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Agricultural Supply Response of

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บทคัดย่อ

ปฏิกริยาตอบสนองทางด้านอุปทานของการปลูกพืชบางชนิดในประเทศไทย

การศึกษานี้ได้พยายามคำนวณหาขนาดของการตอบสนองด้านอุปทานของการปลูกพืช ๔ ชนิดในประเทศไทย คือ ข้าว ข้าวโพด มันสำปะหลัง และปอ ระหว่างปี ๒๕๐๖-๒๕๒๐ การศึกษาครั้งนี้ จัดได้ว่าเป็นส่วนที่ต่อเนื่องจากการศึกษาของนายจีรี เบอร์แมน (Jere Behrman) ซึ่งได้ศึกษาการปลูกพืชเดียวกันนี้ไว้ระหว่างช่วงเวลา ๒๔๘๐-๒๕๐๖ ผู้ศึกษาได้ให้ความสำคัญเป็นอย่างมากในการวางรูปแบบของสมการที่ใช้คำนวณ โดยการกำหนดตัวแปรด้านราคาพืชผลที่สะท้อนถึงการแข่งขันระหว่างพืชต่าง ๆ เข้าด้วยกัน ด้านผลผลิตโดยเปรียบเทียบ และด้านความเสี่ยงของการปลูกพืชแต่ละพืช ส่วนวิธีคำนวณนั้นก็ใช้วิธีการทางเศรษฐมิติที่มิได้เป็นเส้นตรง (non-linear estimation techniques) ซึ่งมีความสลับซับซ้อนระดับเดียวกันกับของนายเบอร์แมน

ผลการศึกษาปรากฏว่า ราคาของพืชผลในลักษณะต่าง ๆ กันมีอิทธิพลต่อปฏิกริยาตอบสนองทางด้านอุปทานซึ่งวัดโดยการเปลี่ยนแปลงในเนื้อที่เพาะปลูกของเกษตรกรโดยทั่วไป หรือกล่าวอีกนัยหนึ่งคือ โดยทั่วไปแล้ว เกษตรกรไทยจะขยายเนื้อที่เพาะปลูกมากขึ้นเมื่อราคาพืชนั้น ๆ สูงขึ้น และจะลดเนื้อที่เพาะปลูกลงเมื่อราคาพืชลดลง แต่ปฏิกริยาตอบสนองดังกล่าว ไม่มากจนเกินไปนัก และแตกต่างกันไปตามชนิดของพืช อย่างไรก็ตามพอจะกล่าวได้ว่า นโยบายทางด้านราคาพืชอาจช่วยในการกำหนดปริมาณการผลิต และการเปลี่ยนแปลงในเนื้อที่เพาะปลูกได้บ้าง

Abstract

Agricultural Supply Response of Some Major Crops in Thailand

This study attempted to estimate the total supply response of four major annual crops of Thailand namely rice, maize, cassava and kenaf for the period between 1963-1977. It is more or less a continuation of a previous study done by Jere Behrman for 1937-1963. A great deal of attention was given to model specification where elaborate relative farm-gate price, yield and risk variables were constructed, and the non-linear estimation techniques were used to run most of the equations.

The results have shown that the price of the crop and its variations are generally significant determinants of farmers' response measured by the change in the area planted. In other workds, it could be stated that Thai farmers still respond to changes in the price of crop in a normal way although for some crops such as rice this responsiveness may be weak and many other variables such as the limitation of areable land, the size of farm population, and so on may have influenced this responsiveness. To a certain extent, farm price policy could be designed to generate desired production or area responses.

I. INTRODUCTION

When Jere R. Behrman (3) began his study on the supply response of four major crops in Thailand in the early 1960s, he mentioned, as a rationale for his study, the need to cope with "impending, if not already existing, crisis in world agricultural production." In this, he seemed to imply that increase in world agricultural production was necessary if the threats of hunger and starvation, particularly in poor countries, were to be averted. Out of several aspects of agricultural production and policies to increase agricultural output, Behrman selected the responsiveness of agricultural supply to changes in price as his theme of study. His completed work has been widely accepted as a definitive study in the area of farmer's supply response, and has generated much greater interest in this already established field of agricultural research.

Significance of the Problem

Although industrialization is still considered the prime goal of economic development of many developing countries including Thailand, the success of such as endeavor often is not possible without a strong and efficient agricultural sector. Imagine a situation where population continues to grow at a fairly rapid rate, where each year the demand for food increases. The spread of urbanization may have drawn labour force from the farm sector to the non-farm sector, leaving the farmer sector with a greater responsibility of providing larger food supply both for domestic consumption and for export. This situation clearly calls for increase in farm production and productivity, and various agricultural policies of the government such as crop diversification, selection of high yielding varieties of seeds, promotion of fertilizer uses, agricultural credits and marketing facilities have now become most relevant.

But to predict the outcome and to evaluate the implication of a government agricultural policy, it is necessary to develop accurate behavioral models for the agricultural sector and an important aspect in the overall development of such a model focuses on the supply of agricultural output, its elasticity and the dynamics of the supply response. This model would tell us for example, the price elasticity of supply which would help us in predicting and evaluating the behavior of domestic food production in the face of some changes and disturbances in outside food supply such as the surplus food disposal by the United States (P.L. 480-type programs) and other countries. If domestic output is responsive to price changes, output will likely be curtailed since these surplus food disposal programmes tend to depress market prices. Moreover, accurate evaluation of attempts to diversify production will also depend on the supply response. In Thailand, for example, the rice premium has served to reduce domestic prices paid to farmers. If supply is sensitive to changes in relative prices, such reductions may have reduced areas planted in rice while at the same time stimulating some diversification into other annual crops production. If, on the other hand, supply is not sensitive to relative price changes, the rice premium would have little effect on agricultural output, but would simply depress farm income.

Is agricultural supply in a developing country such as Thailand really responsive to price changes? The debate over supply response in general has been going on for quite a long time. As Behrman (3, p. 3) summed up, the various a priori hypotheses about the supply responsiveness of underdeveloped agriculture to price changes may be divided into 3 major categories : (1) the hypothesis that farmers in underdeveloped agriculture respond quickly, normally, and efficiently to relative price changes. (2) the hypothesis that the marketed production of subsistence farmers is inversely related to price. (3) the hypothesis that institutional constraints are so limiting that any price response is insignificant. His findings which are in support of the first hypothesis gave much credibility to market forces in a free enterprise system. A critical policy question arises whether these findings for the situation in the 1950's is still applicable for the situation in the 1960's, 1970's and the 80's.

It should be mentioned also that other factors beside relative prices have an impact on the supply and agricultural output. Yield is a major factor and has to be included as an explanatory variable, especially when technological change is an important consideration. There has also been speculation that supply is sensitive to variations in prices and yields as well as to the levels of these variables. Viewing crops as "assets" in the farmers "portfolio", we would expect the farmer to be risk averse in the sense that there will be a negative relationship between supply and the variance of prices and yields, other things being equal. If, in the aggregate, supply tends to respond favorably to reduction in risk, then marketing boards of government monopolies which serve to smooth out the sequences of prices paid to farmers may induce expansion in output which might not otherwise be forthcoming.

Purpose and Scope of the Study

The purpose of this study, therefore, is to attempt to estimate the significant and relevant supply response functions of Thai farmers on some major agricultural crops. Four crops have been selected for this study on the basis of their major contributions to export earnings of Thailand. They are (1) rice, (2) maize, (3) cassava, (4) kenaf. All crops listed are annual crops.

It is important to keep in mind that the term "supply response" may be used in numerous contexts and several distinctions should be noted. For example, the difference between marketed surplus and total production is important. If a large proportion of a crop is consumed by the farm families, supply is less likely to be responsive than if it is a cash crop. Also, a distinction as between aggregate output and the output of individual crops must be noted. Supply of individual crops may be quite responsive without total output changing whatsoever if relative prices and relative outputs change in an offsetting way. Suppose, for example, that the price of rice falls and the price of cassava rises, the relative supplies of the two crops could be altered so as to reflect a highly elastic supply response while leaving total agricultural output unaffected. Finally, it should be noted that both the short and long run must be considered in the analytical development of supply response models. Neglect of the long run may lead to serious errors in the evaluation of alternative policy prescriptions. Technical and social rigidities in the structure which cause long adjustment lags do not necessarily mean that supply is not responsive, but rather that a longer time horizon needs to be condisered in evaluating the impact of a particular policy.

This study is conducted in such a way that the comparison with the original Behrman's models and results is possible. The essential features of Behrman's models will be retained but several modifications have been incorporated into our models. Attempts have even been made to link the new data sets with Behrman's data so that estimation of the whole period from the late 1930's to the late 1970's could be carried out. But there exist apparent disparities in our new data sets with the old ones so that such link up was not successful. So our study continues from where Behrman has left off (1963) and continues to 1977. [1/]

Brief Survey of Past Studies

There have been many studies on supply responses of various crops in various countries around the world since the seminal work of Mar c Nerlove (7) in the U.S. in late 1950's, and particularly after the publication of Behrman's book (3) in 1968, and the results of these studies were compiled and presented in a book by Askari and Cummings (1). As for the post-Behrman study of supply response in Thailand, this seems rather limited and somewhat fragmented. For rice, there were studies by Somsak

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[1/] This is only true for rice and maize. For cassava and kenaf the farm-gate price series were not available before 1967, so on estimates for cassava and kenaf only covered the period 1967-1977.

(9) and Sarum (11) but they were more production studies than supply response studies of the Behrman or Nerlovian types. Tamnong Dasri's study on maize supply response seemed to be the only econometric supply response study attempted where the result is publicly available. Studies by Jamlong Atikul (2) on cassava and Sunthorn Rajvongsuek (10) on the competition between kenaf and cassava represent two authoritative studies for cassava and kenaf.

The studies mentioned have achieved varying degrees of success. Dasri used simple regression, first difference and distributed lag models to estimate both the output and area responses of maize farmers and found positive relationship between maize price and its supply but the maize supply response to price was not "solidly good". Jamlong and Sunthorn's studies on the supply response of cassava and kenaf were satisfactory in terms of statistical outcomes but the models used were quite simple and many modifications were made to model specifications and data requirements. All in all, however, all the studies appeared to support the hypothesis of supply responsiveness to changes in price in general. But, as these studies used different models and estimating techniques, and they were set in different time and location frames, which made interstudy comparison difficult, there is a need for more comprehensive supply response study encompassing many crops in one study package and using more sophisticated estimation techniques (at least on the same level as the techniques of Behrman). Our present study is an attempt to satisfy that need.

Plan of the Study

Section II is concerned with the discussion on the specification of supply response models, the method of estimation, and data requirements. In Section III, the estimates of the total supply response of four major annual crops, namely, rice, maize, cassava and kenaf will be presented and discussed in turn. Section IV concludes the study and discusses some policy implications. And Annex I and II analyse the supply responses of two non-annual crops, rubber and sugar cane. 1/

1/ These two annexes were written by one of the researchers (J. Malcolm Dowling) with the help of a research associate using data which were gathered as part of the overall project.

II. SUPPLY RESPONSE MODELS AND METHODOLOGY

General Specification of a Supply Response Model

The supply response model originally constructed by Nerlove for US agricultural products has served as the working model for most studies in this general area. The model consists of 3 structural or behavioral equations. Deterministically, that is without the consideration of stochastic disturbances, these three equations can be written as follows:

$$X^* = a_o + a_1 P_t^* \quad .....(1)$$

$$P_t^* - P^*_{t-1} = b_o + b_1 (P_{t-1} - P^*_{t-1}) \quad .....(2)$$

$$X_t - X_{t-1} = c_o + c_1 (X^*_t - X_{t-1}) \quad ......(3)$$

where X^* is desired planted area, P^* the expected normal farm price of the product under consideration, X and P actual planted area and farmers' price, respectively, and t is the time subscript. Equation (1) simply says that desired area planted depends on expected normal price for this period is seen as the last period's expected normal price plus or minus some degree of adjustment depending upon the elasticity of expectation and last period's actual price, or the difference between expected price for this period and last period is seen as a fraction of the difference between last period's actual and expected normal prices. And Equation (3) represents area adjustment process whereby the difference between the actual area planted for this and the last period is seen as a fraction of the difference between the desired area planted and the actual area planted in the last period.

Several modifications of this basic Nerlove model have been made in subsequent researches especially in the study by Behrman. The modified nerlovian model used by Behrman is stated as follows:

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

$$\text{(b)} \quad A_t = a_{21} + A_{t-1} + a_{22} (A_t^d - A_{t-1}) + u_{2t}$$

$$\text{(c)} \quad P_t^e = a_{31} + P_{t-1}^e + a_{32} (P_t + a_{33} D_{t-1} - P_{t-1}^e) + u_{3t}$$

$$\text{(d)} \quad Y_t^e = a_{41} + a_{42} (R_t - \bar{R}) + a_{43} t + a_{44} t^2 + u_{4t}$$

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

A_t = actual planted area

P_t^e = expected normal farmers' price relative to alternative crops

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

Y_t^e = expected yield

Y_t = actual yield

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

σY_t = standard deviation of actual yields over the last three preceding periods

N_t = farm population

M_t = annual malaria death rate

D_t = dummy variable for distance from Bangkok

R_t = annual rainfall

t = time trend; or the production period if appeared as a subscript

u = disturbance term

Two important parameters should be noted: the a_{22}, which is the area adjustment coefficient and a_{32} which is the price expectation or price adjustment coefficient. They appear in the distributed lag equations for the desired area planted and the expected normal relative price, thus:

$$\text{(e)} \quad A_t = \sum_{i=0}^{\infty} (1-a_{22})^i \, (a_{21} + a_{22} A^d_{t-1} + u_{2,\, t-i})$$

$$\text{(f)} \quad P^e_t = \sum_{i=0}^{\infty} (1-a_{32})^i \, (a_{31} + a_{32} (P_{t-1-i} + a_{33} D_{t-1-i}) + u_{3,t-1})$$

According to Behrman, a priori expectations are that the estimates of a_{22} and a_{32} or the area and price adjustment coefficients respectively may be characterized as an under adjustment, an exact adjustment, or an over adjustment, depending upon whether the adjustment parameter is, respectively, between zero and one, not significantly different from one, or between one and two.

General specification of the model used in our study was not much different from that used in Behrman. The relative rather than the absolute price of rice was adopted as the main explanatory variable. But unlike Behrman, we used the farm-gate prices and not Bangkok prices to compute price index series. In recent years, farm-gate prices have become available for rice and a wide variety of upland crops. While these data are not complete for all provinces, the gaps of missing prices are relatively narrow in most cases and were filled by reference to the prices in the adjacent provinces. We believed that these data represent an improvement over Bangkok prices because the latter may fail to register regional transportation differences and middleman monopolistic elements which may cause distortions and differences between the upcountry and Bangkok price structures.

Apart from relative price, additional independent variables such as expected yield (Y^*), rainfall (R), farm population (N) and risk factors expressed as the standard deviations of the prices and yields in the last 3 years (σp and σy) may also be important determinants of area planted. The structural equation for the supply response model would become

$$X_t^* = a_o + a_1 P_t^* + a_2 Y_t^* + a_3 R_t + a_4 N_t + a_5 \sigma_{Pt} + a_6 \sigma_Y t) \quad \ldots.(1a)$$

combining equation (1a) with equations (2) and (3) gives the reduced equation of the form:

$$\begin{aligned} X_t = \; & b_1 (c_o + c_1 a_o) + a_1 b_o c_1 + a_1 b_1 c_1 P_{t-1} + (\phi + \lambda) X_{t-1} \\ & - (\phi \lambda) X_{t-2} + a_2 (Y^* - \lambda Y^*_{t-1}) + a_3 (R_t - \lambda R_{t-1}) \\ & + a_4 (N_t - \lambda N_{t-1}) + a_5 (\sigma_{Pt} - \lambda \sigma P_{t-1}) \\ & + a_6 (\sigma_{Yt} - \lambda \sigma_{Y_{t-1}}) \quad \ldots\ldots\ldots\ldots..(4) \end{aligned}$$

where:

$$\lambda = 1 - b_1, \text{ and } \phi = 1 - c_1$$

There are sound theoretical reasons for the inclusion of these additional variables. Yield has been utilized in several studies to reflect the expected value of future production. Nerlove does not incorporate yield into his model for the U.S. because he observed no significant fluctuations in yield. This may not be true a priori for Thailand, especially since the green revolution in rice technology started by IRRI has spread through Asia over the last decade or so. Farm population (N) is included in the supply response function to capture the duality of rice as both a subsistence and a cash crop. Although 70 to 80 per cent of total rice production is consumed domestically, a significant proportion is still exported each year. Because farmers near the subsistence level first plant enough of the staple crop to satisfy their own consumption needs, supply response will be positively related to the size of farm population. Since the farm population has been growing throughout the sample period, it may also serve as a kind of catch-all trend variable. The level of rainfall is a potentially important factor in determining the ease with which fields can be ploughed and prepared for planting. Lack of sufficient rainfall can seriously reduce planted areas for some crops especially in areas of the Northeast which are mainly rainfed.

The inclusion of two variables representing risk factors indicates our acceptance of Behrman's reasoning on the risk aversion of Thai farmers. The associated parameters of these variables are expected to be negative because increased variances would generally make production of the crop less desirable. The Malaria death variable included in Behrman's model was deleted from our model owing to the fact that such death rate is at present rather small and no longer is a major factor inhibiting agricultural production. On the other hand, another independent variable which should be included in the model but was not, was the fertilizer use by farmers. Its influence on farm output is well documented but difficulty in knowing the size and distribution of fertilizer use by province forced us to abandon the attempt to include it in the model. We can only hope that its exclusion does not seriuosly distort the resulting regression results.

Method of Estimation

The standard approach to the problem of estimating the parameters of supply response models of the Nerlove type is to use nonlinear maximum likelihood techniques on the autoregressive form of the reduced equation, and this is the method used by Behrman. While this method will give consistent and efficient estimates of the population parameters as long as the error term is properly specified, inconsistent and inefficient estimates result from the use of this method if the residuals are misspecified. This is because of the simultaneous presence of lagged endogenous variables and autocorrelated disturbances. If the residuals can be properly modelled and incorporated into the estimation procedure, the maximum likelihood technique retains its desirable properties. However, proper specification of the generative process underlying the sample residuals in the reduced form may be difficult if all of the structural equations are stochastic. Consider, for example, the reduced form model given in Equation (4). If the three structural equations each have stochastic components, say, u_1, u_2 and u_3, respectively, then the reduced form disturbance in (4) will be

$$C_1(u_{1t} - \lambda u_{1t-1}) + a_1 c_1 u_2 t + u_{3t} - \lambda u_{3t-1} \quad \ldots.(5)$$

Even if one or more of the structural coefficient errors is zero, the usual autocorrelation tests will not be appropriate since u_1 and u_3 both are involved in a moving average process. Furthermore, even if the residual process is properly specified, nonlinearities create some estimating difficulties, especially in hypothesis testing and the interpretation of t and F tests. In any event, only asymptotic standard errors can be calculated and extreme care exercised in the interpretation of the usual ratios of coefficient to standard error.

To avoid the simultaneous presence of nonspherical residual and lagged endogenous variables, we could consider the distributed lag form of the model instead of the autoregressive form. Grouping current and lagged endogenous variables and introducing the lag operator L in equation (4) we have:

$$Y_t = \frac{B(L)}{A(L)} P_{t-1} + \frac{C(L)}{A(L)} Y_t^* + \frac{D(L)}{A(L)} R_t + \frac{E(L)}{A(L)} N_t$$

$$+ \frac{F(L)}{A(L)} O_{P_t} + \frac{G(L)}{A(L)} O_{Y_t} + \text{constant} \quad \ldots\ldots (5)$$

where $A(L) = (1-\lambda L)\ (1-\emptyset L)$ $\qquad \lambda = 1-c, \ o<C_1<1$

$B(L) = (a_1\ b_1\ c_1)$ $\qquad \emptyset = 1-b_1 \quad o<b_1<1$

$C(L) = a_2\ (1-\lambda L)$

$D(L) = a_3\ (1-\lambda L)$

$E(L) = a_4\ (1-\lambda L)$

$F(L) = a_5\ (1-\lambda F)$

$G(L) = a_6\ (1-\lambda G)$

If we define $P^1_{t-1} = \frac{1}{A(L)} P_{t-1}$; $Y^1_t = \frac{1}{A(L)} Y^*_t$;

$R^1_t = \frac{1}{A(L)} R_t$; $N'_t = \frac{1}{A(L)} N_t$; $\sigma'_{P_t} = \frac{1}{A(L)} \sigma_{P_t}$;

and $\sigma'_{Y_t} = \frac{1}{A(L)} \sigma_{Y_t}$, then we have the nonlinear regression

$$X_t = a_1 b_1 c_1 P'_{t-1} + a_2(1-\lambda L)\ Y'_t + a_3\ (1-\lambda L) R'_t + a_4(1-\lambda L) N'_t$$

$$+ a_5(1-\lambda L)\ \sigma'_{P_t} + a_6(1-\lambda L)\sigma'_{Y_t} \quad + \text{Constant} \quad \ldots.(6)$$

We can reduce this to a linear function by making a second definition.

Let $P''_{t-1} = b_1 c_1 P'_{t-1}$; $Y''_t = (1-\lambda L)\ y'_t i$

$R^*_t = (1-\lambda L)\ R'_t$; $N^*_t = (1-\lambda L) N'_t i$; $\sigma''_p t = (1-\lambda L)\ \sigma'_{Y_t} i$

and $\sigma''_t = (1-\lambda L)\ \sigma'_{Y_t}$, then we have

$$X_t = a_1P^{*}_{t-1} + a_2Y^{*}_t + a_3R^{*}_t + a_4N^{*}_t + a_5\sigma^{''}_{P_t} + a_6\sigma^{''}_{Y_t}$$
$$+ \text{constant} \qquad \ldots\ldots\ldots\ldots(7)$$

Iteration on b_1 and c_1 yields the maximum likelihood estimate when the residucal sum of squares in (7) is minimized. In generating P", Y", R", N", σ_{py}", σ_{yt}", there are certain incidental unknown parameters corresponding to values before the beginning of the sample. Various suggestions exist as to how they are to be treated. Although they cannot be estimated consistently and several authors suggesting that they be assumed to be zero, there is some evidence that they should be estimated. This creates additional complexity and uses up degrees of freedom. Therefore, we will assume that these incidental parameters are all zero. Notice also that Equation (7) does not contain any lagged endogenous variables. Although our estimates will not be fully efficient, we do not run the risk of inconsistency if the residuals are misspecified. Nonlinear estimation computer programs were designed by one of the researchers of this study after we had tried linear estimation programs and were not satisfied with them and was used in conjunction with the Time Series Processor (TSP) computer program.

III. ESTIMATES OF THE TOTAL SUPPLY RESPONSES FOR FOUR MAJOR CROPS

Estimates of the total supply responses for rice, maize, cassava and kenaf are presented and discussed in this section. For each crop, beginning with rice, major aspects of the specification of its supply response function will be briefly mentioned first, then the estimates will be discussed, and, when possible, comparison made with the findings of Behrman.

Rice

Relevant explanatory variables included in the rice model are (1) the constant price of rice (PCRD) which is obtained from weighing the price of rice by the Bangkok price index; (2) rice yield (YDRA) expressed in logarithmic terms of weighted average of the yields in the last 3 periods; (3) standard deviation of constant price of rice (SDPCR); (4) standard deviation of yield (SDYD); (5) amount of rainfall (RAN); and (6) total farm population (TPP) which is regarded as the production trend.

The number of provinces is reported somewhat smaller than the set of all rice producing provinces in the Kingdom or the number of provinces reported by Behrman. In selecting provinces to be sampled, we relied on a production and export criteria, using 1968 as a benchmark year. We included provinces producing more than 300kg/capita in that year for inclusion in the study and 32 provinces were selected. Our rationale for using this cut off system was that provinces which produce a substantial rice surplus were more likely to respond to market mechanisms and thus have significant supply response coefficients. From previous experimental runs using linear regression techniques, we had found that the risk variables (SDPCR and SDYD) were insignificant as explanatory variables. So, in the nonlinear estimation model these two variables were deleted from the equations of the majority of rice producing provinces. The majority of equations were run using the nonlinear estimation techniques, and the best estimates in terms of statistical fit, direction and significance of coefficients of explanatory variables were selected and presented in Table 1. And for comparison purpose the corresponding estimates of Behrman for Thai rice are reproduced and presented in Table 2.

Table 1 : Nonlinear estimates of the total supply response model for rice in surplus rice producing provinces 1963-1977.

Province No.	Region and Provinces	Dep. Var.	Constants	Estimates of structural coefficients of						Price Adjustment Coefficient B_1	Area Adjustment Coefficient B_2	$\overline{R}^2$
				PCRD	YDRA	SDPCR	SDYD	RAN	TPP			
NORTHEAST												
19	CHAIYAPUM	APRS (2)	-1019.90 (-.6863)	.0002676 [b] (1.5601)	-863.173 [b] (-1.9976)	-	-	.5761 [a] (.8736)	2.2246 [a] (1.3251)	1.1313 [b] (1.8194)	1.2462 [c] (2.3647)	.7706
20	NAKORNRATCHSRIMA	APRS (2)	-7098.63 [b] (-1.5633)	.0003163 [a] (.9437)	-4249.99 [e] (-3.9034)	-	-	3.2517 [c] (1.6467)	5.5942 [c] (2.3345)	1.7842 [illegible] (3.3433)	.7389 [d] (3.3968)	.8865
22	SURIN	APRS (3)	-3992.66 [a] (-1.3964)	.0007149 [a] (1.0360)	-	-	332.406 [a] (.9166)	2.8442 [b] (1.7395)	5.9981 [b] (1.5717)	1.2744 [c] (2.3414)	.7026 [b] (2.0444)	.7138
23	SRISAKET	APRS (3)	60.3060 (.07415)	.02518 (1.0690)	-1760.79 [a] (-1.3951)	- -	- -	.2920 [a] (.7520)	1.5862 [b] (1.7951)	.9338 [b] (1.8365)	1.2453 [e] (3.7947)	.7189
25	NONGKHAI	APRS (3)	181.200 [a] (1.0733)	.0006061 (.07876)	-269.337 [a] (-1.0619)	-	-	.06812 [a] (.7665)	1.4385 [e] (4.0447)	.7070 (.7203)	1.4479 [d] (3.5318)	.9271
27	UDONTHANI	APRS (2)	-1006.72 [c] (-1.8887)	.005506 (.3036)	.002784 [g] (5.2206)	-	-	.5190 [d] (2.3374)	-	-	1.2855 [g] (5.4408)	.7293
33	ROI-ET	APRS (3)	-13497.3 [f] (-6.8466)	.007908 [a] (.7621)	23.4204 [g] (8.0195)	-	-	.6672 [c] (2.2670)	-874.939 [b] (-1.8920)	1.0853 [b] (2.0857)	1.2795 [f] (5.1663)	.9342
21	BURIRAM	APRS (1)	-7559.09 [d] (-2.8935)	-.00166 [f] (-3.2180)	-	-	-	3.9209 [d] (2.6597)	9.2062 [g] (4.9744)	1.4300 [f] (3.4679)	1.0448 (2.7047)	.8252
24	UBONRATTHANI	APRS (2)	-1006.72 [c] (-1.8887)	.00551 (.3036)	.00278 [g] (5.2206)	-	-	0.5190 [d] (2.3374)	-	-	1.2855 [g] (5.4408)	.7293

Table 1 : (cont.)

Province No.	Region and Provinces	Dep. Var.	Constants	Estimates of structural coefficients of PCRD	YDRA	SDPCR	SDYD	RAN	TPP	Price Adjustment Coefficient B_1	Area Adjustment Coefficient B_2	$\bar{R}^2$
28	SAKONNAKHORN	APRS (3)	30,5891 (0,1996)	-0,0461 (g) (-6.5212)	582,893 (f) (3,8279)	-	-	0.1029 (e) (2.9463)	3,1202 (g) (11,7029)	0,6753 (g) (5.2958)	0,9941 (g) (7,6037)	.9894
31	MAHASARAKHAM	APRS (1)	-478,573 (-.0003)	0,1478 (0.0025)	-	-	-	2,1256 (0,00185)	0.0508 (0.0029)	-	0.00124 (0.00359)	.1377
32	KALASIN	APRS (1)	-518,783 (a) (-0,8713)	-0,0184 (b) (-1,4059)	2,7820 (e) (2,7205)	-	-	0,5682 (d) (2,2770)	-	0,9751 (f) (3,1378)	-	.6383
CENTRAL PLAIN	BANGKOK											
1	CHAINAT	APRS (3)	1026,15 (g) (7,7459)	,0007350 (a) (1,0799)	-1,4798 (b) (-2,0311)	-	-	.03006 (a) (,8514)	-25,2043 (a) (1,0179)	1,2217 (b) (1.5172)	1.4922 (c) (2.6394)	.6432
2	SINGBURI	APRS (1)	347,419 (g) (18.5088)	.0008096 (d) (2,5171)	.3317 (d) (1,7810)	-	-	-,008657 (a) (-,7158)	-	1,1881 (g) (5.0352)	-	.4574
4	SARABURI	APRS (6)	6176,70 (c) (2,5136)	,0001375 (e) (4,1535)	-,006173 (b) (-1,9791)	113,781 (a) (,8126)	-606,664 (a) (-1,3271)	.2687 (c) (2,7691)	-471,625 (c) (-2,1892)	-	1,4599 (f) (6.6145)	.8890
5	ANGTHONG	APRS (5)	462,064 (g) (210,574)	.0004276 (g) (12,9913)	-,2359 (g) (-16,3781)	-	1,4144 (d) (3,4944)	.003303 (d) (3.0089)	-	1,6217 (g) (13,5093)	.9766 (g) (15.1222)	.9926
6	AYUTHAYA	APRS (5)	1015,07 (g) (5,0201)	,00004089 (f) (3,5054)	-	-	-	-,04532 (a) (-1,3914)	2,9608 (g) (12,7686)	1,4333 (g) (6.1250	-	.932
8	PATHOMTHANI	APRS (3)	-1752,52 (-,7296)	,005128 (,2266)	352,769 (,5257)	-	-	.1428 (.4047)	21,5175 (a) (1.1951)	1,2003 (b) (1,7306)	.2791 (,5344)	.96
11	NAKHORNAYOK	APRS (5)	552,672 (b) (1,5788)	-0,00002 (a) (-0,8418)	-	-	-	-0,00932 (-0,6604)	-1,0293 (a) (-0,8527)	0.6358 (c) (1,8386)	-	0,57

Table 1: (cont.)

Province No.	Region and Provinces	Dep. Var.	Constants	Estimates of structural coefficients of: PCRD	YDRA	SDPCR	SØYD	RAN	TPP	Price Adjustment Coefficient B_1	Area Adjustment Coefficient B_2	$\bar{R}^2$
48	NAKHORNSAWAN	APRS (3)	112854,0[g] (8,6095)	-0,00761[f] (-0,3635)	-219,135[g] (-8,4952)	-	-	-0,1257[f] (-0,3676)	699,157[a] (1,3481)	1,6130[f] (4,2161)	0,7222[a] (1,1343	,9483
57	PRACHUAP-KHJRIKHAN	APRS (1)	51,9294[a] (1,2154)	0,00163 (0,6006)	-0,1080 (-0,3224)	-	-	0,01558 (0,3843)	-	0,7247 (2,0003)	-	,1747
MARGINAL PLAINS												
12	PRACHINBURI	APRS (4)	-1907,10[f] (-5,7140)	,01867[d] (3,0548)	-	-	-99,7469[d] (-3,0946)	,5089[e] (5,5890)	9,3237[g] (8,4729)	1,2351[g] (7,6117)	,7601[f] (6,5562)	[illegible]
14	CHACHOENGSAO	APRS (3)	1086,88[g] (9,3884)	,006946[b] (2,0595)	,1758 (,3296)	-	-	-,07969[a] (-1,4330)	-474,142[c] (-2,2797)	1,5493[e] (3,8391)	,6536[b] (1,9896)	[illegible]
UPPER PLAINS												
41	UTTARADIT	APRS (3)	-2742,02[f] (-5,5299)	,009273[e] (4,0839)	13,0771[f] (5,8576)	-	-	,04597[b] (1,7059)	-184,040[d] (-3,1179)	1,8854[c] (2,5674)	1,2423[d] (3,1935)	[illegible]
43	SUKHOTHAI	APRS (3)	-541,609[c] (-2,6590)	,02186[d] (3,4169)	2,6812[e] (4,2404	-	-	,4300[d] (3,0552)	-567,772[c] (-2,5394)	1,5997[f] (4,7723)	1,2215[f] (4,8965)	[illegible]
44	PHITSANULOK	APRS (1)	-592,679[g] (-6,9874)	,006514[d] (2,4448)	3,6285[g] (17,4491)	-	-	,1564[c] (2,1939)	-	1,7446[g] (7,0526)	-	[illegible]
45	KUMPHAENGPHETCH	APRS (1)	-220,847[a] (-1,3136)	,03506[c] (2,2518)	1,2636[f] (3,5029)	-	-	,8154[f] (4,0977)	-	1,4631[g] (5,8254)	-	[illegible]
47	PHETCHABOON	APRS (2)	-235,598[a] (-1,3895)	,01496[a] (1,1167)	-	-	-	,1926[a] (,9520)	,001458[f] (4,3227)	-	,8456[d] (2,7624)	[illegible]
49	UTHAITHANI	APRS (4)	-966,604[b] (-1,6653)	,02406[c] (2,3252)	8,8776[c] (2,0482)	-	-	,1455[a] (,8535)	-	,8897[a] (1,2986)	,7182[a] (1,1561)	[illegible]
NORTH												
34	MAEHONGSORN	APRS (4)	-137,981[e] (-3,9520)	,001334[d] (2,5177)	2,8844[g] (7,0770	-	-	-,02950[c] (-2,1339)	-	1,6051[f] (4,1949)	,8740[b] (1,8587)	[illegible]
35	CHIENG MAI	APRS (3)	-502,514[g] (-28,7070)	,007394[g] (50,0707)	1,8785[g] (65,4608)	-	-	-,04730[g] (-15,8783)	82,7901[g] (16,8652)	(2,1341[g] (26,6273)	1,5603[g] (26,5561)	,398
36	CHIENG RAI	APRS (3)	-49,1938 (-,6628)	,001202 (,4091)	1,6767[g] (22,3138)	-	-	-,01517 (-,3892)	-423,551[c] (-2,6301)	2,7059[f] (5,5311)	-1,7377[d] (-3,0579	[illegible]

T - test show the above estimates significantly non-zero at the following levels of significance.

(a) 25,0 %

(b) 10,0 %

(c) 5,0 %

(d) 2,5 %

(e) 1,0 %

(f) 0,5 %

(g) 0,1 %

Rice

PCRD = (PCR/BKP) × 1000 = Constant price of rice (per thousand ton)

PCR = Price of rice

BKP = Bangkok price

YDRA = $\left[\log(YDR_{t-1}) + \log(YDR_{t-2}) + \log(YDR_{t-3})\right] / 3$
Weighted average of YDR in the past 3 periods (in log value)

YDR = (PRR/APR) × 1000 = Yield (per thousand rais)

PRR = Production of rice

APR = area planted in rice

SDPCR = $\left\{ \left\{ \left[\log(PCRD_{t-1}) - PCRDA\right]^2 + .5\left[\log(PCRD_{t-2}) - PCRDA\right]^2 + \left[\log(PCRD_{t-3}) - PCRDA\right]^2 \right\} / 3 \right\}$
Standard deviation of constant price of rice (in log value)

PCRDA = $\left[\log(PCRD_{t-1}) + \log(PCRD_{t-2}) + \log(PCRD_{t-3})\right] / 3$
weighted average of constant price of rice (in log value)

SDYD = $\left[\left\{ \left[\log(YDR_{t-1}) - YDRA\right]^2 + .5\left[\log(YDR_{t-2}) - YDRA\right]^2 + \left[\log(YDR_{t-3}) - YDRA\right]^2 \right\} / 3 \right]$
Standard deviation of yield (in log value)

RAN = Rainfall (in thousand millemeter)

TPP = Production trend

B_1 = Price adjustment coefficient

B_2 = Area adjustment coefficient

APRS = APR/1000 = planted area in rice (in thousand rai)

(a) t-tests significant at 75%
(b) t-tests significant at 90%
(c) t-tests significant at 95%
(d) t-tests significant at 97.5%
(e) t-tests significant at 99%
(f) t-tests significant at 99.5%
(g) t-tests significant at 99.9%
(h) F-tests significant at 75%
(i) F-tests significant at 90%
(j) F-tests significant at 95%
(k) F-tests significant at 99%
(l) F-tests significant at 99.5%

Note to Table 1

APRS = APR/1000 = planted area in rice (in thousand rai)

PCRD = (PCR/BKP) x 1000 = Constant price of rice (per thousand ton)

PCR = Price of rice

BKP = Bangkok price

YDRA = $\left[\log(YDR_{t-1}) + \log(YDR_{t-2}) + \log(YDR_{t-3})\right]/3$

Weighted average of YDR in the past 3 periods (in log value)

YDR = (PRR/APR) x 1000 = Yield (per thousand rais)

PRR = Production of rice

APR = area planted in rice

SDPCR = $\left[\left\{\left[\log(PCRD_{t-1}) - PCRDA\right]^2 + \left[\log(PCRD_{t-2}) - PCRDA\right]^2 + \left[\log(PCRD_{t-3}) - PCRDA\right]^2\right\}/3\right]^{.5}$

standard deviation of constant price of rice (in log value)

PCRDA = $\log(PCRD_{t-1}) + \log(PCRD_{t-2}) + \log(PCRD_{t-3}) \quad 3$

weighted average of constant price of rice (in log value)

SDYD = $\left[\left\{\left[\log(YDR_{t-1}) - YDRA\right]^2 + \left[\log(YDR_{t-2}) - YDRA\right]^2 + \left[\log(YDR_{t-3}) - YDRA\right]^2\right\}/3\right]^{.5}$

Standard deviation of yield (in log value)

RAN = Rainfall (in thousand millemeter)

TPP = Production trend

B_1 = Price adjustment coefficient

B_2 = Area adjustment coefficient

T-test shows the above estimates significantly non-zero at the following levels of significance:

(a) 25.0 %

(b) 10.0%

(c) 5.0%

(d) 2.5%

(e) 1.0%

(f) 0.5%

(g) 0.1%

Table 2 Nonlinear estimates of the total supply response model for rice in provinces in Northeastern and Central Regions, 1980-1963.[a]

Region and provinces	Reduced equation constant (b_1)	Estimates of structural coefficients of P_t^e	D_t	Y_t^e	σ_{P_t}	σ_{Y_t}	N_t	Area adjustment coefficient (a22)	Price adjustment coefficient (a32)	Years for complete adjustment[x]	$\bar{R}^2$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Northeast											
19 Chayaphum	-3.81 (1.40)[d]	0.260 (0.08)[c]			-0.018 (0.01)[g]	-0.180 (0.06)[d]	2.15 (0.18)[b]	0.990 (0.20)[b]	1.46 (0.19)[b]	4	0.81
20 Nakornratsima	-5.85 (2.14)[d]	1.04 (0.28)[c]					1.16 (0.22)[b]	1.59 (0.15)[b]	0.608 (0.14)[b]	1	0.56[m]
21 Buriram	-6.74 (1.18)[b]	0.151 (0.07)[e]					2.00 (0.09)[b]	1.35 (0.18)[b]	1.35 (0.18)[b]	4	0.80
22 Surin	-6.67 (2.30)[c]	0.453 (0.18)[e]		0.531[u] (0.19)[d]		-0.278 (0.18)[g]	1.33 (0.49)[d]	0.836 (0.22)[c]	1.39 (0.23)[b]	4	0.60[m]
23 Srisaket	-4.01 (2.91)[g]	0.427 (0.30)[g]		0.267[u] (0.27)[h]		-0.222 (0.18)[h]	2.11 (0.52)[b]	1.04 (0.27)[c]	0.60 (0.26)[e]	4	0.63[m]
24 Ubonratthani	-0.766 (0.40)[f]	0.147 (0.04)[b]					0.291 (0.05)[b]	0.474 (0.13)[c]	1.32 (0.19)[b]	5	0.82
	-0.588 (0.60)[h]	0.130 (0.04)[e]				-0.141 (0.06)[f]	0.274 (0.09)[e]	0.748 (0.21)[c]	1	3	0.81
25 Nong-kai	-1.07 (0.25)[b]	0.166 (0.05)[c]		0.562[v] (0.33)[g]	-0.0072 (0.01)[h]		1.81 (0.17)[b]	0.464 (0.12)[c]	1.04 (0.19)[b]	5	0.96
26 Loei	0.710 (0.30)[e]		-0.232 (0.09)[e]	0.472[v] (0.16)[d]				1.30 (0.20)[b]	1[y]	3	0.36[m]

Table 2 (continued)

Region and Provinces	Reduced equation constant (b_1)	Estimates of structural coefficient of P_t^e	D_t	Y_t^e	σP_t	σY_t	N_t	Area adjustment coefficient (a_{22})	Price adjustment coefficient (a32)	Years for complete adjustment[x]	$\bar{R}^2$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
27 Udornthani	-0.224 (0.65)	0.964 (0.43)[e]				-0.0717 (0.06)[h]	1.14 (0.39)[c]	1.58 (0.15)[b]	0.179 (0.08)[e]	16	0.94
28 Sakonnakhorn	-0.40 (0.81)	0.392 (0.39)[h]			-0.010 (0.01)[h]		2.53 (1.07)[e]	0.656 (0.25)[d]	0.237 (0.19)[h]	12	0.96
29 Nakhornphanum	-0.064 (0.33)	0.153 (0.12)[h]			-0.0040 (0.004)[h]		1.12 (0.28)[b]	1	0.281 (0.11)[e]	10	0.89
30 Khon-kaen	-12.90 (2.15)[b]	0.495 (0.12)[b]					2.34 (0.16)[b]	1.15 (0.31)[c]	1.15 (0.31)[c]	2	0.77
31 Mahasarakham[w]	-24.32 (5.94)[c]	0.451 (0.19)[e]					4.04 (0.48)[b]	1.38 (0.22)[b]	1.37 (0.22)[b]	4	0.64
32 Kalasin[w]	-30.5 (13.3)[f]	0.334 (0.06)[b]	-5.25 (1.01)[b]				20.3 (3.53)[b]	0.872[t] (0.10)[b]	0.899[t] (0.11)[b]	2	0.53[q]
33 Roiet	0.040 (0.29)	0.015 (0.02)[h]					0.194 (0.04)[b]	1.14 (0.21)[b]	1.14 (0.21)[b]	2	0.29[q]
Central Bangkok plain											
1 Chai-Nat	-0.267 (0.22)[h]	0.270 (0.05)[b]		1.79[u] (0.12)[b]				1.03 (0.40)[d]	0.743 (0.33)[e]	3	0.94
2. Singhburi	0.488 (0.24)[f]	0.531 (0.50)[h]		0.287[v] (0.21)[g]				0.207 (0.10)[f]	0.915 (0.17)[b]	13	0.76

Table 2 (continued)

Region and Provinces	Reduced equation constant (b_1)	Estimates of structural coefficients of						Area adjustment coefficient (a22)	Price adjustment coefficient (a32)	Year for complete adjustment	R^2
		P_t^e	D_t	Y_t^e	σ_{P_t}	σ_{Y_t}	K_t				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
3 Lopburi	3.18 (0.46)^{b}	0.513 (0.042)^{b}					0.0882 (0.11)^{h}	1.05 (0.92)^{h}	1.05 (0.92)^{h}	2	0.75
	3.13 (0.49)^{b}	0.510 (0.04)^{b}		0.112^{u} (0.11)^{h}				1.05 (0.67)^{g}	1.05 (0.67)^{g}	2	0.75
4 Sara-buri	5.95 (0.35)^{b}	0.0824 (0.061)^{g}						1	1	1	0.08^{q}
5 .Ang-thong	1.46 (0.34)^{b}	0.0745 (0.03)^{e}		0.344^{v} (0.10)^{b}				0.726 (0.16)^{b}	0.673 (0.17)^{b}	4	0.60^{j}
6 Ayuthya	1.41 (0.20)^{b}	0.187 (0.003)^{b}		0.0271^{v} (0.16)^{d}				1.12 (0.24)^{b}	1.03 (0.25)^{b}	2	0.48^{m}
7 Nonthaburi^{w}	2.14 (0.40)^{b}	0.117 (0.03)			-0.0021 (0.002)^{h}			1.15 (0.31)^{c}	0.847 (0.30)^{d}	1	0.36^{q}
8 Pathum-thani	1.71 (0.90)	0.364 (0.10)^{c}	-4.33 (1.10)^{c}	3.47^{u} (1.03)^{c}	-0.017 (0.01)^{d}	-0.123 (0.04)^{c}		0.860 (0.14)^{b}	0.550 (0.15)^{c}	4	0.72^{j}
9 Thonburi	-0.192 (0.51)	1.13 (0.58)^{f}	-1.85 (0.90)^{f}					0.447 (0.21)^{e}	0.447 (0.21)^{e}	7	0.75
10 Phra-nakhorn (Bangkok)	1.33 (1.97)	0.958 (1.0)^{h}	-0.219 (0.15)^{g}			-0.0972 (0.093)^{h}		0.667 (0.35)^{f}	0.437 (0.47)^{h}	6	0.67^{j}
11 Nakhornayok^{w}	2.31 (0.49)^{b}	0.185 (0.05)^{c}			-0.11 (0.004)^{e}	-0.099 (0.34)^{d}	1.97 (0.39)^{b}	1.01 (0.16)^{b}	0.745 (0.17)^{c}	3	0.78^{n}

Table 2 (continued)

Region and Provinces	Reduced equation constant (b_1)	Estimates of structural coefficient of						Area adjustment coefficient (a22)	Price adjustment coefficient (a32)	Years for complete adjustment[x]	$\bar{R}^2$
		P^e_t	D_t	Y^e_t	σ_{P_t}	σ_{Y_t}	N_t				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
13 Samutprakan[w]	1.17 (0.73)[g]	0.107 (0.05)[f]			-0.0035 (0.002)[e]	-0.0115 (0.02)[h]	0.573 (0.07)[b]	1	0.774 (0.25)[d]	3	0.90
48 Nakhornsawan	-0.487 (0.12)[b]	0.0682 (0.014)[b]		0.282[v] (0.066)			0.164 (0.16)[b]	0.785 (0.14)[b]	1.13 (0.18)[b]	3	0.89
51 Suphanburi	0.467 (0.12)[b]	0.0163 (0.017)[h]					0.0590 (0.036)[g]	0.348 (0.10)[c]	1.38 (0.14)[b]	7	0.65[j]
53 Nakhornpathom	5.82 (0.87)[b]	0.330 (0.05)[b]			-0.0223 (0.007)[c]			0.727 (0.15)[b]	1.22 (0.18)[b]	3	0.58[j]
54 Samutsongkhram	1.23 (0.49)[d]	0.257 (0.10)[d]	-3.16 (1.1)[d]					0.607[t] (0.32)[f]	0.958[t] (0.37)[d]	4	0.63
55 Samutsakhorn[w]	17.5 (4.1)[b]	0.0657 (0.02)[d]	-0.227 (0.05)[b]			-0.0227 (0.01)[e]		0.811 (0.17)[b]	1	2	0.78
Southeast coast											
15 Cholburi	-2.73 (1.02)[d]	0.069 (0.04)[f]		3.38[u] (0.51)[b]		-0.088 (0.04)[d]		0.670 (0.12)[b]	0.971 (0.16)[b]	3	0.85
	-4.58 (0.98)[b]	0.0718 (0.03)[e]		3.49 (0.40)[b]			0.143 (0.063)[e]	0.937 (0.17)[b]	0.935 (0.175)[b]	2	0.83
16 Rayong	0.390 (0.14)[d]	0.0332 (0.027)[h]				-0.0287 (0.026)[h]		0.0238 (0.086)[d]	1.56 (0.15)[h]	11	0.60[j]
17 Chan-buri	0.381 (0.09)[b]	0.0401 (0.008)[b]			-0.0021 (0.001)[f]		0.586 (0.07)[b]	1	1	1	0.70

Table 2 (continued)

Region and Provinces	Reduced equation constant (b_1)	Estimate of structural coefficient of P_t^e	D_t	Y_t^e	σP_t	σY_t	N_t	Area adjustment coefficient (a22)	Price adjustment coefficient (a32)	Years for complete adjustment[x]	$\bar{R}^2$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
17 Chant-buri	0.522[b] (0.14)	0.0332[b] (0.009)				-0.0159[h] (0.017)	0.506[b] (0.08)	1	1	1	0.68
18 Trat	2.15[b] (0.51)	0.352[b] (0.07)			-0.0081[h] (0.011)			0.406[b] (0.10)	1.190[b] (0.17)	6	0.71
Marginal plains											
12 Prachinburi	0.415 (1.26)	0.304[h] (0.44)		2.14[v] (1.06)[f]			0.963[h] (1.03)	1.09[b] (0.17)	0.379[e] (0.16)	7	0.43[q]
14 Cha-choengsao	3.57[b] (0.55)	0.253[b] (0.03)			-0.0058 (0.004)[g]	-0.120[b] (0.03)	2.03[b] (0.11)	0.931[b] (0.13)	1.18[b] (0.16)	2	0.91
Upper plain											
41 Uttaradit	0.11 (0.43)	0.180[b] (0.04)				-0.0076 (0.005)[g]	0.663[b] (0.10)	1.48[b] (0.15)	0.371[b] (0.08)	7	0.87
43 Sukhothai	-0.081 (0.30)	0.127 (0.39)[illegible]					1.08[b] (0.11)	1.01[d] (0.39)	1.02[d] (0.39)	1	0.73
44 Phitsnulok	-0.884[c] (0.29)	0.488[b] (0.11)			-0.0454[c] (0.015)		1.78[b] (0.18)	0.381[b] (0.09)	1.31[b] (0.16)	7	0.92
45 Kamphaengphet	0.126 (0.08)[g]	0.0220 (0.013)[g]			-0.0020[h] (0.002)		1.19[b] (0.05)	1	1	1	0.92
46 Phichit	-0.021 (0.53)	0.552[b] (0.08)				-0.0404[h] (0.05)	2.08[b] (0.13)	0.888[c] (0.26)	0.943[c] (0.28)	2	0.93
	-4.23[b] (0.73)	0.555[b] (0.07)			5.05[u] (0.34)[b]			0.896[b] (0.23)	0.895[b] (0.23)	2	0.92

Table 2 (continued)

Region and Provinces	Reduced equation constant (b_1)	Estimates of structural coefficients of P^e_t	D_t	Y^e_t	σ_{P_t}	σ_{Y_t}	N_t	Area adjustment coefficient (a22)	Price adjustment coefficient (a32)	Years for complete adjustment[x]	$\bar{R}^2$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
47 Phetchbun	-1.23 $(0.18)^b$			0.677^u $(0.09)^b$			0.353 $(0.12)^c$	1.05 $(0.14)^b$	1^y	1	0.95
49 Uthai-thani	-1.01 $(0.26)^b$	0.132 $(0.03)^b$		0.195^v $(0.12)^g$	-0.0063 $(0.006)^h$		3.30 $(0.24)^b$	0.412 $(0.05)^b$	1.51 $(0.15)^b$	5	0.89
Western highlands											
42 Tak	-16.17 $(3.40)^b$	0.733 $(0.16)^b$		5.17^u $(1.03)^b$	-0.021 $(0.02)^h$	-0.231 $(0.09)^d$	6.12 $(0.77)^b$	0.826 $(0.21)^c$	1.31 $(0.25)^b$	3	0.72
50 Kanchanburi	-0.30 $(0.37)^h$	0.0368 $(0.04)^h$					0.921 $(0.17)^b$	1.24 $(0.50)^e$	0.880 $(0.523)^g$	3	0.40^n
52 Ratburi	3.05 $(0.55)^b$	0.0745 (0.062)					0.558 $(0.17)^c$	1	1	1	0.38^k
Peninsula											
56 Phetburi	-1.27 $(0.39)^c$	0.169 $(0.03)^b$			-0.0048 $(0.004)^g$		1.58 $(0.16)^b$	1.14 $(0.18)^b$	0.975 $(0.17)^b$	2	0.75
57 Prachuapkhirikhan	1.47 $(1.47)^h$	0.177 $(0.15)^h$		1.33^v $(0.87)^g$		-0.227 $(0.13)^f$		1	1	1	0.36^n
KINGDOM	0.266 $(0.17)^g$	0.121 $(0.02)^b$				-0.0437 $(0.03)^g$	1.17 $(0.07)^b$	1.05 $(0.12)^b$	0.922 $(0.06)^b$	1	0.92
	-0.703 $(0.39)^f$	0.274 $(0.051)^b$		1.95^u $(0.40)^b$		-0.0323 $(0.024)^g$		1.60 $(0.13)^b$	0.247 $(0.04)^b$	11	0.89

Source: Reproduced from Behcman (3), Table VIII-1

Total and marketed supply responses for Thai rice

Notes to table VIII-1:

a. The Nerlovian supply model and the nonlinear estimation procedure which was utilized are both discussed in chapter 5. The data is discussed in chapter 7 and is presented in Appendix A. Asymptotic standard errors are presented in parentheses under each point estimate. F-tests indicate that each coefficient of determination is asymptotically significantly nonzero at the 0.1% level, unless otherwise noted.

b. t-tests indicate that this estimate is asymptotically significantly nonzero at the 0.05% level.

c. t-tests indicate that this estimate is asymptotically significantly nonzero at the 0.5% level.

d. t-tests indicate that this estimate is asymptotically significantly nonzero at the 1.0% level.

e. t-tests indicate that this estimate is asymptotically significantly nonzero at the 2.5% level.

f. t-tests indicate that this estimate is asymptotically significantly nonzero at the 5.0% level.

g. t-tests indicate that this estimate is asymptotically significantly nonzero at the 10.0% level.

h. t-tests indicate that this estimate is asymptotically significantly nonzero at the 25% level.

j. F-tests indicate that this coefficient of determination is asymptotically significantly nonzero at the 0.5% level.

k. F-tests indicate that this coefficient of determination is asymptotically significantly nonzero at the 1.0% level.

m. F-tests indicate that this coefficient of determination is asymptotically significantly nonzero at the 2.5% level.

n. F-tests indicate that this coefficient of determination is asymptotically significantly nonzero at the 5.0% level.

p. F-tests indicate that this coefficient of determination is asymptotically significantly nonzero at the 10.0% level.

q. F-tests indicate that this coefficient of determination is asymptotically significantly nonzero at the 20.0% level.

t. For this regression, a two-point identification problem exists for the adjustment parameter estimates.

u. The first formulation of expected yields was used. See section 7.2.

v. The second formulation of expected yields was used. See section 7.2.

w. Because of incomplete data the regressions for the seven following provinces are based on fewer than 24 observations: Mahasarakham and Kalasin (1949-1963); Prachuap-khirikhan (1940-1958, 1962-1963); Nonthaburi, Nakhornnayok, Samutprakan, and Samutsakhorn (1940-1941, 1948-1963).

x. Number of years which are implied for adjustment to be within 5% of complete.

y. Because the estimate of the coefficient of relative prices was not significantly nonzero for this regression, the price adjustment coefficient was restricted to a value of one.

The coefficients of determination for the 34 regression which are included in Table 1 are given in the last column of that table. The majority of the equation (21 out of 32 equations) has $\bar{R}^2$ higher than 0.8 and only 6 equations have coefficients of determination lower than 0.7. The lowest $\bar{R}^2$ is for Mahasarakham.

The provinces of the upper northeast, Nong-kai, Udornthani and Sakonnakhorn, are primarily rice producers. Udornthani is the exception. There, kenaf, sugarcane, cassava and maize are also grown in large amounts. Rice area planted has been expanding rapidly in all three provinces since the mid-1960s. This expansion has been primarily into virgin land which is available here in much larger proportions than in the remainder of the northeast. Population growth has also been rapid in this region, suggesting substantial immigration from other provinces has occurred. Much of this immigration has probably been from other north-eastern provinces where population pressures have squeezed the available supply of arable land. Rainfall and population are the most important explanatory variables and price is never a statistically significant determinant of planted area. Rice yield is significant at a low level in Nongkai but is highly significant with the correct _a priori_ sign in Udornthani. R^2 values are generally high and the regressions fit rather well. These results suggest that population pressure and weather to some extent are the most important explanatory variables in this region. Because of the lack of substitute crops in general and because of the pressing need to expand rice area to meet expanding population, price doew not play an important role. This occurs despite the fact that all three provinces were rice surplus by the criteria selected.

The provinces of the mid-northeast, Chayaphum, Nakhorn-ratsima, Khon Khaen, Kalasin, Mahasarakham and Roi-et are not generally as dependent upon rice as the upper north. Traditionally, kenaf has been the most favored upland crop in these provinces but recently cassava and in some instances maize have grown in importance. Rice still predominates as the major crop, however, although growth in upland crop cultivation has been more rapid. This is because much of the recently cleared virgin land is more conducive to upland crops and lacks sufficient rainfall for rice cultivation. However, much of the land is still cultivable in either rice or upland crops and there is evidence of substitution between the two over the sample period. Well over half of all farmers grow an upland cash crop as compared with less than 20% in the early 1960's. This greater crop diversification should, *a priori* result in larger and more significant price responsiveness of rice production. After the farm rice needs are met, farmers should be prepared to adjust rice area and production to take advantage of favorable cash crop alternatives. These *a priori* notions are somewhat confirmed by the statistical results from the mid northeast. For Chayaphum and Nakornratsima prices are significant, although not at very high levels of significance. Population and rainfall are again statistically significant explanatory variables while yield continues to perform poorly. As in the upper northeast, the R^2 values are relatively high and the fits relatively good. Auto-correlation does not appear to be a problem. The provinces of the midnortheast have a better developed marketing system and more infrastructure than the upper northeast which may also account for its greater responsiveness to economic incentives. We did observe a high degree of sensitivity to drought conditions which prevailed in 1972 and to some extent in 1974. Despite the inclusion of a significant variable, large negative residuals were observed for most provinces. This suggests that the impact of the drought was not fully captured by the variables in the model. Apparantly, some highly non-linear responses result from failure of rainfall to reach minimum levels of accumulation during the planting season. Further investigation of weather variables which might capture these effects is needed. Population pressures are not so great here as they are in the upper northeast but it is still a rapidly growing region. The opportunities for continued exploitation of virgin lands appears to be limited in most provinces of this region with the possible exceptions of Chayaphum and some parts of Kalasin and Roi-et.

The lower northeast consists of the provinces bordering Cambodia: Buriram, Surin, Srisaket, and Ubonratthani. These provinces are separated from the mid-northeast because of their ethnic Cambodian background and because the level of access to government services (aside from roads which were primarily built for military purposes) and other infrastructure is quite low. Despite the lack of social services, crop diversification has proceeded here to a similar extent as in the mid northeast. Upland crop area has expanded rapidly in the past few years with cassava, kenaf and to some extent maize leading the way. The regression estimates for the lower northeast are quite discouraging. In only two of the four provinces does price appear with the correct a priori sign and in both cases with an extremely high standard error. Rainfall and farm population are statistically significant in three cases out of four but the overall significance of the regressions is also low. We are at a loss to explain the behavior of planted area response in these provinces except to say that the model is apparantly ill fitting. We are obviously missing whatever variables are important in the determination of rice planting. Perhaps the addition of an index of upland crop prices would provide some increase in the explanatory power of the model. This may be especially relevant in the lower part of the Northeast where rice and upland crops can be substituted more easily than in other parts of the

the country. The introduction of such an index is further supported by the fact that between 1974 and 1977, the area planted in rice fell in all four provinces. At the same time, the prices of upland crops were high.

We did some experiments with such an index at the regional level and the results were encouraging. However, time did not permit the construction and inclusion of such a variable at the province level.

For the central plain, provinces of Chainat, Suphanburi, Singhburi, Angthong, Ayuthya, Pathumthani and Nakhornayok, there is very little variation in area planted and very little substitution between rice and other crops. Price is significant at high levels for Ayuthya, Angthong and Saraburi only. The supply response coefficients are small and the model explains a small percentage of the variation in area planted in many cases. Yield and population are marginally significant but a firm pattern is not observed. If we had sufficient information to analyze the dry season crop then we might get some responsiveness here but the time series is too short and the impact of irrigation is extremely important but difficult to assess. That is, dry season production is possible only if access to irrigation is possible. The proportion of cultivated area out of the dry season holding area would definitely be influenced by price. However, we do not have sufficient information to determine what this proportion is at this time. We could also analyze the impact of fertilizer prices if a model of this sort could be constructed.

In the lower north, or upper part of the central plain, we have the provinces of Sukhothai, Uttaradit, Kamphaengphet, Phitsnulok, Phetchbun, Nakhornsawan and Uthai thani. The alternatives to rice in this region are maize and mung beans. Here the supply response model is characterized by large and significant price responsiveness. The elasticities also tend to be larger than in the other regions. Population and rainfall are also statistically significant and the fits are quite good in most cases. The regression results in this region tend to support the conclusion that Thai farmers respond to market incentives where sufficient infrastructure exists and where sufficient land exists to permit substitution among crops. When compared to the results in the northeast, the infrastructure differences appear to be the determining difference in price responsiveness.

For the provinces to the east and west of the central plain (Saraburi, Phetburi and Chachoengsao) often called the marginal plain we notice some price responsiveness, but not as much as in the upper part of the central plain. The provinces are characterized by great variations in cropping pattern because of differences in terrain.

The provinces of the upper north (Maehongsorn, Chiengrai and Chiengmai) are a typical when compared with the rest of the country in several respects. The nature of the terrain is different, with farming occupying mountain valleys primarily. The average land holding in this region is considerably smaller than in the rest of the country and population density higher. Irrigation is used during the wet season because of the hilly terrain. Rice yields are higher than those observed in the rest of the country. Because of population pressures in this region, clearing of virgin lands has been attempted, and planted area in the three sampled provinces has increased. This is especially true in Chiengrai and Maehongsorn where planted areas increased 70% and 44% respectively between 1963 and 1977. Further expansion will be inhibited by the increasing steepness of the land and associated problems of erosion.

Tobacco is an important alternative to rice in these provinces. Price and yield are generally important explanatory variables in these provinces as we might expect, whereas rainfall and population are either insignificant or have the wrong sign. This latter result is unexpected and we are hard pressed to explain it.

In summary, the price coefficients are positive for the majority of provinces studied but their statistical significance varies regionally. Prices in the Northeast were often insignificant especially in the upper parts whereas in the Central Plains, the Marginal Plains, Upper Plains and in the North, the price coefficients are more often significant. In addition, the yield coefficient (YDRA) has the expected plus signs for all provinces in the Marginal Plains, the Upper Plains and the North. But for the majority of provinces in the Northeast and the Central Plain, yield is negatively related with the area planted in rice. Two explanations are possible. For the Northeast, the rice production is, in large measure, in response to subsistence need of families as this argument is partly confirmed by the significance of farm population variable (TPP). For the Central Plains, the rice yield is probably at maximum under existing irrigation system and soil fertility, and expectation of much greater yield is not feasible without large increase in fertilizers, which are still quite expensive.

The amount of rainfall appears to have significant impact on the planted area of rice in all regions except for some provinces in the Central and Marginal Plains and the North. Again, some explanation is possible. These provinces in the Central and

Marginal Plains are already endowed with good irrigation system such that the amount of rainfall could only be of marginal importance in the area response. Thai reasoning is probably also true for provinces in the North where the irrigation system has been well established from the past. On the contrary, and as expected, the rainfall variable is significant for the Northeast where the poor water retention capability of its soil requires sufficient and continuous rainfall.

The farm population variable exhibits rather strange results in the estimates. While it shows a normal, expected behaviour in the Northeast, its behaviour has been haphazard elsewhere. Changes in population structures through changes in birth rates and migration patterns could affect the rice production of many provinces quite differently in the recent past. The risk coefficients, where they were specified in the model, also show erratic behaviour. It is difficult to explain why farmers in Saraburi and Chachoengsao are risk averse as regard fluctuations in rice yield while farmers in Angthong would enjoy them.

Comparisons between Behrman's and our supply price elasticities are shown in Table 3. In both instances, the values are quite small, often less that.3. Thus, our results confirm the generally held belief that the responsiveness of supply of rice to changes in rice prices in Thailand is low. But one does observe certain changes in the magnitudes of these elasticities over time. In general, it appears that both short run and long run price elasticities of area planted have decreased from the period 1937-1963 to the period 1963-1977. Although there a few exceptions such as the Upper Plains provinces of Uttradit, Sukhothai, Kam-phaengphet, Phetchbun and Uthai-thani where the short run elasticities appeared to increase quite substantially, reflecting land clearing, satisfactory infrastructure and modern farm methods, the results elsewhere are pervasive. In the Northeast smaller price elasticities, perhaps reflect even stronger dependence on rice growing for subsistence purpose, whereas, the low elasticities in the North may also reflect the problem of subsistence farming due to small land holding of the majority of farmers. The already low elasticities in the Central Plains still continue without much change in the latter periods.

To conclude, like Behrman's study, sufficient evidence has been assembled to demonstrate that Thai rice farmers still respond to changes in the price of rice in a normal way, though this responsiveness is weak and many other variables have influenced this responsiveness. This makes the uniform implementation for rice and other agricultural policies difficult since problems may be location-specific and thus policies must be tailored to apply

Table 3: Comparison of short-run and long-run elasticities of area planted in rice with respect to price of rice, 1937-1963 and 1963-1977.

Region and Province	Behrman (1937-1963) SR	LR	Medhi & Dowling (1963-1977) SR	LR
Northeast				
19 Chayapum	0.34	0.24	0.30	0.21
20 Nakornratchsrima	0.55	0.57	0.19	0.14
21 Burirum	0.25	0.14	-	-
22 Surin	0.36	0.31	0.12	0.13
23 Srisaket	0.16	0.26	0.17	0.14
24 Ubonratchthanee	0.22	0.33	-	-
25 Nong Khai	0.15	0.31	0.01	0.01
26 Loei	-	-	-	-
27 Udonthanee	0.15	1.04	0.03	-
28 Sakolnakorn	0.04	0.28	-	-
29 Nakorn Panom	0.05	0.18	-	-
30 Khon Kaen	0.38	0.28	-	-
31 Mahasarakham	0.57	0.30	-	-
32 Kalasin	0.18	0.23	-	-
33 Roi-Et	0.08	0.06	0.04	0.03

Table 3 cont.

		Behrman (1937-1963)		Medhi & Dowling (1963-1977)	
		SR	LR	SR	LR
	North				
34	Maehongsorn	-	-	0.16	0.23
35	Chiengmai	-	-	0.03	0.11
36	Chiengrai	-	-	0.00	0.01
	Central Bangkok Plain				
1	Chai-nat	0.19	0.25	0.01	0.01
2	Singburi	0.02	0.08	0.02	-
3	Lopburi	0.50	0.46	-	-
4	Saraburi	0.07	0.07	0.21	-
5	Angthong	0.04	0.09	0.01	0.01
6	Ayuthaya	0.08	0.07	0.03	-
7	Nonthaburi	0.23	0.24	-	-
8	Pathumthani	0.12	0.23	0.07	0.21
9	Thonburi	0.62	3.12	-	-
10	Phranakorn (Bangkok)	0.24	0.83	-	-
11	Nakhornayok	0.12	0.16	-	-
13	Samutprakan	0.15	0.19	-	-
48	Nakhornsawan	0.28	0.32	-	-
51	Suphanburi	0.03	0.07	-	-
53	Nakhornpathom	0.19	0.21	-	-
54	Samutsongkram	C.33	0.57	-	-
55	Samutsakhorn	0.18	0.22	-	-

		Behrman (1937-1963) SR	LR	Medhi & Dowling (1963-1977) SR	LR
	Southeast				
15	Cholburi	0.10	0.12	-	-
16	Rayong	0.06	0.16	-	-
17	Chantburi	0.14	0.15	-	-
18	Trat	0.14	0.30	-	-
	Marginal Plains				
12	Prachinburi	0.08	0.18	0.14	0.15
14	Chachoengsao	0.15	0.14	0.07	0.07
	Upper Plains				
41	Uttradit	0.24	0.45	0.25	0.11
43	Sukhothai	0.21	0.21	0.30	0.15
44	Phitsanulok	0.28	0.56	0.07	-
45	Kamphaengphet	0.07	0.07	0.33	-
46	Phichit	0.27	0.33	-	-
47	Petchbun	-	-	0.22	-
49	Uthai Thani	0.13	0.21	0.46	0.72
	Western Highlands				
42	Tak	0.50	0.46	-	-
50	Kanchanaburi	0.13	0.12	-	-
52	Ratburi	0.07	0.07	-	-

Table 3. cont.

		Behrman (1937-1963) SR	Behrman (1937-1963) LR	Medhi & Dowling (1963-1977) SR	Medhi & Dowling (1963-1977) LR
	Peninsula				
56	Phetburi	0.34	0.30	-	-
57	Prachuap Khirikhan	0.29	0.29	-	-

to or to suit the local situations. Without such tailor-made policies the analysis of regional impacts will have to be made and the overall impact on the economy difficult to measure.

Maize

In the maize regressions, the dependent variable is the area planted of maize. The relevant explanatory variables included in the maize model are (1) relative price of maize (RPCM); (2) relative yield of maize (RYDM); standard deviation of price of maize (SDPCM); standard deviation of yield of maize (SDYDM); and a time trend (T). The relative variables (both price and yield) are derived from some elaborate steps of data management. Take an example of the relative maize price series. First, an index of farm gate maize prices is calculated using the 1970 price as base. This price index is then weighted by the other composite index which is estimated from the weighted averages of price indices of five other competing crops, namely, cassava, mungbean, sorghum, sugar cane and kenaf. The weitht used in these latter indices is the share of area planted of each crop to total area planted of the five crops. [1/] So, the relative

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[1/] This relative price and yield derivation method is also used in the analysis of the supply response of all other crops under study. For details, see notes at the end of the table which presents the results of the estimation.

price variable is actually the relative price index not the true price. The results of the supply response estimation for maize using the nonlinear estimation techniques are presented in Table 4. And for comparison purpose, Behrman's estimates are also presented here in Table 5.

The best estimates of maize supply response equation in 17 provinces are presented with the values of $\bar{R}^2$ ranging from 0.6372 to 0.9903 but with estimates of more than two-thirds of the provinces having an $\bar{R}^2$ higher than 0.8. The relative price variable is significant at least at the 10 percent level in the majority of provinces and with the correct sign except for 3 provinces, Buriram, Sukhothai and Supanburi, which have wrong (negative) signs. The relative yield variable, however, has erratic influence on maize supply response. For 7 out of 17 provinces, this variable has a negative sign, and for those provinces of which the sign is correct, the significance of this variable is rather low. The same can also be said with respect to the risk variables, that is, the price risk (SDPCM) and the yield risk (SDYDM) which show erratic signs and are quite insignificants in general. The time trend variable, however, is shown to be highly significant for all provinces where this variable had been considered (Nakhornratsima, Loei, Lopburi, Phetchbun, and Uthaithani), excep just one (Buriram).

sksksk

Table 4 Nonlinear estimates of the total supply response model for Maize

Province No.	Region and Province	Dep.Var.	Constants	RYDM	RPCM	SDYDM	SDPCM	Price Adjustment Coefficient B_1	Area Adjustment Coefficient B_2	R_2
NORTHEAST										
19	CHAIYAPUM	APM (7)	-90906,3 (b) (-1,9900)	-49845.4 (g) (-7,2799)	6361,53 (c) (2,1318)	531786 (g) (23,7932)	174903 (g) (11,7487)	1,9670 (g) (7,2185)	1.9475 (f) (6.0143)	.9903
20	NAKORNRATCHASIMA	APM (2)	564683 (d) (2,2833)	-34528,8 (-.1303)	164331 (a) (,8853)	-195320 (-.4499)	118667 (.1299)	-	-	.9386
23	SRISAKET	APM (1)	-92612,6 (a) (1.2566)	105800 (b) (1,6274)	46831.5 (d) (2.5744)	519297 (d) (2,4295)	-298887 (c) (-2.3132)	-	-	.6372
26	LOEI	APM (2)	324871 (c) (2,3309)	-13652,5 (-,4394)	70634,7 (c) (2,0471)	-188873 (a) (-1,0570)	-619815 (b) (-1,6845)	-	-	.9540
30	KHONKAEN	APM (9)	,01706 (a) (1,1197)	-	,03285 (f) (3,8411)	-	-.07563 (b) (-1.5290)	1.1755 (c) (2.1681)	.9585 (b) (1.4951)	.7733
21	BURIRAM	APM (6)	0,1208 (g) (4,9257)	0,01608 (0.6124)	-0,06832 (c) (-1,8985)	-0.06007 (c) (-2,0041)	0.2019 (a) (1.2476)	-	-	0.9021
CENTRAL BANGKOK PLAIN										
3	LOP BURI	APM (3)	522384 (a) (1,3097)	-579029 (a) (-1,3589)	523216 (b) (1,7347)	,1617 (a) (1,0528)	774422 (a) (.7982)	-	-	.8209
4	SARA BURI	APM (7)	132205 (a) (,7757)	5554,75 (,3653)	364810 (b) (1,7495)	-130259 (b) (-1,5397)	236087 (a) (,9044)	.5722 (c) (2.5538)	.9121 (c) (2.7372)	.8363
48	NAKORNSAWAN	APM (7)	,1578 (d) (2,8077)	293304 (e) (3,7832)	304240 (c) (2,6302)	-349948 (d) (-3,0478)	-645515 (d) (-3.2340)	2,3091 (f) (4.7710)	1.1182 (f) (5.7451)	.8217

Table 4 (cont.)

Province No.	Region and Province	Dep.Var.	Constants	DYDM	RPCM	SDYDM	SDPCM	Price Adjustment Coefficient B_1	Area Adjustment Coefficient B_2	R_2
43	SUKHOTHAI	APM (5)	987459.0 (e) (3.1834)	-213557 (d) (-2.4348)	-942161 (d) (2.6868)	455098 (a) (1.1625)	-0.1176 (e) (-3.0717)	0.4601 (b) (1.5118)	1.2308 (f) (3.5276)	0.9416
51	SUPHANBURI	APMT(8)	-0.4562 (a) (-1.4359)	0.5547 (c) (2.1549)	-0.03044 (-0.6955)	0.7553 (b) (1.4162)	0.4269 (c) (1.8492)	1.7680 (g) (6.9086)	0.7692 (b) (1.7012)	0.7337
UPPER PLAIN										
44	PHITSANULOK	APM (3)	.4510 (g) (9.6873)	.03910 (b) (1.5136)	.08258 (d) (2.7343)	.4201 (d) (2.7150)	-.03031 (-.3860)	-	-	.8370
45	KUMPHAENGPHETCH	APM (3)	-.1582 (-.5431)	.2233 (a) (.8297)	.3432 (b) (1.8244)	-.3623 (b) (-1.5123)	1.10150 (c) (2.2208)	-	-	.7672
46	PICHIT	APM (6)	-2.7573 (-.2484)	2.0821 (.3283)	1.9435 (.2956)	1.5404 (.2870)	.8354 (.1372)	1.5857 (f) (5.5169)	-.05176 (-.3032)	.8875
47	PHETCHABOON	APM (2)	-212682 (-.5831)	384746 (a) (.9908)	301070 (b) (1.6139)	-583381 (a) (-.8279)	719245 (a) (1.0466)	-	-	.9738
49	UTHAITHANI	APM (2)	-3586.14 (-.08855)	37251.9 (b) (1.7312)	42139.8 (e) (3.2081)	51446.3 (a) (1.2834)	119861 (a) (1.1060)	-	-	.9759
WESTERN HIGHLAND										
42	TAK	APM (5)	33159.0 (.4235)	-47209.0 (-.1581)	44281.9 (.2066)	98202.0 (-.2137)	484549 (.4465)	1.4889 (c) (2.5889)	-.1902 (-.3561)	.6717

Table 4 (Cont.)

Note : RPCM = IPCM/IP

RYDM = IYDM/IY

SDPCC = $[\{(LRPCM_{t-1} - ARPCM)^2 + (LRPCM_{t-2} - ARPCM)^2 + (LRPCM_{t-3} - RPCM)^2\} /3 \quad .5$

SDYDC = $[\{(LRYDM_{t-1} - ARYDM)^2 + (LRYDM_{t-2} - ARYDM)^2 + (LRYDM_{t-3} - RYDM)^2\} /3 \quad .5$

IP = (APC/APSUM) x IPCC + (APMB/APSUM) x IPCMB + (APS/APSUM) x IPCS (APSC/APSUM) x IPCSC + (APK/APSUM) x IPCK

IY = (APC/APSUM) x IYDC + (APMB/APSUM) x IYDMB + (APS/APSUM) x IYDC + (APSC/APSUM) x IYDSC + (APK/APSUM) x IYDK

IPCC = (PCC/CASP) x 100

IPCM = (PCM/MAZP) x 100

IPCMB = PCMB/MBNP) x 100

IPCS = (PCS/SORP) x 100

T-test shows the above estimates significantly non-zero at the following levels of significance:

(a)	25,0 %
(b)	10,0 %
(c)	5,0 %
(d)	2,5 %
(e)	1,0 %
(f)	0,5 %
(g)	0,1 %

Table 5: Nonlinear estimates of the structural parameters of the Nerlovian dynamic dynamic total supply response model for corn production in the eight leading corn producing provinces 1950-1963[a]

Provinces	Nonlinear estimates of								Number of years for adjustment to within 5% of complete	$\bar{R}^2$
	Reduced equation constant (B_1)	Structural coefficients of					Area adjustment coefficient (a22)	Price adjustment coefficient (a32)		
		P^e_t	Y^e_t	σP_t	σY_t	M_t				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
48 Nakhornsawan	-3,64 (1,4)[e]		3,04[n] (0,49)[b]	-0,257[y] (0,090)[d]			1	1	1	0,81
	5,498 (1,3)[c]			-0,426[y] (0,15)[d]		-0,217 (0,090)[e]	1	1	1	0,45[j]
	0,374 (1,7)	1,70[z] (1,1)[g]		-0,945[z] (0,48)[f]			1	1	1	0,20[k]
4 Sara-buri	-1,57 (0,71)[e]		1,35[n] (0,51)[e]	-0,0655[x] (0,031)[f]			1	1	1	0,92
3, Lopburi[p]	-8,17 (1.32)[b]	0,544[w] (1,62)[d]	4,05[n] (0,39)[b]	-0,124[w] (0,044)[e]			0,689 (0,18)[c]	1.27 (0,19)[b]	3	0,96
20 Nakhornratsima	-5,02 (3,2)[g]	0,966[z] (0,94)[h]	3,51[m] (1,7)[f]	-0,705[z] (0,33)[f]			0,540 (0,23)[e]	1	4	0,85
44 Phitsnulok	4,76 (1,3)[c]		4,36[m] (0,57)[b]	-0.146[x] (0,11)[h]			1	1	1	0.82
46 Phichit	0,600 (1,7)		1,89[m] (0,39)[b]	-0,395[z] (0,25)[g]	-0.460 (0,43)[h]		1	1	1	0,75
	7,42 (1,3)[b]			-0,223[z] (0,30)[h]	-0,463 (0,47)[h]	-0,404 (0,096)[c]	1	1	1	0,70
47 Phetchbun	-9,99 (5,2)[f]	6,70[x] (4,6)[g]	3,94[n] (1,4)[d]				0.315 (0,26)[h]	1	8	0,73
43 Sukhothai	11,0 (1,8)[b]		5,58 (0,69)[b]	-0,279[z] (0,092)[d]	-0,115 (0,063)[f]		1	1	1	0,89
	3,82 (0,73)[b]			-0,553[z] (0,21)[e]	-0,198 (0,15)[g]	-0,173 (0,081)[f]	1	1	1	0,39[k]

Table 5 : (cont.)

a The Nerlovian dynamic total supply model and the nonlinear estimation technique which was used are described in chapter 5. The data is discussed in chapter 7 and is presented in Appendix A. Asymptotic standard errors are given in parentheses beneath each point estimate. The coefficient of determination is corrected for degrees of freedom. F-tests indicate that each coefficient of determination is asymptotically significantly nonzero at the 0.1% level unless otherwise noted.

b t-tests indicate that this estimate is asymptotically significantly nonzero at the 0.05% level

c t-tests indicate that this estimate is asymptotically significantly nonzero at the 0.50% level.

d t-tests indicate that this estimate is asymptotically significantly nonzero at the 1.0% level.

e t-tests indicate that this estimate is asymptotically significantly nonzero at the 2.5% level.

f t-tests indicate that this estimate is asymptotically significantly nonzero at the 5.0% levle.

g t-tests indicate that this estimate is asymptotically significantly nonzero at the 10.0% level.

h t-tests indicate that this estimate is asymptotically significantly nonzero at the 25.0% level.

j F-tests indicate that this coefficient of determination is asymptotically significant at the 2.5% level.

k F-tests indicate that this coefficient of determination is asymptotically significant at the 10.0% level.

m The first formulation of expected yields was used. See section 7.2.

n The second formulation of expected yields was used. See section 7.2.

p This regression is for 1951-1963.

w The relative price index was constructed from local prices and area weights. See section 7.3.

x The relative price index was constructed from local prices and yield weights. See section 7.3.

y The relative price index was constructed from Bangkok prices and area weights. See section 7.3.

z The relative price index was constructed from Bangkok prices and yield weights. See section 7.3.

In all, it seems that the supply of maize is responding well to the relative price and a growth trend. Indeed, the price of maize was quite attractive when the expansion of maize growing was started in the late 1950's and early 1960's. This expansion was made possible by large import demand by Japan and Taiwan whose economies during those periods enjoyed tremendous growth and prosperity. Guaranteed demand with attractive prices naturally induced many rice farmers as well as new farmers to begin growing maize. Vast forest areas in the upper Central Plains, the North and the Northeast were very rapidly cleared for maize plantation. Condisering this virgin land availability complemented by buoyant foreign demand and a favorable price, it is quite reasonable to conclude that other factors such as yield and risk would not be very significant.

An examination of the short-run and long-run elasticities of maize supply response with respect to change in its price reveals some interesting results. Compared with the similar estimates made by Behrman for the period ended in 1963, it can be seen that for most provinces where comparisons are possible, our estimated elasticities are much lower in values. In contrast to the rapid expansion in the late 1950's and early 1960's, recent expansion of maize production in recent years has been reduced along with the supply of new arable land. As the limit of land frontiers is reached,

Table 6: Supply Price Elasticities : Maize

Province	Behrman (1937-1963) SR	Behrman (1937-1963) LR	Medhi & Dowling (1963-1977) SR	Medhi & Dowling (1963-1977) LR
Northeast				
Chaiyapum	-	-	.08	.02
Nakornratchasrima	0.27	0.41	.17	-
Srisaket	-	-	.69	-
Loei	-	-	.35	-
Khon Kaen	-	-	1.18	1.05
Buriram	-	-	-	-
Central Bangkok Plain				
Lop Buri	1.58	1.81	.48	-
Sara Buri	-	-	.61	1.17
Nakornsawan	1.92	1.92	.31	.12
Sukhothai	-	-	-	-
Suphanburi	-	-	-	-
Upper Plain				
Phitsanulok	-	-	.14	-
Kumphaengphetch	-	-	.61	-
Pichit	-	-	3.08	-37.6
Phetchaboon	4.47	14.17	.44	-
Uthaithani	-	-	.34	-
Western Highland				
Tak	-	-	.70	-2.47

further expansion will be quite difficult. However, it should be kept in mind that Behrman had only a limited sample available and his results provide much less conclusive evidence than the results reported here. The supply response coefficients for maize are much larger than those for rice and the overall results represent conclusive support for the significance of the supply response process in maize production. While there is significant variation among provinces in the size of the supply response coefficient there appear to be no systematic differences in response by region. Unlike rice, the supply response seems to be relatively even and strong throughout the country. In part, this may reflect a careful effort to include the price of most relevant alternative crops in the construction of the price index.

It should be mentioned here also that the early 1970's saw the rise cassava as a substantial competing crop in relation to maize. Although the maize price remained sufficiently high, its production had suffered from the ravage of pests and declining fertility of maize land. In contrast to maize, cassava production needed little land preparations and little care and attention during its growing period. Cassava is a hardy upland crop which needs relatively little water and soil nutrients in order to grow. So, its production and expansion had caught on at astronishingly rapid rate, particularly in the Northeast where land areas had been secured through deforestation and encrouchment into the damaged forest reserves. As a result, the growth of maize production was more or less arrested by the growth of cassava production.

Cassava

Unlike the maize model, there are more than one variations of dependent variable in our cassava model. Although the planted area remains the chosen concept of supply response, both absolute and relative planted areas of cassava are used in the supply response estimation. APC is the absolute area planted of cassava measured in rai, whereas APCS and APCT are the areas planted of cassava weighted by the total uncultivated and total cultivated areas, respectively. The idea behind land-area weighting in the above manner is to capture the possible extensive expansion of cassava production as well as its share of existing land-use vis-a-vis other upland crops.

The independent variables in the cassava model are practically the same as in the maize model that is to say, we included (1) the relative price index of cassava (RPCC); (2) the relative yield index of cassava (RYDC); the price risk variable (SDPCC); the yield risk variable (SDYDC); and the time trend variable (T). However, in certain province where the land areas that are being used to grow cassava can also be used to grow upland rice, we have included the price of rice (PCR) as another explanatory variable in the cassava equation on the expectation that rice will substitute for cassava. If this is so, a negative sign is expected as the parameter estimate for this variable.

The results of the estimation as shown in Table 7 and 8, though not very high or consistent in statistical significance, exhibit many interesting characteristics. First of all, the R^2's are quite large in most of the cases under study with more than half of the provinces having the $\bar{R}^2$'s larger than 0.8. The included independent variables, however, do not show much consistent influences on the cassava planted areas in general, but a more careful examination of these results could lead to some interesting revelations. For example, the estimates of some important North-eastern provinces namely, Chiyaphum, Buri Ram and Khon Kaen, have positive, and significant, relative price and yield parameters, and negative price risk and yield risk parameters.

This is very much what is expected of the cassava supply response in most of the Northeast where the diversification into cassava had been a very logical response to the changes in agricultural situations in Thailand in the early 1970's. On the supply side, the population pressure had been constantly increasing since

Table 7 CASSAVA

Province No.	Region and Changwats	Dep.Var.	Constant	RPCC	RYDC	SDPCC	SDYDC	PCR.	T	Price Adjustment Coefficient B_1	Area Adjustment Coefficient B_2	R^2
NORTHEAST												
19	CHAIYAPUM	APCS(1)	-.7776 (g) (-4.6016)	.2416 (c) (2.0010)	-	-.4365 (a) (-.8288)	-	.002806 (g) (6.0265)	-	1	1	.8[illegible]
21	BURI RUM	APC (3)	91035.2 (a) (1.0488)	70496.7 (c) (2.2667)	56146.3 (a) (1.3812)	-360658 (c) (-2.1668)	-480053 (e) (-3.1668)	-	30743.1 (g) (5.4574)	1	1	.927[illegible]
30	KHON KAEN	APCT(7)	-.3856 (f) (-4.2037)	.1781 (c) (2.3011)	.3860 (g) (6.9721)	-.06145 (a) (-.7178)	-.5400 (a) (-.8068)	-	-	1	1	.92[illegible]
20	NAKORNRATSIMA	APCT(5)	0.2333 (e) (3.4922)	-0.008214 (-0.2004)	-0.07941 (a) (-0.9148)	-0.08351 (-0.3732)	0.05872 (0.3111)	-	0.03926 (g) (6.7234)	-	-	[illegible]
MARGINAL	PLAIN											
12	PRACHIN BURI	APC (7)	614345 (a) (.8983)	253984 (a) (1.1275)	-344301 (a) (-1.0489)	-.1168 (a) (1.2949)	-.2236 (a) (-1.2462)	-	-	1.4406 (e) (4.2904)	-.1454 (a) (-1.1355)	.9[illegible]
14	CHACHOENG SAO	APC (1)	2839960 (.6776)	619.899 (.5820)	996.251 (.1427)	67935.4 (.5537)	-389488 (a) (-.9614)	-	-	1	1	.8[illegible]
SOUTHEAST 16	COAST											
16	RAYONG	APCS(1)	.7288 (f) (5.1888)	.09576 (a) (.7775)	-.1662 (c) (-2.3743)	.1532 (.4274)	.2027 (a) (1.4257)	-	-.003302 (.5118)	1	1	.6[illegible]
15	CHOLBURI	APCT	0.3644 (b) (1.4902)	0.009801 (0.08445)	-	0.08356 (a) (1.0322)	-	-	-	0.3685 (b) (1.3830)	1.5922 (g) (5.1280)	.20[illegible]

Table 7 (cont.)

RPCC	=	IPCC/IP
RYDC	=	IYDC/IY
SDPCC	=	$\left[\left\{(LRPCC_{t-1} - ARPCC)^2 + (LRPCC_{t-2} - ARPCC)^2 + (LRPCC_{t-3} - ARPCC)^2\right\}/3\right]^{.5}$
SDYDC	=	$\left[\left\{(LRYDC_{t-1} - ARYDC)^2 + (LRYDC_{t-2} + ARYDC)^2 + (LRYDC_{t-3} - ARYDC)^2\right\}/3\right]^{.5}$
IPCC	=	(PCC/CASP) x 100 = price index of cassava
IYDC	=	(YDC/CASY) x 100 = yield index of cassava
IP	=	(APM/APSUM) x IPCM + (APMB/APSUM) x IPCMB + (APS/APSUM x IPCS + (APSC/APSUM) x IPCSC + (APK/APSUM) x IPCK = Average price index (weighted by planted area)
IY	=	(APM/APSUM) x IYDM + (APMB/APSUM) x IYDMB + (APS/APSUM) x IYDS + (APSC/APSUM) x IYDSC + (APK/APSUM) x IYDK
APC	=	area planted in cassava
APM	=	area planted in maize
APMB	=	area planted in mung bean
APS	=	area planted in sorghum
APSC	=	area planted in sugar cane
APK	=	area planted in kenaf
IPCM	=	(PCM/MAZP) x 100
IPCMB	=	(PCMB/MBNP) x 100
IPCS	=	(PCS/SORP) x 100
IPCSC	=	(PCSC/SUGP) x 100
IPCK	=	(PCK/KENP) 1 x 100
PCC	=	price of cassava

Table 7 (cont.)

PCM	=	price of maize
PCMB	=	price of mung bean
PCS	=	price of sorghum
PCSC	=	price of sugar cane
PCK	=	price of kenaf
CASP	=	PCC in base year 1970
MAZP	=	PCM in base year 1970
MBNP	=	PCMB in base year 1970
SORP	=	PCS in base year 1970
SUGP	=	PCSC in base year 1970
KENP	=	PCK in base year 1970

Table 8: Nonlinear estimates of the structural parameters of the Nerlovian dynamic total supply response model for cassava production in Cholburi and Rayong.[a]

Provinces and time period	Nonlinear estimates of: Reduced equation constant (b_1)	Structural coefficients of: P^e_t	Y^e_t	σP_t	σY_t	Area adjustment coefficient (a22)	Price adjustment coefficient (a32)	Number of years for adjustment to within 5% of complete	$\bar{R}^2$	Price series: (local or Bangkok, area or yield weights)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
15 Cholburi (1950-1963)	0.595 (1.1)		0.469[g] (0.41)[d]	-0.380 (0.16)[d]	-0.0590 (0.050)[d]	0.153 (0.19)[d]	1	18	0.90[e]	Bangkok area
16 Rayong (1955-1963)	8.66 (3.4)[c]			-0.958 (0.79)[d]		0.625 (0.24)[c]	1	4	0.23[f]	Bangkok yield
	2.58 (8.9)	1.30 (1.1)[d]		-0.874 (0.85)[d]		1	1	1	0.14[f]	Bangkok, yield

a The Nerlovian dynamic total supply model and the nonlinear estimation technique which was used are described in chapter 5. The data is discussed in chapter 7 and is presented in Appendix A. Asymptotic standard errors are given in parentheses below each point estimate. The coefficient of determination is corrected for degrees of freedom.

b t-tests indicate that this estimate is asymptotically significantly nonzero at the 2.5% level.

c t-tests indicate that this estimate is asymptotically significantly nonzero at the 5.0% level.

d t-tests indicate that this estimate is asymptotically significantly nonzero at the 25.0% level.

e F-tests indicate that this coefficient of determination is asymptotically significant at the 0.1% level.

f F-tests indicate that this coefficient of determination is asymptotically significant at the 20.0% level.

g The second formulation of expected yields was utilized. See section 7.2.

the early 1960's, giving rice to increasing land pressure. It just so happenned that this early period of systematic economic development where extensive infrastructures such as road systems and encouragement of private development initiatives were the major policy objectives was somehow linked with the massive destruction of forest areas in all regions of Thailand especially in the North and the Northeast. The damaged forest areas now denuded of big trees, provided new farm families with land suitable for upland crops. On the demand side, Japan, Taiwan and several European countries were in great need of feed meals for their food and dairy industries, and cassava was one of their major products of choice. As mentioned earlier, cassava is an easy crop to grow and incurs relatively little costs of maintenance and care. The rate of return is high even with moderate cassava price with the suitable demand and supply conditions, cassava became a major upland crop in upland areas of the Central Plains and in the Northeast. Kenaf which was then the major upland crop in the Northeast could not compete with cassava for its ease of cultivation and profitable returns, so its production drastically declined, and land formerly used to grow kenaf was then used to grow cassava instead.

This cassava phenomenon was most outstanding in the Northeast. One of the reasons why the rice price variable in the estimation for Chiyaphum has a positive sign and is very significant statistically could be that the ease of growing or expanding cassava production through new land areas made available by extensive deforestation in the western part of this province (area joining with Petchabun Province) renders rice the non-competing crop with cassava. The time trend variable for Buri Ram is shown to be very significant as a explanatory variable for cassava supply response in this province (most probably at the expense of declining trend in kenaf production). For the Marginal Plain and Southeast provinces such as Prachin Buri, Chachoeng Sao, Rayong and Cholburi which are the long-established cassava growing areas, however, the supply response estimates do not show consistent or satisfactory results at all. The relative price variable, though positive, is very insignificant. And other remaining relative yield variable, price risk and yield risk variables are all behaving unpredictably. For Rayong, the results are most problematic with negative yield response and positive response to prive and yield risks. Perhaps the farming situation in Rayong, as well as in Cholburi, was a typical of other cassava farming areas, thus making it unsuitable for usual supply response model. These areas have long been in cassava cultivation mostly in plantation style with long established cassava root processing facilities for domestic uses as well as for regular exports. Price and risks then, do not matter much at least in the short-run. In the long-run, however, if the cassava price declines substantially either absolutely or in relative terms to other crops, and risks increase, the supply response in these areas may change. Comparing our Rayong results with those of Behrman, it may be recalled that Behrman also had difficulty with Rayong's estimates (with not very significant parameters and a very low R^2 of 0.14). The short-run price elasticity of 1.09 reported in Behrman had reduced to only 0.11 in our model, indicating the decline in relative prominence of this crop in this province.

In sum, our estimates mainly confirm the significance of price, yield and the absence of risks associated with these two variables in the cassava supply response in the Northeast of Thailand which during the period under study had become the largest cassava producing areas in the country. The response behaviour in other parts of the country was not as clear or as conclusive as the response in the Northeast. It is speculated, however, that supply response situation may change again in the late 1970's or early 1980's when the cassava demand from Western European countries may be drastically curtailed. The signal was given as early as 1974. This was the main reason why the Thai Governmant under the recommendation of its Ministry of Agriculture adopted the area-restriction policy for cassava cultivation. This area restriction policy was heightened by the Ministry's belief that cassava cultivation depleted soil nutrients in the long-run. As from 1976, cassava processing plants are allowed in only six provinces: Cholburi, Rayong, Chachoengsao, Prachinburi, Chiyaphum and Nakhornratsima. This was a part of government policy to control cassava output. Coupled with other surrounding factors, it neidentally gave rise to renewed growth of kenaf cultivation which was eclipsed during the rapid expansion of cassava in the early 1970's. Again, this could be constructed as a logical response to economic reasons: the price of kenaf had increased after many years of low price; the demand even in domestic market had substantially increased; the prospect of demand and price of cassava was not as bright as before; and so on. These points will be discussed in more detail in the next section.

To complete the analysis, the price elasticities of cassava planted areas are presented in Table 9. In Behrman's study, only elasticity for Rayong was estimated at 1.09 of both for the short-run and the long-run. Our short-run estimate for Rayong was only 0.11. This is not quite unexpected, considering the facts mentioned above that Rayong has been a long-established cassava producing area and that the growing of rubber trees appears to be profitable undertaking also. The high elasticities for Chiyapum and Prachinburi could be explained by the expansion of land areas in these two provinces through forest clearing in recent years.

Table 9: Supply Price Elasticities : Cassava

Province	Behrman 1937-1963 SR	Behrman 1937-1963 LR	Mechi-Dowling 1963-1977 SR	Mechi-Dowling 1963-1977 LR
Northeast				
Chiyapum	-	-	2.11	-
Buri Ram	-	-	0.94	-
Khon Kaen	-	-	0.50	-
Nakornratsima	-	-	-	-
Marginal Plain				
Prachin Buri	-	-	2.14	-10.24
Chachoeng Sao	-	-	-	-
Southeast Coast				
Cholburi	-	-	-	-
Rayong	1.09	1.09	0.11	-

Kenaf

The historical development of kenaf cultivation in the last few decades presents a rather interesting epicode of agricultural development in Thailand. In the 1950's and 1960's before maize and cassava became important upland crops, kenaf was the largest and most important crop after rice in the Northeast. Local demand for kenaf for the production of gunny bags was great and in step with the expansion of rice production and export where demand for gunny bags was a clear-cut derived demand. Moreover, export of kenaf fiber itself also was maintained at consistent level. However, the beginning of the 1960's saw a rising, and crippling, competition from synthetic fibers. This resulted in a rapid decline in the price of kenaf in the world market. Coupled with the already difficult process by which kenaf fiber is obtained (sufficient water is needed to wretch the bark from the kenaf stalk, and water is searce the Northeast), it was not unexpected that the Northeastern farmers began to abandon kenaf for other substituted crops yield higher returns. Maize and lates cassava filled the gap nicely from then on.

When synthetic fibers became more expensive in the early 1970's in line with the general rise in oil prices, and with the supply of jute and kenaf to the world markets affected by the war between two of the largest jute and kenaf producers, India and Pakistan, the price of kenaf began to rise again. This upturn in kenaf price was gradual but it stimulated a supubee out responses among the Northeastern farmers who returned to the produetive of kenaf. The competition from Cassava was still very strong during the early parts of 1970's due to its low cost of production and care, and guaranteed demand, as mentioned above. Only toward the end of 1970's when the demand of cassava from Europe and East Asia began to show sign of slackening off, did kenaf cultivation come back to life again in the Northeast. With the impending very large pulp and paper factory in the Northeast (in Khon Kaen) scheduled to go into operation soon where the major raw material required for pulp and paper is kenaf fiber, it is expected that the process of revival of kenaf production will be greatly heightened. It is logical to conclude about expected kenaf supply response from the above development, and this conclusion is sufficiently confirmed by the econometric results from our study.

Table 10 shows the results of estimation from six provinces, all in the Northeast. Prices are significant in all but one case, although the same phenomenon observed for maize also appears for the kenaf results, namely that our coefficient response is lower than that observed by Behrman (see Table 11), and a similar "frontier" case could be made as an explanation for this. The

Table 10: Nonlinear estimates of the total supply response model for Kenaf

Province No.	Region and Changwats	Dep.Var.	Constants	RPCK	RYDK	SDPCK	SDYDK	B_1	B_2	R^2
NORTHEAST										
20	NAKORNRATCHASRIMA	APKS(6)	-,3753[b] (-1,7781)	.3421[e] (3.9058)	,1016[a] (1,0890)	,2653[a] (,9854)	.3623[b] (1.9306)	1,6204[d] (3.6801)	.6403[d] (3.2448)	.8868
21	BURIRUM	APKT(4)	,05905 ((,2523)	.5233[d] (2,7507)	-,004115 (-,1572)	,1411 (,3313)	.04939 (,2929)	-	-	.5717
23	SRISAKET	APKS(3)	,3877[d] (2,7117)	,2100[e] (3,1451)	,2055[a] (1,1466)	-,1433 (-,6177)	1,3359[d] (2,8476)	-	-	.6298
24	UBONRATTHANI	APKS	0,05763 (0,04279)	-0,2154[a] (0,7614)	1,1460[a] (1,1102)	-1,2289[a] (-0,7390)	0,5197 (0,3390)	1,7624[f] (4,9119)	0.3659[c] (2.4934)	0.9686
30	KHON-KAEN	APKT	-0,1885 (-0,5772)	0,1574[d] (2.4962)	1,0017[f] (4,5694)	0.1727[a] (0,9563)	-0,5124 (-0,2962)	-	-	0.8778
33	ROI-ET	APK	144725,0	47596,7[b] (1.4618)	71962,9[a] (1.2574)	-631020[e] (-3,1572)	-36943.0	-	-	0.6447

Table 10: (cont.)

RPCK	=	IPCK/IP
RYDK	=	IYDK/IY
SDPCK	=	$\left[\left\{ (LRPCK_{t-1} - ARPCK)^2 + (LRPCK_{t-2} - ARPCK)^2 + (LRPCK_{t-3} - ARPCK)^2 \right\} /3 \right]^{.5}$
SDYDK	=	$\left[\left\{ (LRYDK_{t-1} - ARYDK)^2 + (LRYDK_{t-2} - ARYDK)^2 + (LRYDK_{t-3} - ARYDK)^2 \right\} /3 \right]^{.5}$
IP	=	(APC/APSUM) x IPCC + (APM/APSUM) x IPCM + (APMB/APSUM) x IPCMB + (APS/APSUM) x IPCS + (APSC/APSUM) x IPCSC
IY	=	(APC/APSUM) x IYDC + (APM/APSUM) x IYDM + (APMB/APSUM) x IYDMB + (APS/APSUM) x IYDS + (APSC/APSUM) x IYDSC
IPCC	=	(PCC/CASP) x 100
IPCM	=	(PCM/MAZP) x 100
IPCMB	=	(PCMB/MBNP) x 100
IPCS	=	(PCS/SORP) x 100
IPCSC	=	(PCSC/SURP) x 100
IPCK	=	(PCK/KENP) x 100
APC	=	area planted in cassava
APM	=	area planted in maize
APMB	=	area planted in mung bean
APS	=	area planted in sorghum
APSC	=	area planted in sugar cane
APK	=	area planted in kenaf
PCC	=	price of cassava
PCM	=	price of maize

Table 10: (cont.)

PCMB	=	price of mung bean
PCS	=	price of sorghum
PCSC	=	price of sugar cane
PCK	=	price of kenaf
CASP	=	PCC in base year 1970
MAZP	=	PCM
MBNP	=	PCMB
SORP	=	PCS
SUGP	=	PCSC
KENP	=	PCK
APSUM	=	APC + APM + APMB + APS + APSC
IYDC	=	(YDC/CASY) x 100
IYDM	=	(YDM/MAZY) x 100
IYDMB	=	(YDMB/MBNY) x 100
IYDS	=	(YDS/SORY) x 100
IYDSC	=	(YDSC/SUGY) x 100
IYDK	=	(YDK/KENY) x 100

Kena

YDC	=	PRC/APC
YDM	=	PRM/APM
YDMB	=	PRMB/APMB
YDS	=	PRS/APS
YDSC	=	PRSC/APSC
YDK	=	PRK/APK
CASY	=	YDC inbase year 1970
MAZY	=	YDM "
MBNY	=	YDMB "
SORY	=	YDS "
SUGY	=	YDSC "
KENY	=	YDK "
PRC	=	production of cassava
PRM	=	" maize
PRMB	=	" mung bean
PRS	=	" sorghum
PRSC	=	" sugar cane
PRK	=	" kenaf
LRPCK	=	log (RPCK)
LRYDK	=	log (RYDK)
ARPCK	=	$\left[LRPCK_{t-1} + LRPCK_{t-2} + LRPCK_{t-3}\right]/3$
ARYDK	=	$\left[LRYDK_{t-1} + LRYDK_{t-2} + LRYDK_{t-3}\right]/3$
APKS	=	area planted in kenaf / Total Uncultivated area
APKT	=	area planted in kenaf / Total Cultivated area
B_1	=	Price adjustment coefficient
B_2	=	Area adjustment coefficient

T - test shows the above estimates significantly non-zero at the following levels of significance:

(a) 25,0 %

(b) 10,0 %

(c) 5,0 %

(d) 2,3 %

(e) 1,0 %

(f) 0,5 %

(g) 6,1 %

Table 11 : Nonlinear estimates of the structural parameters of the Nerlovian dynamic total supply response model for kenaf production in the eight leading kenaf producing provinces, 1954-1963[a]

Provinces	Nonlinear estimates of								Number of years for adjustment to within 5% of complete	$\bar{R}^2$
	Reduced equation constant (B_1)	Structural coefficients of					Area adjustment coefficient (a22)	Price adjustment coefficient (a32)		
		P^e	Y^e_t	σP_t	σY_t	M_t				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(1)
31 Mahasarakhan	1,74 (0,85)	1,22[w] (0,26)[d]			-0.718 (0,070)[c]	-0,181 (0,037)[c]	1,48 (0,18)[c]	0,344 (0,16)[d]	[illegible]	0,85[q]
	1,929 (0,74)[e]	1,14[w] (0,23)[c]		-0,167[w] (0,085)[g]	-0,947 (0,24)[d]	-0,246 (0,046)[c]	1	1	1	0.83[m]
20 Nakhornratsima	-0,027 (2.4)	16,1[w] (2,3)[c]				-13,6 (2,2)[c]	0,473 (0.071)[c]	1.35 (0.082)[b]	5	0.86[n]
19 Chayaphum	6,31 (6,2)[h]	5,68[w] (3,3)[g]				-1,31 (0,26)[c]	0.495 (0,23)[f]	1.49 (0,18)[c]	3	0.73[p]
24 Ubonratthani	0.664 (1,3)	65,2[x] (16,6)[e]		-20.8[x] (5,8)[e]	-12,4 (3,9)[e]		0,100 (0,025)[c]	1,80 (0,022)[b]	29	0,99[f]
	-11,3 (6,0)[g]	4,87[x] (1,9)[e]	5.00[s] (5,0)[h]		-1,68 (1,4)[h]		1	1	1	0,47[q]
30 Khon-kaen	-6,66 (0.83)[c]	42,6[w] (10,9)[d]	6.77[t] (1.20)[c]				0.945 (0,095)[b]	0.118 (0.032)[d]	24	0.96[j]
	-10,3 (2,7)[c]	5,76[y] (1,1)[c]	11,8[t] (2,3)[c]	-0,642[y] (0,36)[g]			1	1	1	0,88[k]
21 Buriram[u]	16.4 (12,1)[h]	6,99[x] (1,9)[f]		-3,04[x] (2.0)[h]	-1.66 (0,65)[g]		1	1	1	0.80[r]
	5.38 (5.1)[h]	4,27[w] (2,22)[g]			-0,951 (0,31)[f]	-0,460 (0.14)[f]	1	1	1	0,75[r]
23 Srisaket	-14.96 (1.3)[b]	4,57[w] (0,43)[b]	4,53[t] (0,48)[b]				1,05 (0,16)[c]	1,04 (0.16)[c]	2	0,87[n]
33 Roi-et	-3.73 (0,85)[c]	1,87 (0,45)[c]					1,51[v] (0,21)[b]	0,480[v] (0,12)[d]	3	0,73[q]

Table 11 : (cont.)

a The Nerlovian dynamic total supply model and the nonlinear estimation technique which was used are described in chapter 5. The data is discussed in chapter 7 and is presented in Appendix A. Asymptotic standard errors are given in parentheses beneath each point estimate. The coefficient of determination is corrected for degrees of freedom. In regressions in which neither adjustment parameter has been restricted to a value of one, the observations are for 1955-1963.

b t-tests indicate that this estimate is asymptotically significantly nonzero at the 0.05% level.

c t-tests indicate that this estimate is asymptotically significantly nonzero at the 0.5% level.

d t-tests indicate that this estimate is asymptotically significantly nonzero at the 1.0% level.

e t-tests indicate that this estimate is asymptotically significantly nonzero at the 2.5% level.

f t-tests indicate that this estimate is asymptotically significantly nonzero at the 5.0% level.

g t-tests indicate that this estimate is asymptotically significantly nonzero at the 10.0% level.

h t-tests indicate that this estimate is asymptotically significantly nonzero at the 25.0 % level.

j F-tests indicate that this coefficient of determination is asymptotically significant at the 0.1% level.

relative yield variable is significant at very low levels in the majority of provinces and in Buriram it has the wrong sign. The standard deviation variables (SDPCK and SDYDK) have the right signs about half of the cases. In Nakhornratsima, the standard deviation is positively and significantly related to the area planted. The relationship is fortuitous, and probably reflects some common trend elements.

As mentioned above, over the years, kenaf and cassava have fought for a leadership position in an upland cropping pattern in the Northeast. Wide swings in area planted are often observed, primarily as a response to changing relative price and expected probitability. Yields for both crops have stagnated in the 1970's and have fluctuated as much from changing rainfall and weather patterns as from anything else. Therefore, it is not surprising that yield is also marginally important in the kenaf results.

The supply price elasticities for kenaf from Behrman's and our studies are shown in Table 12. Ours are not as complete as Behrman's, but the general trend is that the elasticities are lower across the board. This of course reflects the relative prominence of kenaf in the earlier years.

In summary, the picture for kenaf is reasonably similar to that of maize in terms of the important explanatory variables, with the exception that trend is not as important as explanatory variable.

Table 12 : Supply Price Elasticities : Kenaf

Province	Behrman 1937-1963 SR	Behrman 1937-1963 LR	Medhi&Dowling 1967-1977 SR	Medhi&Dowling 1967-1977 LR
Northeast				
Nakornratchasrima	2.61	4.09	1.92	1.85
Buriram	1.92	1.91	.77	-
Srisaket	3.30	3.03	.42	-
Ubonratthani	5.50	22.45	-	-
Khon Kaen	1.67	6.69	-	-
Roi-et	3.31	4.56	-	-

IV. Conclusions and Policy Implications

In this study, we have attempted to estimate the total supply response of four major crops in Thailand (rice, maize, cassava and kenaf) to a number of factors, mainly price yield and risk. Special care has been taken to specify the response model properly: various aspects of area response were used; prices were indexed to reflect the relative influences of competing or complementary crops, and the change through time; the risk factors were incorporated into the model in the form of deviations from the past price and yield; the weather factor as measured by the amount of rainfall was used in some models, whereas the time trend was specified for some rapidly growing crops; and so on. The periods covered were 1963-1977 for rice and maize, and 1967-1977 for cassava and kenaf. The reason for the difference in time period covered was that the data on farm-gate prices for cassava and kenaf were available only from 1967 onward. Most of the data needed in this study were available from the Ministry of Agriculture and Agricultural Cooperatives.

The results of the estimation using mainly non-linear estimation techniques revealed that the price of the crop and its variations are generally significant determinants of supply response measured by the change in area planted. However, the magnitude of this causal relationship varies from crop to crop and from province to province. Take rice for example: It has been sufficiently demonstrated that Thai rice farmers still respond to changes in the price of rice in a normal way, that is to say they tend to grow more rice when its price increases, and grow less rice or more of other crops when the rice price falls, though this responsiveness is weak and many variables such as the limitation of areable land, the size of the farm population, and so on may have influenced this responsiveness. The same positive supply response to price can also be said for all other upland crops, although factors other than price also play important roles in determining the area response. And where price failed to exert its influence on the area response, or did so in a perverse way, reasons can be found to explain the said phenomena. For example, supply response estimates of cassava for Cholburi and Rayong, the two traditional cassava-growing provinces, seemed to be very poor. This could be explained by the fact that the production in the said areas has evolved into plantation-type system where processing plants have been well-established for domestic consumption and disposal. This institutional rigidity has probably reduced the determining effect of price somewhat, but this is a rather special case.

Nevertheless, when compared with Behrman's, our results appear to provide lesser proof of supply responsiveness to price and other related variables. The use of price data could be responsible for this. While Behrman's use of Bangkok prices had turned out to give satisfactory results, we still felt that the proper price variable should be farm-gate prices, not Bangkok prices. Since the data on prices at the farm level have been available only recently, it is possible that the earlier data collected in this new series were not accurate or consistent, and this could disturb the entire estimation process. It is hoped that, as the Ministry of Agriculture's experience in collecting farm-gate prices increases, these price series will become more reliable and more useful for future supply response studies.

In terms of policy implications, a conclusion made by Behrman probably is still valid that an increase in total supply of rice could be induced by lowering the rice premium and, thus, increasing domestic rice prices. We could add that in addition to rice primium, the government could also reduce rice export tax of the local governments and rice reserve requirements. As for other upland crops, the rapid agricultural diversification in recent year gives evidence to the determining power of price to area planted. Since price may fluctuate widely from year to year, it may be the concern of the government to try to dampen the effect of this cyclical swing so that the farmers will not suffer too much in a sudden bad year or gain too much to induce unrestrained enthusiasm in a sudden good year. This constitutes a part of agricultural stabilization program which is outside the confine of this study. Suppice it to say in conclusion that price is an effective and powerful factor creating supply response, but in actual policy, factors other than price can also be important and should be carefully considered in the whole package as we have attempted to demonstrate in this study.

With regard to major upland crops under study, the policy recommendation could be as follows:

(a) It has been shown that price compled with other factors such as guaranteed demand, availability of land areas for productive expansion, and the infrastructural supports (roads, storages, export facilities, and so on), have contributed to the increase in most of upland crops in Thailand. But the increased output has been the result of more extensive cultivation, using up new lands rather than intensive cultivation of the old lands. As a rule, the productivity or yield of maize and cassava production would be sufficiently high in the first few years of cultivation on new lands due to the soil quality. But then the yield would decline, creating a new pressure for land expansion. Fertilizer uses have been small due to its high price as well as the relative ease of acquiring new lands. Now that the land frontier has been pushed to its ecological limit, the question of increased productivity in the existing lands used for upland crops has become of paramount importance if the level of output is to increase or even sustain. The government must seriously reconsider its fertilizer policy which, up to now, has not helped the upland crop farmers very much. Fertilizers should be made more easily available to the farmers at lower prices than now prevailing. In addition to this, there are questions of seed improvement, farm techniques or even agricultural credits for more investments on the farm.

(b) Prices of maize and cassava which have relatively declined in the latter part of the 1970's and the early 1980's have become a major source of concern for farmers and the Government alike. In the beginning of the boom periods in 1960's and early 1970's, the prices were high and the planted areas still kept expanding. Together, they reinforced the profitability of these two crops. Now, if the Government wishes to retain the relative significance of these two crops, it must also reconsider its price policy in addition to its production policy. Either a certain price stabilization scheme be instituted or market demand arranged so that the income of farmers will not be too adversely affected. In the last few years, both price and marketing policies of the Government regarding these two crops have been constantly adjusted to give the best results (for example, when to have or not to have export quota systems, what kind of contracts should be agreed with foreign buyers, what new markets should be explored, and so on). It should continue to do so, discarding bad policies and adopting good ones.

(c) The above policy recommendations are given under the assumptions that the present upland crop systems are to be continued and improved. Price as well as other incentives have been used for that purpose. It should be mentioned here also that the same price incentives can also be used to switch one crop to another, or from cropping to non-cropping activities such as livestock raising or cottage industries. The main points are economic and institutional flexibilities on the part of farmers: they should be able to adjust themselves quickly to new economic incentives and opportunities. And it should be the equal concern of the Government to remove supply regidities and facilitate the said process of adjustments.

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