crop concern for the crop year t.

Unit: 1,000 rai.

Sources: 1968-1973, unpublished data from OAE.

1974-1977, Agricultural Statistic of Thailand Crop Year 1977/78.

P_t = the average yearly price computed from monthly prices and using percentages of monthly sale as the weight. The unit and grade or type for the price variable used for each crop is given in Table A.1.

Table A.1. Unit and grade or type used for the price variable for each crop[a]

Crop	Grade/type	Unit	Zone/country
Rice	Glutinous first grade paddy	Baht/metric ton	1, 2, 3 (use country average price)
	Simple average of glutinous first grade and nonglutinous first grade paddy	Baht/metric ton	4, 5 (use country average price)
	Nonglutinous first grade paddy	Baht/metric ton	6, 8, 11
	Mixed grade paddy	Baht/metric ton	Country
Corn	Mixed	Baht/kilogram	1, 5, 6, 7, and country
Cassava	Mixed	Baht/kilogram	1, 3, 5, 15
Sugarcane	Mixed	Baht/metric ton	1, 11, 12 Zone 15—use country average price
Kenaf	Mixed	Baht/kilogram	1, 2, 3, 4, 5
Mungbean	Mixed	Baht/kilogram	6, 7, 8
Soybean	First grade	Baht/kilogram	6, 7
Groundnut	Mixed	Baht/kilogram	5
Cotton	Mixed	Baht/kilogram	Use country average price

[a]Source: Unpublished data from OAE.

APPENDIX B. NAME OF PROVINCES IN EACH ZONE

Zone 1	Loei
	Nakhonphanom
	Nongkhai
	Sakonnakhon
	Udonthani
Zone 2	Ubonratchathani
	Yasothon
Zone 3	Kalasin
	Kohnkaen
	Mahasarakham
	Roi-et
Zone 4	Buriram
	Sisaket
	Surin
Zone 5	Chaiyaphum
	Nakhonratchasima
Zone 6	Nakhonsawan
	Petchabun
	Uthaithani
Zone 7	Lopburi
	Saraburi
Zone 8	Kamphaengphet
	Pichit
	Pitsanulok
	Tak
Zone 9	Lampang
	Nan
	Phrae
	Sukhothai
	Uttaradit
Zone 10	Chiangmai
	Chiangrai
	Lamphun
	Maehongson
	Payao
Zone 11	Angthong
	Ayutthaya
	Bangkok
	Chainat
	Nakhonnayok
	Nakhonpathom
	Nonthaburi
	Pathumthani
	Singburi
	Suphanburi
Zone 12	Kanchanaburi
	Phetchaburi
	Prachuapkhirikhan
	Ratchaburi
Zone 13	Chachoengsao
	Prachinburi
Zone 14	Samutprakan
	Samutsakhon
	Samutsongkhram
Zone 15	Chonburi
	Rayong
Zone 16	Chanburi
	Trat
Zone 17	Chumphon
	Nakhonsithammarat
	Phatthalung
	Songkhla
	Suratthani
Zone 18	Krabi
	Phangnga
	Phuket
	Ranong
	Satun
	Trang
Zone 19	Narathiwat
	Pattani
	Yala