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Potentials in the economic development of Thailand's agriculture

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POTENTIALS IN THE ECONOMIC DEVELOPMENT

OF THAILAND'S AGRICULTURE

by

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TABLE OF CONTENTS

I. INTRODUCTION

A. The Importance of Agriculture in the Economy of Thailand

The economy of Thailand is predominantly agricultural. The total area is about 514,000 square kilometers or 321 million rai[1] of land. In 1963, farm land occupied about 21.94 percent of the total area and rice which is the main crop of farmers, occupies almost 13 percent or 41.3 million rai of land. Agriculture also occupies over 81 percent of the working population, and, together with a few extractive industries such as tin-mining, lumbering and fishing, forms the essential foundation of the economic structure.

Agriculture in Thailand not only serves as the source of supply for foods and fibers sufficient for home consumption but also is considered as the main source of foreign exchange earnings. During the period of 1951-1962 the annual value of export varied considerably depending mainly on the world market prices and the production of the three main export commodities, namely, rice, rubber and tin, as may be seen from the Appendix. On the whole the importance of these three commodities has shown a steady downward trend in relation to the total value of other exports. It is also significant that for the last three years, the value of export of goods other than rice, rubber and tin, for the first time in Thailand's history, ex-

[1]rai = .359 acres.

ceeded that of rice exports. This was due mainly to the spectacular rise in the exports of jute and kenaf, maize and tapioca products which together in 1961 and 1962 accounted for about 16-17 percent of total exports compared with only about one percent in 1951 (Ungphakorn 1965).

B. Agriculture and the Farmer

Agriculture has an extensive character in the sense that agriculture uses more land than any other form of economic enterprise. Many factors determine the nature and extent of the land-use pattern in agriculture. The importance of physical factors is obvious. Such characteristics as climate, growing season, topography, and soils combine in different ways to establish limits to the type of farming enterprise. Biological factors, such as the geographic extent of pests and the survival characteristics of livestock, also exert an important influence. Those physical factors, associated with biological factors, existing in a particular area determine the type of farming pattern. A certain farm production function, consisting of several individual production functions for crops and livestock using conventional farm tools and implements, exists with variation in different locations. A subsistence type of farming in the most cases probably falls to this form of operation.

However, all of these factors are in a sense, passive. The

Crusoe-firm-households are gradually changing as the national economic growth moves ahead. Changes in relative factor-factor input prices, as well as the relative product output-factor input prices, are encountered by the farm-firms-household complex; therefore, profits or net returns become the attendant motive in adjusting along the existing production function or in creating a new production function.

C. Objectives of this Study

A well-known saying in Thailand is: "the farmer is the back-bone of the nation". Since the largest part of the population is still engaged in agriculture, the gains from national economic growth should reward sufficiently the larger part of the population; i.e., the farmer. Growth that favors the smaller portion of the population and leaves the larger part (the farmer) no better or worse off, might be considered as mis-directed growth.

An analysis of forces that cause farm income to be low in Thailand is the general objective of this dissertation. These forces will be analyzed to considerable extent.

In attaining these general objectives, the study has the following specific objectives:

1. to estimate the production function from a random sample of farms in ten provinces,
2. to use these production functions to compute marginal

productivitive of land, labor and capital and to compare the marginal productivity of different forms of capital and labor used in various types of soil in Thailand,

3. to figure out the relative factor-factor input prices, as well as the relative product output-factor input prices in relation to the marginal productivity of the different forms of capital used,
4. to explain why the farm income is low,
5. to set up the model to increase farm income.

In general, there are two important components that determine gross income of the farmer. These components are farm output and its price. The structure of farm output to be produced will be considered first and the structure of market price will be presented later. The argument of this dissertation is based on the premise that the individual farm unit which controls and commits resources in the productive process, is the decision-making unit. Therefore, we consider that the approach which considers the actions of individual farms and manufacturing firms would be a fruitful method of determining the procedures that will accelerate economic development. So, the following analysis will ensue to the above pattern.

II. THE HYPOTHETICAL MODEL AND THEORETICAL CONSIDERATIONS

Suppose that I am a farm management economist and the Ministry of Agriculture assigns me to help farmers in increasing their incomes. First, I will go to a farm. At a particular farm unit, I will consider the attitude of the farmer regarding my presence. Assume further that the farmer's attitude towards me is quite good in the sense that he recognizes the need for help. In this case, I will then consider his attitude towards his enterprise. This is not a one-day study, but will take a year or more. Next, I will ask the question; what is the existing situations of his farm enterprise? The farmer will face three major categories of considerations.

1. The first category includes resources which he has available. Resources include his land, family labor, farm tools and equipment, as well as his money and his intellectual capabilities.

2. The second category includes the external factors associated with the farm business. Included here are product markets and prices, resource markets and prices for hired labor, borrowed capital and rented land. Also included are technological advancement, risk and uncertainty.

3. The third category includes questions of how to manage the above two categories, to attain maximum profit under the natural risk and uncertainty. The first two categories will

affect the production function selected.

In the changing economy where profit or net return becomes the attendant motive to the farmer in adjusting along the existing production function or in creating a new production function, the marginal productivity of resource used plays an important role to the agricultural development. The new resource input with high marginal productivity will be forthcoming, if the relative price is satisfied. We will examine the various marginal productivities of resource used first; afterward the price condition will be scrutinized.

A. Production Function and Marginal Productivity

From the farmer's resources of land, labor and capital, we can assume the well known Cobb-Douglas production function as shown in equation (2.A.1) (Cobb and Douglas 1928)

$$Y = A\, X_1^{\beta_1} X_2^{\beta_2} \ldots X_m^{\beta_m} \qquad (2.A.1)$$

or

$$Y = A \prod_{i=1}^{m} X_i^{\beta_i} ,$$

where Y is the physical output, $X_i (i=1,2,\ldots,m)$ are the relevant physical inputs in the production procession, and A and β_i are constants. In our case, X_1, X_2, and X_3 are defined as the input of land, capital and labor respectively. The existing form of production function has the properties as follows:

1. The β_i's are the production elasticities with respect to each productive input X_i, respectively.

2. The function is homogeneous of degree $\sum_{i=1}^{m} \beta_i$, the sum of all production elasticities. If the sum of production elasticities is greater than, equal to, or less than one, then there is correspondingly, increasing return to scale, constant return to scale, or decreasing returns to scale.

When the inputs $X_i (i=1,2,3)$ are defined, the marginal productivities of various inputs can be obtained as follows:

The marginal productivity of land is

$$\frac{\partial Y_i}{\partial X_i} = A \beta_1 X_1^{\beta_1 - 1} X_2^{\beta_2} X_3^{\beta_3} , \tag{2.A.2}$$

the marginal productivity of capital is

$$\frac{\partial Y}{\partial X_2} = A\beta_2 X_1^{\beta_1} X_2^{\beta_2 - 1} X_3^{\beta_3} \tag{2.A.3}$$

and the marginal productivity of labor is

$$\frac{\partial Y}{\partial X_3} = A\beta_3 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3 - 1} . \tag{2.A.4}$$

The marginal physical productivity of various inputs has properties as below:

1. The marginal physical productivity of the i^{th} input declines if $\beta_i<1$ as the quantity of the i^{th} input is increased.

$$\frac{\partial Y}{\partial X_i} = A\beta_i \; X_1^{\beta_1} \; X_2^{\beta_2} \; \ldots \; X_i^{\beta_i - 1} \; \ldots \; X_m^{\beta_m} \qquad (2.A.5a)$$

The second derivative of X_i is

$$\frac{\partial^2 Y}{\partial X_i^2} = \beta_i(\beta_i - 1) \; A \; X_1^{\beta_1} \; X_2^{\beta_2} \; \ldots \; X_i^{\beta_i - 2} \; X_m^{\beta_m} \qquad (2.A.5b)$$

and is negative if $\beta_i < 1$.

Observation suggests that the marginal productivities of capital and labor in Thailand are very low. Therefore, the sum of the production elasticities might be expected to be less than one. One might also expect that the output derived from the production process would largely come from land in the traditional agriculture; therefore, the marginal productivity of land would be high relative to the marginal productivities of capital and labor. However, present farming practices pay little attention to the maintenance of suitable levels of either organic matter or plant nutrients. The impoverishment of the soil still continues. These conditions will cause the marginal productivity of land to gradually decline.

It is quite typical that the year-by-year investments of farmers are made in line with their historical experiences of their customary inputs such as ploughes and harrows, carts, sickles, knives, ropes, draft animals, including the maintenance and repairing of house, granary and animal pen and hired help labor during the peak season. These inputs have low productivity. Hence, where there are only forms of capital used, the marginal productivity of capital is expected to be low.

The lack of alternative employment opportunities outside of agriculture causes the predominant portion of the labor force to engage in agriculture. For it is the lack of alternative employment opportunities that makes it impossible to shift any significant portion of labor force to the non-agricultural sector. The entire agricultural labor force can be used effectively during the growing and harvesting seasons but not during the in-between periods. The marginal productivity of labor is probably exceeding low in this case. Furthermore, the marginal productivity of labor is low because agriculture is characterized by an excess number of farm workers applied to the ancestor's pattern of farming.

As mentioned above that the marginal productivities of capital and labor are low. However, the new forms of capital inputs such as chemical fertilizers, machines are available in the market. The new capital inputs are usually known by the farmer that it will increase yield per acre or saving the labor used. The problem will arise that why the farmer is seldom to use the new form of capital inputs. The amount of new capital inputs to be used in agriculture is linkage to the marginal productivity and the relative price. We will examine price structure in the next section.

B. Market Model

In Thailand, the buyer of farm products is generally the seller of agricultural inputs. This same merchant also handles the sale of consumption items. Consequently, the farmer sells his products and buys factor inputs such as tools and equipment and also consumptive items from the same store. This merchant also is the chief source of credit to the farmer.

We will examine a brief sketch of the market structure of agricultural products in Thailand.

1. A general business transaction

Farmers grow rice as a main crop for home consumption. The rice surplus, after deducting the home use, is not large. It is sold on the market for income. The upland crops such as castor-beans, soybeans, mungbeans, jute, kenaf, bananas, etc., are grown not only because of they grow better than rice in the upland area, but because the income from upland crops supplement cash income. Livestock such as poultry, hogs and draft animals is produced for similar reasons.

A number of exporters, most of them in Bangkok, have representative dealers as wholesale dealers. The wholesale dealers also have local representative dealers in the local areas. The exporter and the wholesale dealer, in many cases, are the same. Similarly, the wholesale dealers are the local dealers. The local dealers receive the money in advance from the wholesale dealer and act as the agencies in the rural area to buy crops and livestock from farmers and to loan money to farmers. Each local dealer usually has a specific wholesale dealer in Bangkok, but in some instances he has more than one. The local dealer buys almost all the farm products that are grown in that region. Storage capacities are limited, so, if the crop has been large enough for shipping he would ship to the wholesale dealer in Bangkok. The shipping mechanisms are truck, railroad, and boat, depending on convenience of facilities. When the truck reaches the wholesalers place, the wholesaler will count and weigh the crops and pay at that day's market price. The wholesale dealer will give the current price list to the local dealer and the truck driver or the local dealer representative will then take it back to the local area.

The price list sheet includes all prices of crops in which the wholesale dealer does business. The daily prices of crops at the local dealers store are the prices that are deducted from the expected cost of handling, transportation and the local dealer profit per unit of crop measurement. This is a practical business transaction for upland crop dealers in the rural area. From the writer's long-time observation and discussion with many rural crop dealers, he found that almost all rural crop dealers in a certain region set up a similar price for a particular crop, even though they received a different price information sheet from a different Bangkok wholesaler. This is the normal situation that prevails in the rural area. If prices of crops sometimes vary among rural crop dealers, it could result from the following causes:

a. Suppose that A is an exporter who has a number of correspondent Bangkok crop wholesalers. He has a signed contract with a Japanese importer to deliver corn in June. If, during March and April, A does not have enough corn for delivery and a cargo ship is expected at the Bangkok port during the second half of April and this cargo ship is the only ship that will deliver corn to the Japanese importer in time, A has to hurry in collecting enough corn for shipping. If this is the case, his price of corn would increase in the certain line of business transactions which A is associated with. Price of corn in some local dealer areas would go up as an incentive for collecting a larger amount of corn.

b. In a similar situation, if corn has been collected in advance in large amounts for the contract which would be delivered in the future, price of corn, in this line of transaction would go down.

c. The Bangkok wholesaler not only sells his output to an exporter but to local distributors when some crops are scarce in that region. Sometimes, they expand their credit to a very large degree for many varieties of crops traded. If the credit transactions are tight due to any reason, the whole set of prices in this line of transaction would go down.

These are the major causes of the different prices of local dealers. There are some other causes which will explain this phenomena, but they will not be considered here and may be assumed to be minor causes.

2. The type of market structure

The interesting point to be made here is one involving the question, what kinds of markets described by economic theory would be suitable for analyzing these situations. Observations show that the final prices set up for each crop by different local dealers in a certain region are almost always the same. Assume that each line of business transaction involves the same firm and that each firm has many branches of business transactions. Each firm has farm products as the input and, after some processing and/or storing, these products will be sold as the output. Homogeneity of products will be assumed here. Each firm operates two major parts of business; buying crops from the farmers and loaning money to the farmers. The rate of interest prevailing in the local market is almost the same for each local dealer, as it is with the product prices.

An attempt is made to generally classify individual industries as competitive or monopolistic. No attempt is made to give a detailed classification to specific crops or livestock. In neoclassical economic theory, pure competition and monopoly represent the polar extremes of types of markets. The essence of a competitive market is its impersonal character. No individual buyer or seller can exert significant influence on demand or supply, but the interaction of all participating together determines the price of the homogeneous commodity being traded by the combined effect of their independent actions. In contrast, monopoly features an isolated participant on one side of the market. The only alternative the monopolist provides to his buyers or sellers is acceptance or rejection of the price he establishes.

We now recognize that while the distinction between the polar extremes of competition and monopoly may be clearcut, actual market situations may fall into neither extreme, or not even close to either, but will fall in between these two polar extremes.

A broad view for the market situations prevailing in agricultural products in Thailand may be classified by three categories.

a. Monopoly - monopsony

b. Oligopoly - oligopsony

c. Perfect competition

a. Monopoly - monopsony There is no distinction between the industry and the firm in a monopolistic market. The demand function of a monopolist can be expressed as

$$q = f(p) \qquad (2.B.1)$$

where q is quantity and p is price and $dg/dp<0$. The demand curve has a unique inverse, and price may be expressed as a single-valued function of quantity:

$$p = F(q) \tag{2.B.2}$$

where $dp/dq<0$ which is the monopolist's price decreases as he increases his sales. If the monopolist is also a monopsomist, the price which the monosonist must pay is generally an increasing function of the quantity he purchases. In the case of a monopolist-monopsonist who uses a farm product for the production of a final form of agricultural product which he sells in a monopoly market, his production function states output as a function of the quantity of farm product (x) employed:

$$q = G(x) \tag{2.B.3}$$

The cost equation and revenue function are

$$C = rx, \; R = pq$$

where r is the price of a farm product. However, the price of farm product is now an increasing function of the amount purchased:

$$r = H(x) \tag{2.B.4}$$

where $dr/dx>0$. The equation (2.B.4) is nothing more than the supply function of the farm product.

His profit may be expressed as a function of the quantity of the farm product which he purchases (Henderson and Quandt 1958):

$$\Pi = pq - rx = F[G(x)]\ G(x) - H(x)x \qquad (2.B.5)$$

where total revenue and total cost are expressed as functions of the quantity of farm product purchases.

Setting the derivative of (2.B.5) with respect to x equal to zero,

$$\frac{d\Pi}{dx} = p\,\frac{dq}{dx} + q\,\frac{\partial p}{\partial q}\,\frac{dq}{dx} - r - x\,\frac{dr}{dx} = 0 \qquad (2.B.6)$$

The first order condition for profit maximization requires that the quantity of farm product be employed up to a point at which the value of its marginal product equals its marginal cost. The second-order condition requires that the rate of change of the value of the marginal product of farm product be less than the rate of change of its marginal cost, that is

$$\frac{d^2\Pi}{dx^2} < 0 .$$

The monopolist-monopsonist's optimum output and the price of farm product are determined by solving (2.B.6) for x and substituting the value for which the second order condition is satisfied.

The equation (2.B.6) can be also expressed

$$[p + q \frac{\partial p}{\partial q}] \frac{dq}{dx} = r + x \frac{dr}{dx} \qquad (2.B.7)$$

we shall see that $(p + q \frac{\partial p}{\partial q})$ is ordinary marginal revenue for monopoly and dq/dx is the marginal productivity, finally the whole magnitude of $[P + q \frac{\partial p}{\partial q}]\frac{dq}{dx}$ is the value of marginal productivity for monopoly or the demand curve of the firm. The magnitude of [r + x dr/dx] is the marginal cost of firm and since dr/dx>0, the marginal cost of the farm product exceeds its price for x>0. Then the price of farm product can be expressed as:

$$r = p \frac{dq}{dx} + q \frac{\partial p}{\partial q} \frac{dq}{dx} - x \frac{dr}{dx} \qquad (2.B.8)$$

where dq/dx>0, ∂p/∂q<0 and dr/dx>0. That is the price of farm product (r) is low.

Suppose that the production function of the firm is not only a function of the input x but also a function of y and L. Let us define y as the amount of labor needs for processing and distributing services and the amount of y would be increased if the amount of x increases. L is defined as the amount of loan that the monopolist-monopsonist makes to farmers in order to increase the amount of x where will be purchased. Then the production function may be expressed as:

$$q = G(x,y,L) \qquad (2.B.9)$$

and

$$y = y(x), \quad L = L(x)$$

The monopolist-monopsonist's profit may be expressed as a function of the quantity of farm product which he purchases.

$$\Pi = F[G(x,y,L)]\ G(x,y,L) - H(x)x - Sy(x) - ZL(x) \tag{2.B.10}$$

where S and Z are the price of labor and the cost of loan, respectively.

Setting the derivative of (2.B.10) with respect to x equal to zero:

$$\frac{d\Pi}{dx} = p\,\frac{dG}{dx}\,(x,y,L) + q\,\frac{dF}{dx}\,[G(x,y,L)] - r - x\,\frac{dH(x)}{dx}$$

$$- S\,\frac{dy}{dx}(x) - Z\,\frac{dL}{dx}(x) = 0$$

$$= [p + q\,\frac{dp}{dq}]\,[\frac{\partial q}{\partial x} + \frac{\partial q}{\partial y}\,\frac{dy}{dx} + \frac{\partial q}{\partial L}\,\frac{dL}{dx}] = r + x\,\frac{dr}{dx}$$

$$+ S\,\frac{dy}{dx} + Z\,\frac{dL}{dx} \tag{2.B.11}$$

If we compare the equation (2.B.7) and the equation (2.B.11) and assume that the amount of farm product (x) is the same, one would see that the price of the farm product of the latter case is lower.

The monopolist-monopsonist may be thought of as employing various quantities of factors x_{m+1}, $x_{m+2}, \ldots, x_n$ to produce quantities of products q_1, $q_2, \ldots, q_m$. Its object is to maximize its profit (Hicks 1946)

$$\Pi = p_1q_1 + p_2q_2 + \ldots + p_mq_m - p_{m+1}x_{m+1} - p_{m+2}x_{m+2} - \ldots - p_nx_n \tag{2.B.12}$$

subject to the production function connecting the q's and the x's. Since, from the firm point of view, the difference between factor and product is only a difference in sign, it will save trouble if we treat the products as negative inputs, write $q_K = -X_K$, then the production function can be expressed as the implicit function:

$$F(q_1, q_2 \ldots q_n) = 0 \tag{2.B.13}$$

We may then say that the firm is seeking to maximize

$$\Pi = \sum_{k=1}^{n} p_k q_k \tag{2.B.14}$$

subject to the production function (2.B.13).

If we assume that the demand curves for the various products are dependent, so that p_1 depends not only on q_1 but also on $q_2 \ldots q_m$, the supply curves of the various farm products are also dependent, so that the price of farm product r_{m+1} depends not only x_{m+1} but also $x_{m+2} \ldots x_n$. Therefore, the firm's profit function can be also expressed as

$$\Pi = \sum_{i=1}^{m} q_i p_i - \sum_{i=m+1}^{n} x_i r_i + \lambda F(q_1, q_2 \ldots q_n) \qquad (2.B.15)$$

Setting the partial derivatives of (2.B.15) equal to zero:

$$\frac{\partial \Pi}{\partial q_k} = p_k + \sum_{i=1}^{m} q_i \frac{\partial p_i}{\partial q_i} + \lambda \frac{\partial F}{\partial q_k} = 0 \qquad (2.B.16)$$

$$\frac{\partial \Pi}{\partial x_j} = - r_j - \sum_{i=m+1}^{n} x_i \frac{\partial r_i}{\partial x_j} + \lambda \frac{\partial F}{-\partial x_j} = 0 \qquad (2.B.17)$$

$$p_k + \sum_{i=1}^{m} q_i \frac{\partial p_i}{\partial q_k} = - \lambda \frac{\partial F}{\partial q_k}$$

$$r_j + \sum_{i=m+1}^{n} x_i \frac{\partial r_i}{\partial x_j} = - \lambda \frac{\partial F}{\partial x_j}$$

$$r_j + \sum_{i=m+1}^{n} x_i \frac{\partial r_i}{\partial x_j} \Big/ p_k + \sum_{i-1}^{m} q_i \frac{\partial p_i}{\partial q_k} = - \lambda \frac{\partial F}{\partial x_j} \Big/ - \lambda \frac{\partial F}{\partial q_k}$$

$$r_j + \sum_{i=m+1}^{n} x_i \frac{\partial r_i}{\partial x_j} = [p_k + \sum_{i=1}^{m} q_i \frac{\partial p_i}{\partial q_k}] \, [\frac{\partial q_k}{\partial x_j}] \qquad (2.B.18)$$

The equation (2.B.18) is the equilibrium condition that is the marginal cost equal to the marginal revenue. If the factors of production are not independent of each other, the marginal productivities $[\partial q_k/\partial x_j]$ which the input x_j is the direct input for producing output k will be changed to become similar to the marginal productivity of equation (2.B.11). And if the cross-coefficients ($\partial p_i/\partial q_k$ etc.) are negative, the case in which the different products are competitive in consumption, such as beef and pork and also different brands of cigarettes, involve reactions which will lower the marginal revenue curve for any particular product, and so tend to restrict output. The cross-coefficient ($\partial r_i/\partial x_j$ etc.) are positive. The case in which the different farm products are competitive, as in the above example, involves reactions which will also raise the marginal cost curve for any particular product. Finally, the price of farm product is forced to be low. Besides the tobacco monopoly which is monopolized by the government, the hog and beef cattle-buffalo slaughter house in Bangkok would be considered as the monopolistic-monopsonistic firm. The prices of pork and meat in the consumer market are high; but the prices received by the farmers are low. The behaviors that the quantities of pork and beef to be sold in the capital city, which is the largest source of beef and pork consumption market are monopolized by only one slaughter house is a good example of how the above mathematical model would work.

b. Oligopoly-oligopsony An oligopolistic industry contains a number sufficiently small that the actions of any individual seller have a perceptible influence upon his rivals. It is not sufficient to distinguish oligopoly from perfect competition for a homogeneous product or from the many-sellers case of monopolistic competition for a differentiated product on the basis of the number of sellers alone. The essential distinguishing feature is the interdependence of the various sellers' actions. If the influence of one seller's quantity decision upon the profit of another, is imperceptible, the industry satisfies the basic requirements for either perfect competition or the many-sellers can of monopolistic competition. If the influence of one seller's quantity decision upon the profit of another is of a noticeable order of magnitude, it is a duopolistic or oligopolistic (Henderson and Quandt 1958). If the oligopolist acts also as oligopsonist in the market and two firms are assumed to produce a homogeneous product; therefore, the inverse demand function would state price as a function of the aggregate output sold:

$$p = F(q_1+q_2) \qquad (2.B.19)$$

where q_1 and q_2 are the levels of the outputs of the oligopsonist-oligopsonist I and II respectively. The supply curve of the farm product can be also expressed as

$$r = H(x_1+x_2) \qquad (2.B.20)$$

where x_1 and x_2 are the levels of the inputs of these two firms and each firm production function can be expressed as

$$q_1 = Q_1(x_1) \qquad (2.B.21)$$

$$q_2 = Q_2(x_2) \qquad (2.B.22)$$

The total revenue of each firm depends upon his own output level and that of his rival:

$$R_1 = q_1 F(q_1+q_2) \qquad (2.B.23)$$

$$R_2 = q_2 F(q_1+q_2) \qquad (2.B.24)$$

The profit of each equals his total revenue less his cost, which depends upon his input level alone:

$$\Pi_1 = Q_1(x_1)F[Q_1(x_1)+Q_2(X_2)] - x_1 H(x_1+x_2) \qquad (2.B.25)$$

$$\Pi_2 = Q_2(x_2)F[Q_1(x_1)+Q_2(x_2)] - x_2 H[x_1+x_2) \qquad (2.B.26)$$

Setting the appropriate partial derivatives of (2.B.25) and (2.B.26) equal to zero,

$$\frac{\partial \Pi_1}{\partial x_1} = p\,\frac{dq_1}{dx_1} + q_1\left[\frac{\partial p}{\partial q_1}\,\frac{dq_1}{dx_1} + \frac{\partial p}{\partial q_2}\,\left[\frac{\partial q_2}{\partial x_2}\,\frac{dx_2}{dx_1}\right]\right]$$

$$- r - x_1\,\left[\frac{\partial r}{\partial x_1} + \frac{dr}{dx_2}\,\frac{dx_2}{dx_1}\right] = 0 \qquad (2.B.27)$$

$$\frac{\partial \Pi_1}{\partial x_2} = p\,\frac{dq_2}{dx_2} + q_2\,\left[\frac{\partial p}{\partial q_2}\,\frac{dq_2}{dx_2} + \frac{\partial p}{\partial q_1}\,\left[\frac{\partial q_1}{\partial x_1}\,\frac{dx_1}{dx_2}\right]\right]$$

$$- r - x_2\,\left[\frac{\partial r}{\partial x_2} + \frac{\partial r}{\partial x_1}\,\frac{dx_1}{dx_2}\right] = 0 \qquad (2.B.28)$$

First-order conditions require that each firm equate his MR to his MC.

If each firm has the same conditions with respect to the processing plant and management, then, $\frac{dq_1}{dx_1}$ would be equal to $\frac{dq_2}{dx_2}$. Let $\frac{\partial p}{\partial q_1} = \frac{\partial p}{\partial q_2}$ and $\frac{\partial r}{\partial x_1} = \frac{\partial r}{\partial x_2}$.

The equation (2.B.27) can be rewritten as:

$$p \frac{dq_1}{dx_1} + q_1 \left[\frac{\partial p}{\partial q_1} \frac{dq_1}{dx_1} + \frac{\partial p}{\partial q_1} \left[\frac{\partial q_1}{\partial x_1} \frac{dx_2}{dx_1}\right]\right]$$

$$= r + x_1 \left[\frac{\partial r}{\partial x_1} + \frac{\partial r}{\partial x_1} \frac{dx_2}{dx_1}\right]$$

$$p \frac{dq_1}{dx_1} + q_1 \frac{\partial p}{\partial q_1} \frac{dq_1}{dx_1} \left[1 + \frac{dx_2}{dx_1}\right] = r + x_1 \frac{\partial r}{\partial x_1} \left[1 + \frac{dx_2}{dx_1}\right]$$

(2.B.29)

The magnitude of "dx_2/dx_1" is nothing more than the "conjectural variations." We can see that dx_2/dx_1 is negative and firm I can increase his profit if the more x_1 can be bought. One of the most popular practices to increase the firm input is to make loans to farmers. The more farm products are needed, the more and more loans would be increased. Therefore, the production function might be similar to the equation (2.B.9).

The oligopoly-oligopsony model of equations (2.B.27), (2.B.28) and (2.B.29) would very well represent the market structures of various upland crops such as corn, soybeans, mung-beans, castor beans, jute and kenaf etc. which were described earlier and we shall not repeat in detail here. Each line of business transaction included exporter, Bangkok wholesaler and local representative dealers, acting as a oligopolist-oligopsonist altogether having the exporter-Bangkok wholesaler as the headquarters. Even though there are many different solutions for oligopolistic-oligopsonistic market concerning the profit of each is the result of the interaction of the decisions of all market members. Nevertheless, the oligopolist-oligopsonist making loans to farmers would be considered as one of other ways of seeking to increase his profit. The collusion solution and the Stockelberg solution might also be considered as the other solutions. It might be possible to believe that oligopolist-oligopsonists of Bangkok's headquarters may recognize their mutual inter-dependence and agree to act at some certain degree in unison in order to maximize the total profit of the industry. Furthermore,the leadership and followership is also a possible solution that the small scale oligopolist-oligopsonists desire to be a follower.

Since farmers have to borrow the money from the local merchants in order to support their family living and to invest in their farm operations, and those farmers usually have to repay the loans during the harvesting period, the farmer must sell his crops during lowest prices within the year. The interest rate is quite high, partly due to risk and uncertainty in agriculture. The farm which depends upon a single crop and some number of chickens will very adversely be effected if the weather is unfavorable. This farm will hardly be able to repay the loan. The risk and uncertainty of this type will form part of the cause of a high rate of interest. The linkage of this type between farmer and merchant has been taking place for a long time. Evidence shows that the upland crops have a narrow market in the sense that those crops will be sold to the local dealers and the local dealers have to sell to their corresponding Bangkok's wholesalers for export or distributing to other areas; hence the oligopoly-oligopsony type of market will still exist.

c. Perfect competition As we mentioned before, if the influence of one firm's decision upon the profit of another is imperceptible, the industry would satisfy the basic requirements for perfect competition of the homogeneous product and the many firms case. The oligolpoly-oligopsony type of market will be developed into perfect competition if any particular crop has a wide market. The rice market for example has been developed from oligopoly-oligopsony to perfect competition or nearly perfect competition. In the old days when the city and the urban populations were much smaller than now-a-days, farmers lived almost everywhere. Almost every farmer grew a paddy for his home consumption. Farmers processed their paddies for consumption with primitive tools of processing at home or within their communities. The rice surpluses from home consumptions were sold in the open market. A very excellent document concerning rice marketing can be found in Ingram's book on Economic change in Thailand since 1850 (Ingram 1955). The relevant subject matter can be introduced as follows:

> "The weight of evidence seems to justify the conclusion that rice was a common item of export in Siam before 1850, but that the volume of exports was erratic, depending as it did on conditions in Siam as well as on the nature of the foreign demand---."
>
> "The first steam rice mill in Thailand was constructed in 1858 by an American firm. The mill was not an immediate success and it changed hands several times, finally ending in Chinese ownership. By 1867 there were only 5 important rice mills in Bangkok, but the number increased to 23 in 1889, 25 in 1892, 27 in 1895, 59 in 1910, 66 in 1919, 71 in 1930, and 72 in 1941. Since 1910 the number of mills in Bangkok has thus not increased very much."
>
> "The mill in Bangkok are mostly run by steam, and they are much larger than the up country mills. The capacity of the Bangkok mills, which we call "large", is 100 to 200 tons of paddy per day. The country mills have a capacity of 30 to 40 tons per day."
>
> "The number of mills outside Bangkok has increased greatly in the last three or four decades.---. In the entire country and outside of Bangkok, there were about 500 mills in 1930 and about 800 in 1950.---. A very recent development is the use of small, portable mills with a capacity of only 8 to 12 tons per day. In early 1952, it was estimated that as many as 4,000 of these portable mills were operating. They provide keen competition to the larger mills."
>
> "The trend toward a large number of small mills scattered over the country has changed the marketing pattern. Formerly, farmers sold their surplus paddy and kept the rest at home, where they milled it by hand. Now, the farmer more frequently takes his entire crop to the mill and receives a certain percentage of cleaned rice in return. This he either eats or sells."
>
> "For many years the big rice mills along the Chao phya River near Bangkok processed almost all rice

> exports, and even in 1950 the great bulk of rice exports still passed through them."

The development of portable mills during the 1950's created the new market structure. As the city and urban populations have been growing up throughout the country, the demand for mill rice has been increased. The upcountry investors evidently could afford the establishment of portable mills. These portable mills buy paddies from the nearby farmers and sell milled rices to the nearby towns. Farmers have more convenience in processing their rice. One of the most common practices is that the farmer brings his paddy to the mill for processing without pay and the mill receives the rice bran in return. In making the business more profitable, the mill seeks to expand its number of farmer customers by providing more services to the farmers. In some places the mill handles the transaction by taking the entire paddy from the farmer and the farmer will sell his expected surplus portion to the mill at the future market price. When the farmer feels that he should sell his surplus product, the price at that time will be paid by the mill to the farmer. The farmer also can pick up, at any time without cost, any portion of his paddy as milled rice which he has reserved for home consumption. The portable mill tries to collect the maximum possible quantity of rice from the farmers. If the mill does have a job in processing throughout the whole year, depending upon how much paddy the miller has, it would be the ideal for the portable mill business. The miller can sell milled rice throughout the year. The more new portable mills set into operation, the more competition would occur. The larger number of independent millers in the rural area have changed the oligopoly-oligopsony by the big millers to be a perfect competition or nearly perfect competition.

The surplus of paddy from any region will be sold to other regions. Most of the paddy in the larger surplus areas always is sold to the big millers along the Chao phya River near Bangkok. Milled rice from big millers will either supply Bangkok's market or export trade or both and sometimes, when the shortage of rice occurs in some provinces, milled rice from the big millers in Bangkok will also be supplied to the shortage provinces.

Thailand is a rice exporting country. After World War II, the rice export market was operated entirely by the Thai government. Since January, 1955, while the world rice market has been changed from a seller's market to be a buyer's market, the export of rice changed hands from the government to the individual exporters. Since then, and until now, the government receives a benefit from rice exports by collecting an export tax. The tax imposed to replace the rice monopoly profits was called an export premium. The rate of this "export premium" would change according to world market conditions, and is used as an instrument for preserving rice supplies for domestic consumption at low prices. The rice premium is a major source of government revenue. Although its importance has been steadily declining over the years, it still provides 8 to 10 percent of government revenues. The magnitude of the rice premium as compared to the export price would be considered as the major source of the farm price determination. A low quality of paddy including rice bran has an export value of 1,350 baht[1] (f.o.b.). The rice premium for export on this rice will amount to 495 baht, while the processing costs, transportation cost and middleman profits are about 284 baht, assuming the farm is located in Nakorn phanom, about 30 kilometers from the nearest rice mill (Heyman, Rosen, Taylor, Wilson and Zwick 1965). Undoubtedly, the fact that the farm price of rice is very low even though the market structure is highly competitive is largely due to the rice premium.

The determinations of the price of rice might be set up in the following fashion: Let P_D be the domestic price and the domestic price P_D would be equal to export price P_E, if no tax (t) is imposed. Rice can be exported, if the export price is equal to P_D+t. That is $P_E = P_D + t$. The equilibrium condition can be expressed as

$$D_D(P_D) + D_E(P_E) - S(P_D) = 0 \qquad (2.B.30)$$

---

[1]\$1 equals to 21 baht, approximately.

where $D_D(P_D)$, $D_E(P_E)$ and $S(P_D)$ are the domestic demand function, export demand function and supply functions, respectively, and P_D, P_E are the functions of t. Differentiating (2.B.30) with respect to t,

$$\frac{\partial D_D}{\partial P_D}\frac{dp_D}{dt} + \frac{\partial D_E}{\partial P_E}\frac{dp_E}{dt} - \frac{\partial S}{\partial P_D}\frac{dp_D}{dt} = 0$$

$$\frac{\partial D_D}{\partial p_D}\frac{dp_D}{dt} + \frac{\partial D_E}{\partial P_E}\left[\frac{dp_D}{dt} + 1\right] - \frac{\partial s}{\partial P_D}\frac{dp_D}{dt} = 0$$

$$dp_D = \frac{-\dfrac{\partial D_E}{\partial p_E}}{\dfrac{\partial D_D}{\partial p_D} + \dfrac{\partial D_E}{\partial p_E} - \dfrac{\partial s}{\partial p_D}} \cdot dt \qquad (2.B.31)$$

One will see that the magnitude of $\partial D_E/\partial p_E$, $\partial D_D/\partial p_D$, in equation (2.B.31) are negative; therefore, if the real values are substituted, the equation (2.B.31) then becomes,

$$dp_D = -\frac{\dfrac{\partial D_E}{\partial p_E}}{\dfrac{\partial D_D}{\partial p_D} + \dfrac{\partial D_E}{\partial p_E} + \dfrac{\partial s}{\partial p_D}} dt$$

or

$$dp_D = -\frac{d_E \cdot \dfrac{q_E}{p_E}}{d_D \dfrac{q_D}{p_D} + d_E \dfrac{q_E}{p_E} + s \dfrac{q_s}{p_D}} \cdot dt \qquad (2.B.32)$$

where the elasticities of demand for domestic, export and of supply are defined as

$$d_D = -\frac{\partial q_D}{\partial p_D} \cdot \frac{p_D}{q_D}\ ,\ d_E = -\frac{\partial q_E}{\partial p_E}\frac{p_E}{q_E} \text{ and } s = \frac{\partial q_s}{\partial p_D}\frac{p_D}{q_s}$$

respectively. Evaluating at the initial equilibrium where t=0 and the change of the premium is equal to t; therefore, the change of domestic price can be expressed as,

$$dp_D = -\frac{d_E q_E t}{d_D q_D + d_E q_E + s q_s} \qquad (2.B.33)$$

The magnitude of $d_E q_E / d_D q_D + d_E q_E + s q_s$ is the less than one. If the elasticities of domestic demand and supply are inelastic and close to zero, the above magnitude would come close to one. The magnitude in question is also dependent on the quantity of domestic demand and supply as well as the quantity of export and it's elasticity, all of which can be estimated. Assume that the magnitude of $d_E q_E / d_D q_D + d_E q_E + s q_s$ is equal to .5 and the rice premium is 500 baht, the decrease in domestic price would be 250 baht and the reverse is also true. Now, we come to the conclusion that rice premium reduces the prices farmers receive for their rice, but the decreasing or increasing of the price will be less than the increasing or decreasing of the magnitude of rice premium.

From the above analysis one will see that the market structure which determines the price of farm product is unfavorable. The imperfection of product market causes the price to be low. Most of farm produces will be sold in the imperfect competition market. Besides, the farm product to be sold is linkage with the borrowed money; hence, the farmer has to sell his product during the harvesting period which the price is lowest. Although, rice marketing is more competitive; yet, the rice premium would reduce the price received by the farmer. As mentioned earlier that the relative price is one of other factors that determines the amount of input used. The more elaborate analysis concerning the marginal productivity and price ratio will be examined in the following section.

C. The Existing Farm Operations

1. Single factor input determination

According to previous experiences in Thailand, it appears that farmers in this land do respond to economic incentives. Hence, it is reasonable to believe that they try to maximize the returns from their resources. Supposing farmers know that the application of chemical fertilizer will increase crop yield. A relevant production function can be expressed as:

$$y = a + bx - cx^2 \qquad (2.C.1)$$

where y is the yield per acre, x is the amount of mixed chemical fertilizer application per acre and a, b are the parameters.

The profit equation, then expresses as

$$\Pi = ap_y + bp_y x - cp_y x^2 - (k + p_x x) \qquad (2.C.2)$$

where p_y, p_x and k are the price of product, the price of fertilizer and fixed cost respectively.

Profit is a function of x and is maximized with respect to x. Setting the derivatives of (2.C.2) with respect to x equal to zero,

$$\frac{d\Pi}{dx} = bp_y - 2cp_y x - p_x = 0 \qquad (2.C.3)$$

$$b - 2cx = \frac{p_x}{p_y} \qquad (2.C.4)$$

From equation (2.C.4) it is obvious that to maximize profit the marginal product will need to decrease, through addition of x, as factor price decreases relative to product price. An increase in the magnitude of p_x relative to p_y will call for an increase in the magnitudes of the marginal product, b-2cx, by a reduction in magnitudes of x. For simplicity, suppose that $\bar{p}$ is equal to $\frac{p_y}{p_x}$ which is the inverse of the right hand side of previous expression. The amount of fertilizer application will be determined by,

$$x = \frac{1}{2c}\left(b - \frac{1}{\bar{p}}\right) \qquad (2.C.5)$$

The equation (2.C.5) means that if the ratio of product price to factor price ($\bar{p}$) is large, the large magnitude of fertilizer application (x) will be forthcoming.

According to the previous section we know that the price of product is generally low, furthermore, most of the farmers sell their product at harvesting period; therefore, it is obvious that the low magnitude of $\bar{p}$ will prevent a large increase in the chemical fertilizer applications in Thailand. For the time being, one would believe that more and more farmers know the usefulness of fertilizer. The wider use made of application of animal manure is the answer for the above proposition while the animal manure can be used at lower cost. Even though the determinants of chemical fertilizer with variation from farm to farm and year to year, depending upon the soil, seed, and water, the relative price of crop and fertilizer is one of the most important. The wider application of chemical fertilizer would be realized, if the price ratio is favorable and the yield per acre of crop would be increased.

2. Multiple factor input determination

Now, we turn to over all farm operations. The marginal rate of substitution among input factors would be one of the most important economic criteria. Employing the production function as the same as equation (2.A.1) as land (x_1) is fixed, the farmer will have alternative choices in using labor (x_3) and capital (x_2) along the particular isoquant of some certain output, then the isoquant equation can be expressed as:

$$x_2 = \left[\frac{y}{Ax_1^{B_1} x_3^{B_3}}\right]^{\frac{1}{B_2}} \quad (2.C.6)$$

The expansion path generated by the Cobb-Douglas function is linear. The first-order conditions for a constrained optimum require that

$$\frac{px_2}{px_3} = \frac{\partial y}{\partial x_2} \Big/ \frac{\partial y}{\partial x_3} \quad (2.C.7)$$

$$\frac{px_2}{px_3} = \frac{B_2 x_3}{B_3 x_2} \quad (2.C.8)$$

where px_2 and px_3 are the prices of x_2 and x_3 respectively. Therefore, the expansion path is given by the implicit function

$$px_2 B_3 x_2 - px_3 B_2 x_3 = 0 \quad (2.C.9)$$

which describes a straight line emanating from the origin in the isoquant plane.

If it is obvious that labor is redundant in agriculture and the rate of interest is very high, the optimum point would be at which a relatively small amount of capital will be used and the amount of labor-day employed would be relatively large. As far as the economic growth does not cause differential changes in factor prices in the sense that capital declining is relative price and labor increasing in relative price as it is demanded more for secondary, and tertiary industries, the existing optimum point would not change.

3. Risk and uncertainty involved in the input allocation

The above analysis has referred only indirectly to time. In most cases, however, the time involved in agriculture production does preclude perfect knowledge of the future; and therefore, decision making must take place in an environment of risk and uncertainty. Plans in agriculture must be made at one point in time for a product which will be forthcoming at a future point in time. The producer is faced with two types of eventualities or outcomes which have bearing on plans for the future. One of these is risk; the other is uncertainty. Risk refers to variability or outcomes which are measurable in an empirical or quantitative manner. In contrast to risk, the probability of an outcome cannot be established in an empirical or quantitative sense of uncertainty. Uncertainty is, therefore, entirely of a "subjective" nature. It simply refers to anticipations of the future and is peculiar to the mind of each individual producer. Uncertainty arises because the entrepreneur must formulate an "image of the future" in his mind but has no quantitative manner by which these predictions can be verified. If we take risk and uncertainty in agricultural production together and keep the price ratio of px_2, px_3 of equation (2.C.7) constant, the writer would propose that the amount of x_2 and x_3 of the future known with certainly would be different from the imperfect knowledge of the future. Let x_2^* and x_3^* be the amount of capital and labor-day used in the imperfect knowledge of the future. In Thailand, the actual use of x_2^* and x_3^* might be in the case that $x_2^* < x_2$ and $x_3^* > x_3$. As far as the capital is scarce with high rate of interest interacting with high risk and uncertainty in agricultural production the more intensive use of family labor would be expected. The balance between the loan money to be invested and the family labor used are the critical points of consideration. In borrowing money from somebody else, the outcome of being able to repay a loan in the future must be clear. If the experiences show in some instances that many farmers have gone deeper and deeper in debt and eventually became tenants later on due to high risk and uncertainty in agriculture in repaying loans one may expect that less loan, but more security of the family would be the possible outcome. Furthermore, in many cases, though the farmer needs loans, he cannot borrow from any source, and more intensive use of family labor must be expected.

It is quite clear then why the farmer always invests in inputs which he is accustomed to, that is, precisely the same type of tools and implements, draft animals, seeds, and so on used by farmers for generations and that the small amount of income received from his farming enterprise forces him to do so would be considered as the general case. The high risk and uncertainty of the existing agricultural pattern combined with the scarcity of credit supply and high rate of interest force farmers to apply more intensive family labor. The low rate of return to investment due to the above types of markets also causes the income to be low.

D. The Prospective of Developmental Growth of Farm Unit

It has been shown that the area size of the farm is too small. The rate of interest is too high and most of the farmers have to sell their products at harvesting time in order to pay debts as well as to receive cash for their family living. At the harvesting period, the prices of all products are at the lowest prices during the year. As far as the farm production function is concerned, the farm output sold in the open market is quite small in amount per farm family associated with the low price received and the income left after deduction is made for previous debt is quite low. The small part of their income to be used for next year's investment is too small to invest in more productive inputs. The only thing the farmer can do is to invest in the conventional input the same as he has previously done which is the only thing that he can afford. The cycle is completed for the farm unit poverty.

1. <u>The nature of the cost of production inputs</u>

This section relates to the structure of short-run costs only. In the accepted terminology of economics, the short-run refers to production in a firm (farm) or other technical or economic unit where one or more factors are fixed in quantity. Time is considered only in this manner. Mainly, short-run refers to a production situation where output is varied in the proportional rather than a true scale manner. The production function for one acre of land as a technical unit or a 160-acre farm as an economic unit refers to the short-run. The number of acres (and buildings or similar resources) are held constant in either case while the amount of labor, tractor fuel, feed or other resources can be used in varying amounts on the 160-acre farms or on the single acre, and thus changes take place in the proportion of factors which are involved (Heady 1961). Two major categories of cost are (1) fixed costs and (2) variable costs. Fixed costs refer to those costs which do not vary with (are not a function of) output. Variable costs refer to those outlays which are a function of output in the production period.

a. <u>The productive inputs as the variable cost</u> The new productive inputs are items such as chemical fertilizers, insecticides, pesticides, new varieties of seeds and livestock. For reproduction, new ration of feed etc. can be considered as the variable cost. Suppose that perfect knowledge is prevailing. The amounts of those quantities of new productive inputs might be used if and only if the following conditions are fulfilled under unlimited capital:

The production function is (2.D.1) where $x_1, x_2, \ldots, x_n$ are resources in question and in the production of output y. From the production function, profit Π can be defined in (2.D.2) as gross revenue, the magnitude of output y multiplied by product price py, less the sum of costs. Costs are defined as the sum of resource prices p_i multiplied by resource quantities x_i.

$$y = f(x_1, x_2, \ldots, x_n) \qquad (2.D.1)$$

$$\Pi = f(x_1, x_2, \ldots, x_n)\ py - \sum_{i=1}^{n} p_i x_i \qquad (2.D.2)$$

Setting the partial derivatives of profit with respect to each resource equal to zero, the profit will be maximized

$$\frac{\partial \Pi}{\partial x_1} = \frac{\partial f}{\partial x_1}\ py - p_1 = 0 \qquad (2.D.3a)$$

$$\frac{\partial \Pi}{\partial x_2} = \frac{\partial f}{\partial x_2}\ py - p_2 = 0 \qquad (2.D.3b)$$

$$\frac{\partial \Pi}{\partial x_n} \quad \frac{\partial f}{\partial x_n}\ py - p_n = 0 \qquad (2.D.3c)$$

In general, those equations can be written as

$$\frac{\partial f}{\partial x_i} py = p_i \qquad (2.D.4)$$

$$\frac{\partial f}{\partial x_i} = \frac{pi}{py} \qquad (2.D.5)$$

and

$$-\frac{\partial x_i}{\partial x_j} = \frac{p_j}{p_i} \qquad (2.D.5a)$$

Equation (2.D.5) states that the total amount of each input will be used under the condition that the marginal productivity is equal to the ratio of input price and output price. From the existing production function, if the price of products are low because the farmer has to sell at the harvesting period and the price of inputs are high because of the high cost of foreign exchange needed to import from the foreign countries, the total amount of those inputs used would be too low. Inversely, a decrease in the price of the factor as an increase in the price of product will increase the demand quantity of the factor. In static equilibrium, the value of marginal product of each resource must equal to its price (2.D.4). Furthermore, (2.D.6) indicates that the marginal value product of a given resource must be equal for any product z as well as from y. A departure from these conditions must necessarily reduce profits.

$$(\frac{\partial f}{\partial x_1} py)/p_1 = (\frac{\partial f}{\partial x_2} py)p_2 \dots = (\frac{\partial z}{\partial x_1} pz)/p_1$$

$$= (\frac{\partial z}{\partial x_2} pz)/p_2 = (\frac{\partial f}{\partial x_n} p_y)/p_n = 1 \qquad (2.D.6)$$

If the capital is limited, the allocation of limited capital among product investment opportunities when continuous function are known can be illustrated for a sample situation (Heady and Dillon 1961).

Suppose we have three crops, corn, soybeans, and castor beans represented by y_1, y_2 and y_3 respectively. The production function of quadratic form can be written as

$$y_1 = a_1 + b_1x_1 + c_1x_1^2$$

$$y_2 = a_2 + b_2y_2 + c_2x_2^2 \qquad (2.D.7)$$

$$y_3 = a_3 + b_3x_3 + c_3x_3^2$$

Hence, a subscript is attached to the constants in each equation to indicate the product to which it refers. Similar subscripts indicate the quantity of the resource (e.g. mixed chemical fertilizer) used for each product. Funds are available for only fixed quantity of the resource indicated as $\bar{x}$.

$$x_1 + x_2 + x_3 = \bar{x} \qquad (2.D.8)$$

The marginal physical products of the variable resource are indicated in the first column of equations in system (2.D.9). By multiplying these equations by p_1, p_2, and p_3, the prices of the three crops, we obtain the three equations for the value of the marginal products (VMP's) which are identical with the marginal value productivities for a competitive industry such as agriculture, in the second column of equations in system (2.D.9).

$$\frac{dy_1}{dx_1} = b_1 - c_1x_1 \qquad VMP_1 = b_1p_1 - c_1p_1x_1$$

$$\frac{dy_2}{dx_2} = b_2 - c_2x_2 \qquad VMP_2 = b_2p_2 - c_2p_2x_2 \qquad (2.D.9)$$

$$\frac{dy_3}{dx_3} = b_3 - c_3x_3 \qquad VMP_2 = b_3p_3 - c_3p_3x_3$$

With a limited quantity, $\bar{x}$, of the variable resource, we wish to allocate a quantity to each crop so that the marginal value productivity of the resource will be equal for the three crops. We will denote it as m, of which we do not know the magnitude by now, and set all three marginal value productivities to equal this value as in the first three equations of system (2.D.10).

$$\begin{aligned} b_1p_1 - c_1p_1x_1 &= m \\ b_2p_2 - c_2p_2x_2 &= m \\ b_3p_3 - c_3p_3x_3 &= m \\ x_1 + x_2 + x_3 &= \bar{x} \end{aligned} \qquad (2.D.10)$$

This system can be solved for the quantities of x_1, x_2, x_3 and m as following

$$\begin{bmatrix} -c_1p_1 & 0 & 0 & -1 \\ 0 & -c_2p_2 & 0 & -1 \\ 0 & 0 & -c_3p_3 & -1 \\ 1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ m \end{bmatrix} = \begin{bmatrix} -b_1p_1 \\ -b_2p_2 \\ -b_3p_3 \\ \bar{x} \end{bmatrix} \quad (2.D.11)$$

In this case, how much of resource used for each crop will depend on the coefficient of the slope of each crop's production function associated with the price of each product. In many cases, practical solutions to problems of this type, particularly where many investment opportunities exist, may be more easily obtained by linear programming procedures.

b. The productive input as the fixed cost The variability or constancy of a productive service may be technical in nature: the input of coal or iron to a process, for instance, may be technically variable, while the input of a certain machine is technically fixed (Carlson 1956). When we now proceed to our study of the technical production problem we shall examine the relationship between the variable productive services and the output under the assumption that the plant remains constant; that is, that there exists a given equipment of tools and machine services in farm, acreage of farm, etc. If we denote the quantity of output by y, and the quantities of the variable productive services, n in number, by $x_1 \ldots x_n$, we can write:

$$y = f(x_1, \ldots, x_n) \tag{2.D.12}$$

This production function is defined in relation to a given plant; that in certain fixed services.

Take the total differential of y (2.D.12) gives

$$dy = \frac{\partial f}{\partial x_1} dx_1 + \frac{\partial f}{\partial x_2} dx_2 + \ldots + \frac{\partial f}{\partial x_3} dx_n \tag{2.D.13}$$

As the quantity of output does or does not vary in proportion to a proportional change in all the productive services the production in question will be said to yield a constant or variable proportional return. As a scale of measure of the proportional return we shall introduce the concept of elasticity of production. If the productive services obtain a proportional increment $dx_1 = kx_1, dx_2 = kx_2, \ldots$ etc. which cause the output to vary by an amount dy, the elasticity of production ε expresses the relationship between the relative variations of output and productive services

$$\varepsilon = \frac{dy}{y} / \frac{dx_k}{x_k} \tag{2.D.14}$$

Since $k = \frac{dx_1}{x_2} = \frac{dx_2}{x_2} = \ldots \frac{dx_n}{x_n}$

then equation (2.D.14) can be rewritten as

$$\varepsilon = \frac{dy}{y} / k \text{ or } dy = \varepsilon yk$$

The change in output dy caused by the proportional increment of the services is expressed by

$$dy = \frac{\partial f}{\partial x_1} kx_1 + \frac{\partial f}{\partial x_2} kx_2 + \ldots + \frac{\partial f}{\partial x_n} kx_n$$

and when εyk is substituted for dy this gives us the important relationship

$$\varepsilon y = \frac{\partial f}{\partial x_1} x_1 + \frac{\partial f}{\partial x_2} x_2 + \ldots + \frac{\partial f}{\partial x_n} x_n \tag{2.D.15}$$

Cost function can be expressed as an explicit function of the level of output plus the cost of fixed inputs:

$$TC = \phi(y) + b \tag{2.D.16}$$

or

$$TC = p_{x_1} x_1 \div p_{x_2} x_2 + b \tag{2.D.17}$$

where p_{x_1}, p_{x_2} are the prices of input x_1 and p_{x_2} respectively and b is fixed cost.

A number of special cost relations which are also functions of the level of output can be derived from (2.D.16). Average total (ATC), average variable (AVC), and average fixed (AFC) costs are defined as the respective total, variable, and fixed costs divided by the level of output:

$$ATC = \frac{\phi(y) + b}{y} \tag{2.D.18}$$

$$\text{AVC} = \frac{\phi(y)}{y} \tag{2.D.19}$$

Marginal cost (MC) is the derivative of total cost as well as variable cost if fixed cost is constant with respect to output:

$$\text{MC} = \frac{dc}{dy} = \phi'(y) \tag{2.D.20}$$

The average variable cost reaches its minimum point when its first derivative is equal to zero and its second derivative is positive. That is when

$$\frac{d\ \text{AVC}}{dy} = \frac{d}{dy}\left(\frac{\phi(y)}{y}\right)$$

$$= \frac{\phi'(y)}{y} - \frac{\phi(y)}{y^2} = 0$$

$$= \text{MC} - \text{AVC} = 0 \tag{2.D.21}$$

and when

$$\frac{d^2\text{AVC}}{dy^2} = \frac{\phi''(y)}{y} - \frac{2\phi'(y)}{y^2} + \frac{2\phi(y)}{y^3} < 0 \tag{2.D.22}$$

And we can see from equation (2.D.21) that when AVC reaches its minimum point, at that point AVC will also equal to MC.

Now we want to examine the properties of the minimum cost combinations for a certain output, we need only consider the costs of the variable services. The plant or the fixed services, we have assumed, are constant for the range of outputs under consideration, and the costs of these services are also constant. Consequently they do not affect the choice of minimum cost combinations. We may arrive at the minimum cost for a given output through a process.

Cost (2.D.17) can be minimized subject to (2.D.12) assuming that y is fixed at y^0 level. Form the function

$$L = p_{x_1}x_1 + p_{x_2}x_2 + b + \lambda(y^0 - f(x_1, x_2))$$

$$\frac{\partial L}{\partial x_1} = p_{x_1} - \lambda f_1 = 0 \qquad (2.D.23)$$

$$\frac{\partial L}{\partial x_2} = p_{x_2} - \lambda f_2 = 0 \qquad (2.D.24)$$

$$\frac{\partial L}{\partial \lambda} = y^0 - f(x_1, x_2) = 0$$

From (2.D.23) and (2.D.24) we find that

$$\frac{f_1}{f_2} = \frac{px_1}{px_2} \qquad (2.D.25)$$

At y^0 the cost is minimum when the equation (2.D.25) is satisfied.

From (2.D.25) we can generate to be as the general case such as

$$\frac{f_1}{px_1} = \frac{f_2}{px_2} = \ldots. \frac{f_n}{px_n} \qquad (2.D.26)$$

This is a necessary but not a sufficient condition for cost minimum.

Let me define $\frac{px_k}{f_k}$ as the cost productivity ratio represented by ψ_k, then the equation (2.D.27) must be hold:

$$\psi_1 = \psi_2 = \psi_3 \cdots \psi_n \qquad (2.D.27)$$

Let us now examine the relationship between costs and output when the service prices are fixed. The variable cost, evidently, is equal to the sum of the quantities of the services multiplied by their respective prices

$$VC = \sum_{i=1}^{n} x_i p_{x_i}$$

and MC is equal to the derivative of this sum

$$\frac{dVC}{dy} = \frac{\sum_{i=1}^{n} px_i dx_i}{dy} \qquad (2.D.28)$$

we know from (2.D.27) that

$$p_{xi} = \psi_i f_i$$

then

$$\frac{dVC}{dy} = \frac{\sum_{i=1}^{n} \psi_i f_i dx_i}{dy} \qquad (2.D.29)$$

or

$$\frac{dVC}{dy} = \psi\frac{\sum_{i=1}^{n} f_i dx_i}{dy} \qquad (2.D.30)$$

Since the sum of the marginal products, equation (2.D.13), is equal to dy then

$$MC = \psi_1 = \psi_2 = \ldots\psi_n \qquad (2.D.31)$$

That is, on the expansion path the marginal cost of output and the cost productivity ratios of the different services are equal.

In the case when the productive services are always varied in the same proportions, that is when the expansion is a straight line starting from the point of origin, the average variable, the variable and the marginal costs stand in a simple relation to one another. If in the expression for the average variable cost

$$AVC = \frac{\sum_{i=1}^{n} x_i px_i}{y} \qquad (2.D.32)$$

we make a substitution similar to the above, we get

$$AVC = \frac{\sum_{i=1}^{n} \psi_i f_i x_i}{y}$$

$$= \psi\frac{\sum_{i=1}^{n} f_i x_i}{y} \qquad (2.D.33)$$

$$= \psi \cdot \varepsilon \qquad \text{used (2.D.15)} \qquad (2.D.34)$$

$$= MC \cdot \varepsilon \qquad \text{used (2.D.31)} \qquad (2.D.35)$$

That is, on the expansion path the average variable cost is equal to the marginal cost multiplied by the elasticity of production. It therefore follows that the variable cost must be equal to the product of the marginal cost, the production elasticity and the quantity of output

$$VC = MC \cdot \varepsilon \cdot y \qquad (2.D.36)$$

Now we get the very important relationship among output, marginal cost, variable cost and elasticity of production.

Let us suppose that there are two corn farms. One is a corn farm in Iowa, U.S.A., which has 200 acres and 45 H.P. tractor producing corn as a main crop. The other is also a corn farm but situated in pra-Buddha-Bart, Thailand, which has five acres and two draft buffaloes. We shall denote the corn farm in Iowa as "farm A" and the corn farm in pra-Buddha-bart as "farm B". Farm A has its own production function and cost function. We will denote farm A's variable cost as VC' and marginal cost as MC'. Furthermore, farm A has its own fixed cost concerning the 45 H.P. tractor and land as well as other fixed inputs. Farm B also has its own production function and cost function. We will denote VC" and MC" as the variable cost and the marginal cost of farm B respectively. The fixed cost of farm B consists of two buffaloes, land and other fixed inputs. Farm B produces a bushel of corn at the level of y* and assume that at y* the AVC" is equal to MC". Then we can write the relation of farm A and farm B as follows;

Farm A $\qquad VC' = MC' \cdot \varepsilon' \cdot y \qquad$ (2.D.37)

Farm B $\qquad VC'' = MC'' \cdot \varepsilon'' \cdot y \qquad$ (2.D.38)

It is assumed that the productive services in Farm A and Farm B are always varied in the same proportions.

Now, if farm A and farm B produce the same quantity of corn at level y* the equation (2.D.37) and (2.D.38) can be written as

$$\frac{VC'}{MC'\varepsilon'} = \frac{VC''}{MC''\varepsilon''} \qquad (2.D.39)$$

Divided through by y*, the equation will be

$$\frac{AVC'}{MC'\varepsilon'} = \frac{AVC''}{MC''\varepsilon''} \qquad (2.D.40)$$

while farm B produces at AVC" = MC" then

$$\frac{AVC'}{MC'\varepsilon'} = \frac{1}{\varepsilon''} \qquad (2.D.41)$$

or

$$\varepsilon'' = \frac{MC'\varepsilon'}{AVC'} \qquad (2.D.42)$$

The equation (2.D.42) will be the final result conclusion. We know that at the output level of y* for 200 acres and one 45 H.P. tractor is too small, consequently at this output level the AVC' must be greater than MC'. If ε'' is equal to or less than one, then ε' must be absolutely greater than one. Then the conclusion might be made that more capital investment in tools and machinery in the underdeveloped agriculture, is not economical if that tool or machine is too large and indivisible in relation to the size of a farm. The indivisibility is only overcome, in the sense that large machines can be used for large producing units but are not economical for a small unit. Even in the United States, the farmer with a few bushels of grain or a few head of livestock may use a scoop or a pitchfork, while one with a large volume may employ automatic elevators (Heady 1961).

The above analysis seems to be realistic for Thailand's agriculture. Since the size of farm is too small and credit is too scarce, farmers are seldom to own the big tractors. The hired plowing for the big tractor seems to be a reasonable source for using it. The use of hired plowing tractors owned by crop dealers, a few big farms and provided by some government agencies seems to be spreading wider and wider. The limitation for this kind of business will be most concerned about the crop colander, that is, the more intensification taking place in a small size of farm, the more limitations will occur for the hired tractor.

2. <u>The farm unit developmental hypothesis and the long-run planning curves</u>

Supposing a farm unit faces a production function as

$$y = Ax_1^{b_1}x_2^{b_2}x_3^{b_3} \qquad (2.D.43)$$

where y, x_1, x_2 and x_3 are the level of output, money income, size of farm, amount of capital and family labor respectively, associated with the coefficient A, b_1, b_2 and b_3. This farm unit has the consumption-investment relationship as

$$C = a + bI \tag{2.D.44a}$$

where C and I are the consumption and investment, respectively, and a and b are the coefficients.

At the beginning of the year, the farm unit has to decide how much money will be spent in farming and in family consumption. The total amount of money available at the beginning of the year is denoted by Z. Then the equation (2.D.44b) will be hold

$$x_2 + I = Z \tag{2.D.44b}$$

The possibility curve for consumption and production will be derived as

$$x_2 = \left[\frac{y}{Ax_1^{b_1} x_3^{b_3}}\right]^{\frac{1}{b_2}}$$

$$I = \frac{C-a}{b}$$

$$\left[\frac{y}{Ax_1^{b_1} x_3^{b_3}}\right]^{\frac{1}{b_2}} + \frac{c-a}{b} = Z$$

$$c = bZ - b\left[\frac{y}{Ax_1^{b_1} x_3^{b_3}}\right]^{\frac{1}{b_2}} + a \tag{2.D.45}$$

The equation (2.D.45) is the equation of the possibility curve and states that if the income in the next year is zero (y=0) then C = bZ + a, that is the whole money income available in the beginning of the year (Z) will be spent entirely on the consumption. But if no consumption takes place during the year, then all of the money available at the beginning of the year will be used in farming. Then, at the end of the year the money income will be

$$y = [Z + \frac{a}{b}]^{b_2} [Ax_1^{b_1} x_3^{b_3}] \qquad (2.D.46)$$

The equation (a.D.45) can be depicted as figure 1. The marginal rate of substitution of income from investment for consumption can be derived from equation (2.D.45) by taking the derivative of C with respect to y

$$\frac{dC}{dy} = MRS = -\frac{1}{b_2} b \left[y^{\frac{b_2 - 1}{b_2}} \right] [A^{-1} x_1^{-b_1} x_3^{-b_3}]^{\frac{1}{b_2}} \qquad (2.D.47)$$

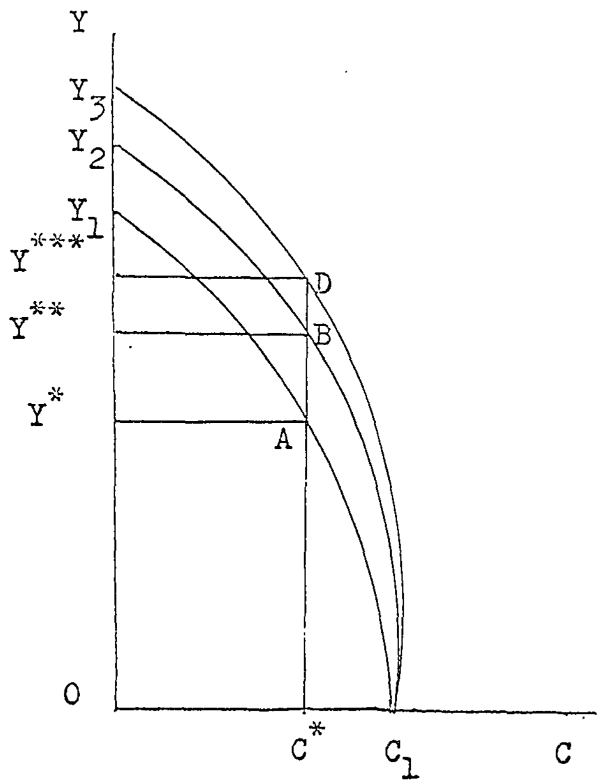
We can see that the slope of the possibility curve is dependent mostly on the marginal propensity to invest and the production coefficient.

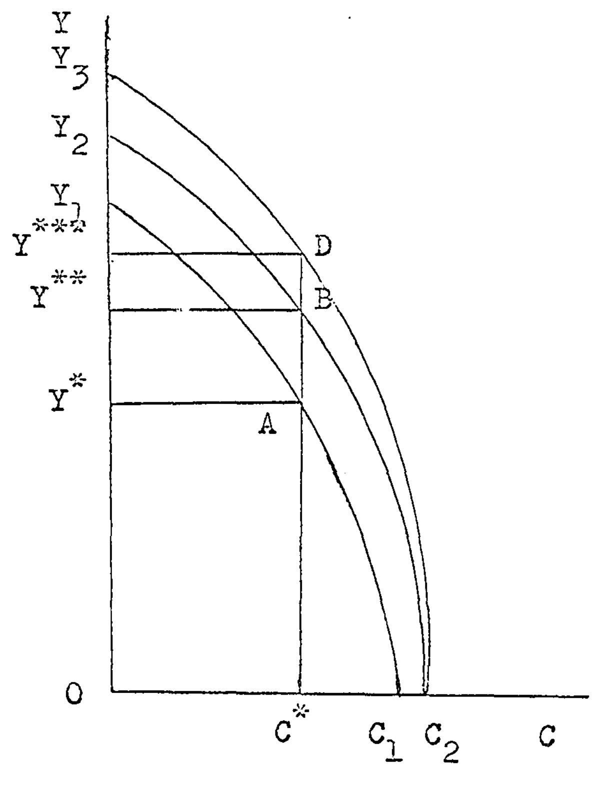
While the magnitude of $[A^{-1} x_1^{-b_1} x_3^{-b_3}]$ is fixed, then the slope of the possibility curve will depend mostly on the magnitude of the marginal propensity to invest and the magnitude of b_2 while y is changed.

Figure 1 curve $C_1 y_1$ is the production-consumption possibility curve. At C*, the amount OC* is the amount of

Figure 1. Shifts in the production-consumption curve

Figure 2. Shifts in the production-consumption curve with more capital invested


Y
Y_3
Y_2
Y_1
Y^{***}
D
Y^{**}
B
Y^*
A
0
C^*
C_1
C


Y
Y_3
Y_2
Y_1
Y^{***}
D
Y^{**}
B
Y^*
A
0
C^*
C_1
C_2
C

income for consumption, the amount of income left for investment is C^*C_1. At the level of investment C^*C_1 will yield the income in the next year amount of OY^*. At this point we will see that the investment of C^*C_1 is too small to invest on the newly productive input, the only thing the farmer can do is to invest on the traditional input such as repairing the old farm equipment, buying seeds, replacing the old tools etc. The process would be almost the same year after year, then the income is almost the same year after year also.

Now let us consider that the marginal productivity of labor is too low in agriculture. One reason would come from the redundant of labor in agriculture associated with the small size of farm relative to family labor supply. The other reasons which also concern the first one are the traditional mono-culture type of farm, lack of knowledge in diversified farming and the existing agronomic limitation by nature as well as the limitation of the market. At the dynamic stage of economic development one would see that the farm firm equilibrium has been destroyed through time. The construction of new roads open the new markets for crops and livestock concerning location, markets and prices. The construction of dams, disk and dikes create a new optimum allocation of resources within the farm firm. The combination of those forces will form the new farm firm equilibrium and also destroy the limitations of markets as well as the agronomic limitations. It happens that although the surrounding conditions in agriculture are more favorable than in the old days; however, the farmers are still poor. There are quite a number of economic reasons for this phenomena. Industrial development is growing at a slow rate, and the industrial sector cannot absorb the labor from agricultural sector more rapidly than its slowly growing capacity. Therefore, the rate of growth of farm population is still high. If the rate of farm production is increased at the same rate that farm population is increased, assuming that prices are constant, the income per person on farms would still be the same as before. Furthermore, if the rate of farm production is increased lower than the increasing rate of population, the income per person on farms would be lower than before and *vice versa*.

Even though the farmer is quite responsive to price, the farm production as well as farm income may not be increased due to the lack of agricultural education of the farmer. Through the stage of dynamic development, the development of farmers' knowledges is needed to make them aware of new inputs which are available and which will produce favorable results. Examples are; new seeds, varieties, breeds of animals, etc. and a knowledge of new techniques of production such as time and technique of planting and harvesting depth, elevation, watering, drainage, etc. Before embarking on the proportionality relationships and size of the producing plant concerned in this context, we would like to make a distinction between proportionality and scale relationships. Referring to a product contour (iso-product) map, one would see that scale relationships refer to a simultaneous increase in all resources that involve long-run production function of which no factors are fixed, nevertheless, proportionality relationships involve the short-run production functions of which one or more factors are fixed (Heady 1961). In short-run, where the size of farm is fixed, farm production might be increased by using the new high yield of seeds and breeds of animals as well as fertilizers and insecticides. In the use of fertilizers and insecticides to increase farm production, we must consider the price ratio of product-input prices which have been analyzed in more detail above. The development of new high yielding seeds and breeds of animals should be considered as an intermediate and long-run developmental program. These developments will take time because their botanical and genetic characters will require much experimentation and no high yield in seeds and breeds of animals can be expected in transplanting from one region to another. Therefore, it would be considered that the new techniques of production are a short-run and immediate alternative needed to bring about an increase in farm production. Furthermore, we would like to clarify the statement about the redundancy of labor in the agricultural sector. In Thailand, it would be suggested that the redundancy of labor means the labor supply of the number of farm workers and also the man-hours per year is not fully utilized. The marginal productivity of labor in farming is low characterized by the excess number workers applied to the ancestor's pattern of farming and, finally, a lot of man hours per-year would be left idle.

Now, we are ready to analyze the usefulness of new techniques of production associated with proportionality relationships and the size of the farm. Assume that in corn farming traditionally corn is grown in May and the crop harvested during September. This farm always grows second crops such as corn, soybeans, mungbeans and also has minor amounts of castor beans scattered around the farm. The income of this farm is low because the size of the farm is only 5 acres and even though this farm can grow second crops; usually the second crops can grow only in a small area, say one or two acres. The problem is that the farmer has to hurry to harvest the first crop during September and has to finish the job of plowing and planting the second crop within the month of October or early in November, otherwise the second crop will fail due to the lack of rainfall during December and

January. Under this pattern of farming the labor used will be peaked in May, June, September, October and January. During the month of July, August, November and December a mild amount of labor is used; but only a very little work will be done in February, March and April.

Now, the new techniques of production will be applied to above situations. Divide the area of land into two segments. The critical point is that one of the two segments must be scaled to the size that will require no more than the amount of family labor that is available in October for the plowing and the planting of the second crop. The farm employed by the conventional farm planning and budgeting program will be as follows: First crop, all area of land will grow corn as before, but after the planting of corn is finished castor beans will be planted as the inter-crop. Two techniques of planting will be employed. First, in the larger segment of the land, the castor-bean will be grown between the rows of corn, the width of the row of castor-bean will be the same as usual. Second, in the smaller segment of the land, the castor-bean will also be grown between the rows of corn, but the width of the row of castor-beans will be wider than the first segment. The idea of the wider row for the castor-bean in this segment comes from the fact that if the row of castor-bean is equal to the ordinary width, the shade of castor-bean-tree will affect the yield of any crop that grows between the rows of castor-beans in the second crop. After the corn in the first crop is harvested, the larger segment of the land will have castor-beans left; but the smaller segment of the land will grow corn, mungbean, or soybean between the rows of castor-beans. The adjustment of labor used will be done easily if needed by trying to finish the harvesting and planting the second crop in the small segment first and then the work in the larger segment will be done later.

Now, the second crop will consist of castor-beans in the larger segment of land which was usually left idle, and the inter-crop of corn or beans and castor-beans in the smaller segment of land. The harvesting of castor-beans will begin in December and continue throughout April and the third crop will be planted by growing sorgum between the rows of corn or beans in the smaller segment before the corn or beans are harvested if the labor used for harvesting castor-beans can be split.

The above farm planning will cause the labor used to be spread throughout the year with the minimum or no increase in capital. But, the income of the farmer will be nearly doubled. The above example has been developed and field tested by the Division of Agricultural Economics, Ministry of Agriculture, Thailand. The writer used to be a project leader of this project since the beginning of the project in the crop-year 1960-61 until the crop-year 1962-63 when the writer left for

Iowa State.

Now, we will return to our production function and synthesize what will happen to our production function if the above farm planning is forthcoming.

Let us separate the labor used into x'_3, x''_3 and x'''_3 according to different jobs to be done. It is clear that the sum of x'_3, x''_3 and x'''_3 denoted by $\bar{x}_3$ must be greater than x_3 in our production function, then the new production function can be written as

$$y' = Ax_1^{b_1}x_2^{b_2}x'_3{}^{b'_3}x''_3{}^{b''_3}x'''_3{}^{b'''_3}$$

and then the marginal productivity of $x'_3(Mpx'_3)$, $x''_3(Mpx''_3)$ and $x'''_3(Mpx'''_3)$ might be greater than the marginal productivity of x_3 that is

$$\begin{aligned} Mpx'_3 &> Mpx_3 \\ Mpx''_3 &> Mpx_3 \qquad (2.D.48) \\ Mpx'''_3 &> Mpx_3 \end{aligned}$$

and also y' is greater than y.

Finding the new production-consumption possibility, the curve C_1Y_2 in figure 1 will be the new possibility curve. At the level of consumption oC^* as before the income of the farm will be increased from y_1 to y_2 by the diversification of farming associated with the intensity of labor used. It is quite clear that while the sum of the coefficients of the scale economy $b_1+b_2+b'_3+b''_3+b'''_3$ is greater than the sum of $b_1+b_2+b_3$, then the curve C_1y_1 will be shifted to C_1y_2 and if more new techniques of production are forthcoming the curve C_1y_2 will be shifted to C_1y_3.

Now, supposing that a farmer can borrow money from somebody else of amount C_1C_2 in figure II and invests in the productive inputs such as fertilizers and/or insecticides, the possibility curve will be C_2y_2; but if the farmer also diversifies crops as the previous plan the possibility curve will become C_2y_3. It is clear that the income increased of y_1y_2 in figure 1 is smaller than the income increased of y_1y_3 in figure II.

The above hypothesis is very important and necessary for agricultural development in the early stage. The knowledge of farm management economics and the experimentations on the crop combinations and inter-crops as well as the cropping systems in the agricultural experiment station are important background in aiding the farm planning.

The second stage of agricultural development will show much more concern with the other sector of the economy. There are three directions that will be considered here. The size of farm would be increased if the other sectors can absorb the farm labor at a high enough rate to cause the farm population to decrease under the existing heritage system and *vice versa*. The size of farm would be constant if the other sectors can absorb the farm labor in the rate such that the farm population is still the same as previously.

In general, as farming becomes more and more intensified in both crop and livestock raising, the family labor will run short, the farm income is not yet high enough and family labor opportunity costs are still high to accomplish this within the farming system. Therefore, the labor saving devices must be introduced. What kinds of labor saving devices will be introduced will be the main discussion here. From the above discussion, we have seen that the 45 H.P. tractor is not economical for a farmer in Pra-Buddha-Bart to buy and use it on his farm of 5 acres. It is quite clear that in agriculture, technologically improved purchased inputs have tended to have a larger production elasticity relative to resources originating in agriculture (Heady and Tweeten 1963). That is, evidently, while the elasticity of substitution of resource i for resource j is defined as the percentage change in x_i associated with a 1 percent change in x_j, and mathematically is expressed as $E_i,j = \frac{dx_i}{dx_j} \frac{x_j}{x_i}$. Equation (2.D.5a) indicates that in equilibrium $- \frac{dx_i}{dx_j} = \frac{p_j}{p_i}$. Multiplying this expression by x_j/x_i, it is apparent that the ratio of expenditures on x_i and x_j is equal to the elasticity of substitutions, i.e.,

$$-E_{i',j} = -\frac{dx_i}{dx_j}\,\frac{x_j}{x_i} = \frac{p_j}{p_i}\,\frac{x_j}{p_i x_i}\,.\quad \text{Since } \frac{dx_i}{dx_j} = -\frac{\partial f}{\partial x_j}\Big/\frac{\partial f}{\partial x_i}\,,$$

and defining the elasticity of production E_i as $\frac{\partial y}{\partial x_i}\,\frac{x_i}{y}$, it follows that in equilibrium $-\frac{E_j}{E_i} = -E_{i',j} = \frac{p_j}{p_i}\,\frac{x_j}{x_i}$. The ratio of production elasticities is equal to the elasticity of substitution and ratio of expenditures. The result indicates that the introduction of a new input; with a high production elasticity and low supply price is likely to change appreciably the resource mix as equilibrium amounts are approached. If the ratio of production elasticities E_j/E_i is greater than one, in equilibrium more will be spent on the new input; than on input i. Now, if we return to our problem, while we still assume that the land is fixed under intensification of farming and the labor is run short, consequently, the new input which will be situated for hired labor must have the elasticity greater than the elasticity of labor. Even though within the farm firm the equation (2.D.35) which expresses that $AVC = MC \cdot \varepsilon$, if the productive services are varied in the same proportions, the elasticity of production ε will be equal to one at the beginning of relevant range of production (MC=AVC) is not appropriate to be applied here. One would agree that the introduction of a new input substituted for hired labor is not only that the elasticity of new input must be greater than the elasticity of hired labor but also that the elasticity of the farm firm production should be at, or closely to, the relevant ranges of production, i.e., $0 \leq E \leq 1$, of the output level specified at the beginning of MC=AVC while the size of the farm is fixed. Therefore, the machinery in question should be a kind of garden tractor, or power tiller, such that is suitable for the soil and the possible conditions of crop combinations. Finally, we can conclude that the development of the new inputs that are suitable for the farm conditions in Thailand is one of the most important in the second stage of agricultural development which is the intermediate stage between short-run and long-run.

Now, we proceed to the third stage which we will consider as the long-run development. The technical externalities are quite important in the intermediate and long-run. If the technology exhibits indivisibility or (smooth) increasing returns to scale in the relevant range of output, the result is to render the set of feasible points in production (input-output space) nonconvex. A straight line connecting some pairs of feasible points will pass outside the feasible set. Now convexity, in turn, has a devastating effect on duality (Bator 1958). Factor indivisibilities may be significant for either firm or industry, or both, and may result in increasing or decreasing costs in either firm as industry, or both. The long-run average cost curve or the planning curve is the envelope and would consist of the scallop of the short-run cost curves. From the existing data on hand, we do not know exactly what the direction of the size of farm in Thailand would be in the future. Consequently we will not proceed further beyond the previous analysis.

E. The Space-Economy of Agricultural Production

In the previous part we were concerned with the problems of the farm entrepreneur in the conduct of his own enterprise, which was referred to as the firm level. Now we shall identify the common forces affecting location of production for a particular crop as commodity. We shall refer to this level as the industry level. It deals with the combined results of all the farms operating to produce a common product that is, operating in a common industry.

1. A general theoretical consideration

We shall follow the lead of Thünen and Dunn by recognizing the controlling factor in the determination of land use is land rent (Dunn 1954). The land rent may be defined as follows:

$$R = y(p_y - C) - y(tx) \qquad (2.E.1)$$

The variables are classified as follows:

R = rent per unit of land

x = distance

y = yield per unit of land

p_y = market price per unit of commodity

C = production cost per unit of commodity

t = transport rate per unit of distance for each commodity

Assume that only one product is considered here. The equation (2.E.1) is nothing more than the possibility curve expressing that the land rent is the linear function of distance (x). Since the distance is independent of direction, therefore, the total rent, $\bar{R}$, derived from the production of this crop must equal not the area under the triangle but the volume of a solid cone of revolution. For the sake of simplicity let $a=y(p_y-C)$ and $b=yt$. Hence the total rent can be expressed as a function of distance, x,

$$\bar{R} = 2\Pi \int_o^x xRdx \qquad (2.E.2)$$

or

$$\bar{R} = 2\Pi \int_o^x (ax-bx^2)\,dx \qquad (2.E.3)$$

Set the derivative of $\bar{R}$ with respect to x equal to zero, then the total rent will be maximized,

$$\frac{d\bar{R}}{dx} = 2\Pi ax - 2\Pi bx^2 = 0 \qquad (2.E.4)$$

or

$$\frac{d\bar{R}}{dx} = 2\Pi y(p_y-C)x - 2\Pi ytx^2 = 0 \qquad (2.E.5)$$

The base radious of the right circular cone is determined by (py-C)/t. Now, we come up to the simple solution but it is very useful for economic development. That is, if the transport rate per unit of distance is reduced, the distance (x) would be increased, The area under the new circular cone would be larger than the previous one. The construction of a new road that reduces the transport rate would bring more crop to the market and also develops new crops to be introduced in the market. The farm unit coming into the new circular zone would get the great opportunity to be developed. The marginal rate of substitution between the respective transport rate of differences farm products would be considered, if more than one crop are included in the concentric and circular zone (Isard 1965).

2. An application of spatial linear programming

There are many aspects of spatial linear programming that may contribute to the study for economic development of agriculture. The possible effect of raising the level of fertilizer and machinery inputs in the important crops production on regional land-use pattern and on an acreage requirements can be found out from the spatial model. Even in a static or unchanging state of importance crop regions, the regional land-use pattern and acreage requirements can be accomplished under the growing population. The effectiveness of new road construction contributed to economic development can also be found from the spatial model. The basic assumption might be made for the spatial programming - that is, a regional producing unit can represent a collection of farm firms. The conditions necessary for the assumptions to be valid are outlined as follows. Only one region is used to illustrate these conditions which generally will be the same for n regions because of the independence in decision-making units (Egbert, Heady and Brokken 1964).

Let there be

n farms (i=1,2,3,...,n)

m products (j=1,2,3,...,m)

p factors (k=1,2,3,...,p)

then let

Y_{ij} = output of the j^{th} product by i^{th} farm,

x_{ijk} = k^{th} factor used to produce the j^{th} product on the i^{th} farm,

$$Yij = f_{ij}(x_{ij1}, x_{ij2}, x_{ij3}, \ldots, x_{ijp}) \qquad (2.E.6)$$

be the production function for j^{th} product on the i^{th} farm. Assume that constant returns to scale exist, at least within the relevant range, i.e.,

$$ky_{ij} = f_{ij}(kx_{ij1}, kx_{ij2}, kx_{ij3}, \ldots, kx_{ijp}) \qquad (2.E.7)$$

we can then express y_{ij} as a function of one factor explicitly, say land, and some combination of all other factors implicity, as in equation (2.E.8)

$$Y_{ij} = a_{ij}x_{ij1} \quad \text{or} \quad x_{ij1} = G_{ijk} \text{ for } k = 1 \qquad (2.E.8)$$

where $a_{ij} = \partial y_{ij}/\partial x_{ij1}$ by the application of Euler's Theorem for the production function is homogeneous of degree one. Then the marginal cost or supply curve for any farm, i, and product, j, is given by equation (2.E.11)

$$P_{ij}Y_{ij} = \frac{\partial y_{ij}}{\partial x_{ij}} P_{ij}x_{ij1} \qquad (2.E.9)$$

$$P_{ij}Y_{ij} = r_{ij1}x_{ij1} \qquad (2.E.10)$$

$$P_{ij} = \frac{r_{ij}}{a_{ij}} = MC \qquad (2.E.11)$$

given the side condition $\sum_j \frac{Y_{ij}}{z_{ij}} \leq A_i$, in which MC_{ij} represents the marginal cost of y_{ij}, z_{ij} is the yield per acre, A_i is the number of acres on the i^{th} farm, P_{ij} is the price of the product and r_{ij} is the price of the bundle of resources as given by function (2.E.11a)

$$r_{ij} = r_{ij1}G_{ij1} + r_{ij2}G_{ij2} + \ldots + r_{ijp}G_{ijp} \qquad (2.E.11a)$$

If these conditions are fulfilled, then

$$\frac{r_{1j}}{a_{1j}} = \frac{r_{2j}}{a_{2j}} = \frac{r_{3j}}{a_{3j}} = \ldots = \frac{r_{nj}}{a_{nj}} \qquad (2.E.12)$$

Hence, within a region the product supply curves are the same for all farms, even though they may have different resource organizations and constraints. The regional side condition is

$$\sum_i \sum_j \frac{y_{ij}}{z_{ij}} \leq \sum_i A_i \ . \qquad (2.E.13)$$

If the foregoing is the case, representing all farms in a region as an aggregate regional unit or firm in linear programming analysis is realistic. In reality, this probably will not be strictly the case. A rough approximation of these conditions, however, would produce reasonably satisfactory results.

From above conceptual framework, the mix structure of the production-distribution model can be formed as follows:

Let

x_{ijk} = the quantity of the k^{th} crop produced in the i^{th} production region and shipped to j^{th} consumption region,

c_{ijk} = the cost of producing the k^{th} crop in the i^{th} production region and shipping it to the j^{th} consumption region,

B_{ijk} = the land required to produce one unit of the k^{th} crop in the i^{th} production region,

T_i = acreage of land available for crop production in the i^{th} region,

a_{ik} = the consumption requirement of the k^{th} product in the j^{th} consumption region.

The programming objective is to

$$\text{Min. } f(C) = \sum_i \sum_j \sum_k x_{ijk} \, C_{ijk} \qquad (2.E.14)$$

Subject to these constraints

$$\sum_j \sum_k x_{ijk} \, B_{ijk} \leq T_i \, , \qquad (2.E.15)$$

$$\sum_i x_{ijk} = a_{jk}, \qquad (2.E.16)$$

$$x_{ijk} \geq 0. \qquad (2.E.17)$$

The above model can be modified to answer the question described above. A lot of work in this field has been done by Heady and his students. The intensification of farming in any region would be more effective and successful through the help of the spatial linear programming model. Furthermore, the <u>ex ante</u> model can also be set up to predict the future concentration of any crop or livestock in a particular region as well as the prediction of output under the future possible economic outcomes and the technological advancements.

III. EMPIRICAL FINDINGS

A. Empirical Production Functions and Marginal Productivities

1. Statistical estimation and procedures

The data used in this study for the production function analysis was received from the Division of Agricultural Economics, Ministry of Agriculture, Thailand. Six different soil type regions were investigated, within region a simple random sampling was taken for the sample farms. The form of the production function is assumed to be the same for all regions in the Cobb-Douglas type, as shown again in equation (3.A.1)

$$y = AX_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} \ldots, X_m^{\beta_m} \qquad (3.A.1)$$

Within region we may transform the above function into a statistical equation and consider that the variable y depends upon these m explanatory factors x_1, x_2, and x_3, etc., such that

$$y_j = AX_{1j}^{\beta_1} X_{2j}^{\beta_2} X_{3j}^{\beta_3} \ldots, X_{mj}^{\beta_m} U_j \qquad (3.A.2)$$

$$j = 1, 2, 3, \ldots, n$$

where U_j denotes a disturbance term for the j^{th} farm, reflecting the stochastic nature of the relationship. This relationship can be transformed into logarithmic form which is linear in the parameters, but not necessarily in the variables as represented in equation (3.A.3)

$$y_j = \alpha + \beta_1 x_{1j} + \beta_2 x_{2j} + \beta_3 x_{3j} + \ldots + \beta_m x_{mj} + \mu_j \qquad (3.A.3)$$

$$j=1,2,3,\ldots,n$$

where y, x's and u stand for log y, log x's and log u respectively.

If we now apply the least-square method to equation (3.A.3) as it stands, we can obtain the estimates of α and β_i, $i=1,2,3,\ldots,m$, which are such that

$$\sum_{j=1}^{n} (y_j - \alpha - \beta_1 x_{ij} - \beta_2 x_{2j} - \beta_3 x_{3j} \ldots \beta_m x_{mj})^2 \qquad (3.A.4)$$

is minimized.

The least-squares estimates of production coefficients can be expressed in matrix notation as shown in equation (3.A.5).

$$\hat{\beta} = (x'x)^{-1} x'y \qquad (3.A.5)$$

where $\hat{\beta}$ is the estimate of the parameter vector of production coefficients, y and x are the observed dependent variable vector and independent variables matrix in terms of logarithmic form respectively. The variance of $\hat{\beta}$ is given by

$$\mathrm{Var}(\hat{\beta}) = \sigma^2 (X'X)^{-1} \qquad (3.A.6)$$

where σ^2 is the variance of u_j for all j. The unbiased estimator of σ^2 is given by equation (3.A.7)

$$\text{est } \sigma^2 = \frac{y'y-\hat{\beta}'x'y}{n-m-1} \tag{3.A.7}$$

where n is the total number of observations and m+1 is the total number of parameters involved in the production function.

2. Alternative grouping of resources and estimation

A different set of production functions based on different groupings of resource inputs were estimated from the sample data for those six agricultural regions. The soil map of Thailand developed by Pendleton was used to classify roughly the agricultural region of this study (Pendleton 1962). The agricultural region may be included more than one of the provinces, if the soil type is the same as shown below:

Regions	Provinces	Soil type
I	Chainat, Supanburi, and Ayuthaya	Bangkok clay
II	Chachoengsao, Prachinburi	Kharat Fine sandy loams
III	Petchaboon	Unclassified soils of rough mountainous land
IV	Ubolrajdhani	Roi-et fine sandy loams
V	Udornthani,	Korat fine sandy loams
VI	Sakolnakorn	Quartzitic and silicious sandstone hills

In each region, four groupings of resource inputs were generally estimated. Of these four groupings of resource inputs, the form of capital used is the only differences.

The different forms of the capital are:

1. Traditional: The traditional form of the capital may be included the accustomed capital inputs such as ploughes and harrows, cart, sickle, knives, ropes, draft animals including the maintenance and repairing of granary and animal pens. The total amount of depreciation and repairs of above farm buildings and farm equipment as well as the operating expenses of above form of capital are included in this category.

2. Fertilizer: Chemical fertilizers and animal manures applied in the farm are classified into this category. The expenses of various kinds of fertilizers and the total expenses of traditional form of capital in the first category are the total amount of expenses of this category.

3. Hired tractor: The practice of hiring tractor to plough the land is going to be widespread. The expense of hired tractor including any expenses of the first category is the total amount of this category.

4. Fertilizer and hired tractor: The farm that applies fertilizer and hires tractor to plough the land along with some form of traditional capital is classified into this group. The total expenses are estimated.

Four different sets of production functions based on different groupings of resource inputs were estimated from the sample data for those six regions. Each region is not necessarily to have all of four practices because the sample of some practices of some regions is not available to be estimated. In outline form, the functions are as follows:

$$Y = AX_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} U$$

Variables involved in the function are:

Y is the total amount of production of paddy for each farm and measured in tang.[1]

X_1 is the area of land for paddy cultivation of each farm and measured in rai.

X_2 is major variable of classification for paddy cultivation. Four groups of capital described as above are the main distinguishing for estimation of each group.

X_3 is the quantity of labor used on paddy fields. It consists of operator's and family labor as well as the hired labor and is measured in manwork days. Ten hours of productive work on the paddy farming were considered as one manwork day.

The empirical production functions estimated of alternative groupings of resource inputs in each region are as follows:

Region I:

Traditional $\hat{y} = 13.5083\ X_1^{0.9113} X_2^{0.1559} X_3^{0.0186}$

Hired tractor $\hat{y} = 40.3366\ X_1^{0.6555} X_2^{0.0267} X_3^{0.1413}$

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[1]One tang equals to 10 kilograms.

Hired tractor and fertilizer $\hat{y} = 35.44859\ X_1^{0.6879} X_2^{0.0830} X_3^{0.0866}$

Region II:

Traditional $\hat{y} = 38.4326\ X_1^{0.6358} X_2^{0.1842} X_3^{-0.0110}$

Fertilizer $\hat{y} = 11.6359\ X_1^{0.6399} X_2^{2352} X_3^{0.0864}$

Region III:

Traditional $\hat{y} = 34.4508\ X_1^{1.1960} X_2^{0.0331} X_3^{-0.0236}$

Hired tractor $\hat{y} = 21.0232\ X_1^{0.6268} X_2^{0.0881} X_3^{0.2803}$

Region IV:

Traditional $\hat{y} = 44.1976\ X_1^{0.5412} X_2^{0.1713} X_3^{-0.1263}$

Fertilizer $\hat{y} = 8.9125\ X_1^{0.4478} X_2^{0.3381} X_3^{0.0433}$

Region V:

Traditional $\hat{y} = 10.0832\ X_1^{0.5441} X_2^{0.0660} X_3^{0.3331}$

Fertilizer $\hat{y} = 15.2545\ X_1^{0.7227} X_2^{0.1400} X_3^{0.0810}$

Region VI:

Traditional $\hat{y} = 91.7062\ X_1^{0.3764} X_2^{0.0212} X_3^{0.0512}$

Fertilizer $\hat{y} = 5.3198\ X_1^{0.3909} X_2^{0.1156} X_3^{0.4314}$

Table 1-6 presents the elasticity or regression coefficients, along with other statistics of interest in this analysis in each region. The power of any factor input in the above equations is the elasticity of that factor input.

3. Elasticity coefficients, scale returns and marginal productivities

As mentioned previously, the production coefficients are the elasticities of production which show approximately the average percentage change in total amount of output which would result if the input of any one resource is increased by one percent, ceteris paribus. For example, an increase of one percent in the quantity of fertilizer used in Region IV would increase the amount of production by 0.3381 percent, ceteris paribus. The negative elasticities or production coefficients of labor of traditional practice in region two, three and four are hardly conceivable that the total amount of production would decrease if more of this input was employed in these regions. However, these negative coefficients are not significantly different from zero even at the 50 percent level of significance. They could arise with a probability of more than one-half even if the true population elasticity is zero.

The sum of the elasticities for each grouping of each region is also shown in Table 1-6 which indicates the return to scale. There are two regions of traditional practices show increasing return to scale. For this aspect, it needs some explanation of the methods of paddy cultivation in Thailand. The methods practiced in Thailand vary according to the prevailing climatic conditions, the topography of the land, the nature of the soil and the labor available. However, they can be summed up as follows:

1. Dry-land rice
2. Wet-land rice which may be cultivated either by:
   (a) Broadcasting
   (b) Transplanting

The dry-land rice planted by the dibbling method, is grown by the hill tribes or those who live near the hilly jungles where new land can be had by clearing it. The fertility of the soil greatly affects the dry-land rice. When the soil begins to lose its fertility in the second year, the yield drops abruptly and the cultivation has to be shifted to a new piece of land. In contrast to the above method, water is required for the cultivation of wet land rice and the soil is submerged for a good part of time while the rice is growing. The broadcasting method is practiced in ordinary low-land, and deep-water or floating rice cultivation. The method is variable. Each technique, however, is intended for a certain particular set of climatic and soil conditions which may present themselves at the time of sowing. The transplanting method is practiced on about 80 percent of the total acreages of the country; where the size of farm holdings is small, impelling them to obtain the best possible yield from these lands, where conditions do not permit successful cultivation of rice by broadcasting such as on high level land where there is no inundation by river water and the crop has to depend entirely on rainfall or supplemented by surface drainage water from waste or forest lands at the higher levels.

In so far as the data available at hand did not permit us to separate the different production functions of different methods of rice cultivation to be estimated. However, the two regions of traditional practice which show the increasing return to scale could be probably explained in that those two functions are the functions of the wet-land rice cultivation. The production coefficient of land of both regions is very high. The average size of farm is too small (the geometric mean is 20 and 9 rai in region one and three respectively). And from the production function, the traditional practice which engages the very high coefficient of land while the other coefficients are very low would increase output largely due to land, but the yield per-rai is lower than the other new input resources within the same region.

For the rest of the production functions in Table 1-6, the sum of the production coefficients tends to be higher than the traditional practice which is due to the use of the new input resources.

The marginal productivities of various resources were also derived from the above production function. The marginal productivities derived at the geometric means for each group of resource inputs of each region are also shown in Table

1-6. Given the estimates of marginal productivity as above, the next step in the analysis is to calculate their variances. Historically, the variance of the marginal productivity has generally been derived by assuming the values of predicted output and resource inputs to be constants. However, such an assumption is unrealistic because the value of the predicted output (y) will vary over alternative samples and it is estimated based on the $\hat{\beta}_1$ values which are only estimates of the true parameters. A more accurate expression of the variances of the marginal productivity estimates has been discussed by Carter and Hartley (Carter and Hartley 1958). The formula is given in equation (3.A.8)

$$\mathrm{Var}(\hat{\beta}_i \frac{\hat{Y}}{X_i}) = \mathrm{Var}\ (\hat{y})(\frac{\hat{Y}}{X_i})^2(\frac{\hat{\beta}_i{}^2}{n} + \mu c \mu') \qquad (3.A.8)$$

where Var($\hat{y}$) is the estimated variance of σ^2 or predicted y based on a regression equation as shown in equation (3.A.7), n is the total number of sample farms, μ represents the vector

$$\hat{\beta}_i(\log X_m - \overline{\log X_m}) \qquad \text{for } i \neq j$$

$$\hat{\beta}_i(\log X_m - \overline{\log X_m}) + 1 \qquad \text{for } i = m$$

and $c = (X'X)^{-1}$ where the element in the r^{th} row and c^{th} column of matrix (X'X) is $\sum(\log X_r - \overline{\log X_r})(\log X_c - \overline{\log X_c})$. In equation (3.A.8), it is assumed that the logarithmic transformation used in the least-squares estimation is to the base e. For using a transformation to the base 10, the term

Table 1. Production elasticity, marginal productivity and average product, region I (standard errors in parenthesis)

Items	Traditional practice	Hired tractor	Hired tractor and fertilizer
Number of sample farms	115	90	68
Value of constant (log A)	1.1306	1.6057	1.5496
Value of production coefficients (elasticities):			
Land	0.9113**	0.6555**	0.6879**
	(0.0721)	(0.0787)	(0.0608)
Capital	0.1559*	0.0267	0.0830*
	(0.0616)	(0.0671)	(0.0583)
Labor	0.0186	0.1413*	0.0866
	(0.0781)	(0.0683)	(0.0693)
Sum of production coefficient	1.0858	0.8235	0.8575
Value of R^2	0.9950	0.9978	0.9981
Geometric mean:			
Product	615.1196	1088.7935	928.8899
Land	20.7594	33.2230	24.4557
Capital	427.5488	1119.7671	1055.1531
Labor	373.6418	313.0979	281.7666
Marginal productivity at geometric mean:			
Land	27.0048	21.4876	26.1159
	(1.5805)	(1.5180)	(0.0162)
Capital	0.2243	0.0259	0.0730
	(0.0004)	(0.03753)	(0.0001)
Labor	0.0306	0.4915	0.2854
	(0.0007)	(0.0982)	(0.0001)
Average product at geometric mean:			
Land	29.63075	32.7723	37.9826
Capital	1.4387	0.9723	0.8803
Labor	1.6463	3.4775	3.2967

*Significant at probability level of 5%.
**Significant at probability level of 1%.

Table 2. Production elasticity, marginal productivity and average product, region II (standard errors in parenthesis)

Items	Traditional practice	Fertilizer
Number of sample farms	42	110
Value of constant (log A)	1.5847	1.0658
Value of production coefficients (elasticities):		
Land	0.6358** (0.1196)	0.6399** (0.0742)
Capital	0.1842 (0.1105)	0.2352** (0.0479)
Labor	-0.0110 (0.1221)	0.0864 (0.0686)
Sum of production coefficients	0.8090	0.9615
Value of R^2	0.9957	0.9968
Geometric mean:		
Product	701.3139	985.0193
Land	26.7725	34.7616
Capital	570.0376	1113.0383
Labor	343.8896	403.6047
Marginal productivity at geometric mean:		
Land	16.4600 (0.0818)	18.1407 (0.0156)
Capital	0.3031 (0.00012)	0.2082 (0.00001)
Labor	-0.0300 (0.0004)	0.2109 (0.00007)
Average product at geometric mean:		
Land	26.1953	28.3364
Capital	1.2302	0.8849
Labor	2.0393	2.4406

*Significant at probability level of 5%.

**Significant at probability level of 1%.

Table 3. Production elasticity, marginal productivity and average product, region III (standard errors in parenthesis)

Items	Traditional practice	Hired tractor
Number of sample farms	64	7
Value of constant (log A)	1.5372	1.3227
Value of production coefficients (elasticities:		
Land	1.1960**	0.6268*
	(0.0906)	(0.4649)
Capital	0.0331	0.0881
	(0.0843)	(0.2949)
Labor	-0.0236	0.2803
	(0.0938)	(0.5165)
Sum of production coefficient:	1.2055	0.9952
Value of R^2	0.9955	0.9988
Geometric mean		
Product	522.7632	643.9529
Land	9.1620	10.0467
Capital	420.8049	549.3611
Labor	239.3026	158.4653
Marginal productivity at geometric mean:		
Land	68.2643	40.1694
	(0.2012)	(0.9189)
Capital	0.0411	0.1033
	(0.00003)	(0.00011)
Labor	-0.0516	1.1389
	(0.00013)	(0.0041)
Average product at geometric mean:		
Land	57.0578	64.0959
Capital	1.2423	1.1722
Labor	2.1845	4.0637

*Significant at probability level of 5%.

**Significant at probability level of 1%.

Table 4. Production elasticity, marginal productivity and average product, region IV (standard errors in parenthesis)

Items	Traditional practice	Fertilizer
Number of sample farms	27	105
Value of constant (log A)	1.6454	0.9500
Value of production coefficients (elasticities):		
Land	0.5412* (0.2366)	0.4478** (0.1136)
Capital	0.1713 (0.1353)	0.3381** (0.0842)
Labor	-0.1263 (0.2330)	0.0433 (0.1245)
Sum of production coefficients	0.5862	0.8292
Value of R^2	0.9886	0.9917
Geometric mean:		
Product	263.0339	320.1521
Land	18.1955	18.8902
Capital	245.7726	328.5293
Labor	322.1624	360.2158
Marginal productivity at geometric mean:		
Land	7.8237 (1.8887)	7.2094 (0.3649)
Capital	0.1833 (0.0022)	0.3129 (0.0007)
Labor	-0.1031 (0.0031)	0.0366 (0.0007)
Average product at geometric mean:		
Land	14.4559	16.9480
Capital	1.07023	0.9745
Labor	0.8165	0.8888

*Significant at probability level of 5%.

**Significant at probability level of 1%.

Table 5. Production elasticity, marginal productivity and average product, region V (standard errors in parenthesis)

Items	Traditional practice	Fertilizer
Number of sample farms	106	41
Value of constant (log A)	1.0036	1.1834
Value of production coefficients (elasticities):		
Land	0.5441** (0.0787)	0.7227** (0.1183)
Capital	0.0660 (0.0500)	0.1400 (0.1019)
Labor	0.3331** (0.0888)	0.0810 (0.1446)
Sum of production coefficients	0.9432	0.9437
Value of R^2	0.9960	0.9977
Geometric mean:		
Product	497.6658	535.4521
Land	18.8396	22.2843
Capital	379.0068	453.8259
Labor	309.1069	287.7309
Marginal productivity at geometric mean:		
Land	14.3753 (0.4553)	17.3659 (0.8997)
Capital	0.0867 (0.0002)	0.1652 (0.0003)
Labor	0.5364 (0.0011)	0.1507 (0.0014)
Average product at geometric mean:		
Land	26.4159	24.0282
Capital	1.3131	1.1798
Labor	1.6100	1.8609

*Significant at probability level of 5%.

**Significant at probability level of 1%.

Table 6. Production elasticity, marginal productivity and average product, region VI (standard errors in parenthesis)

Items	Traditional practice	Fertilizer
Number of sample farms	18	45
Value of constant (log A)	1.9624	0.7259
Value of production coefficient (elasticities):		
Land	0.3764*	0.3909**
	(0.3609)	(0.1127)
Capital	0.0212	0.1156*
	(0.2633)	(0.0686)
Labor	0.0512	0.4314**
	(0.1407)	(0.1140
Sum of production coefficients	0.4488	0.9379
Value of R^2	0.9924	0.9975
Geometric mean:		
Product	397.8193	481.4248
Land	16.4428	21.8448
Capital	248.1415	444.9917
Labor	329.1381	409.0537
Marginal productivity at geometric mean:		
Land	9.1080	8.6107
	(0.3725)	(0.0115)
Capital	0.0339	0.1250
	(0.0008)	(0.0000)
Labor	0.0619	0.5075
	(0.00014)	(0.00003)
Average product at geometric mean:		
Land	24.1941	22.0384
Capital	1.6032	1.0819
Labor	1.2087	1.1769

*Significant at probability level of 5%.

**Significant at probability level of 1%.

$(B_i^2/_n)$ in equation (3.A.8) must be multiplied by the value of $(2.3026)^2$ (Heady and Dillon 1961). The variances of marginal productivities for alternative groups of resources of each region were estimated at geometric means as shown in Table 1-6.

It is quite interesting to note that if the marginal productivities of alternative groups of resources of regions II, IV, V and VI are estimated at the high level of resource used (at the geometric means of column two of Table 2,4,5, and 6) for each regional production function the marginal productivities for land, capital and labor of the new resource input groups are almost higher than the traditional practice as shown in Table 7. It indicates that the using of new resource

Table 7. The marginal productivities of land, capital and labor at high levels of geometric means of region II, IV, V and VI

Items	Geometric means	Traditional	Fertilizer
Region II;			
Land	34.7616	17.3001	18.1407
Capital	1113.0383	0.2069	0.2082
Labor	403.6047	-0.0341	0.2109
Region IV:			
Land	18.8902	6.1891	7.2094
Capital	328.5293	0.1372	0.3129
Labor	360.2158	-0.0850	0.0366
Region V:			
Land	22.2843	13.1573	17.3659
Capital	453.8259	0.0784	0.1652
Labor	287.7309	0.2238	0.1507
Region VI:			
Land	21.8448	7.8109	8.6107
Capital	444.9917	0.0216	0.1250
Labor	409.0537	0.0567	0.5075

inputs will enlarge the capability of production.

In regions I and III the traditional practice shows that the coefficient of land is very high even though we estimate the marginal productivity of land at high level of resource inputs. However, the marginal productivity of land is still higher than the function of new resource inputs (Table 8). But the productivities of capital and labor tend to be increased and the average product of land is increased by using the new inputs (Table 1 and 3).

Table 8. The marginal productivities of land, capital and labor at high levels of geometric means of region I and III

Items	Geometric means	Traditional	Hired tractor	Fertilizer	Hired tractor & fertilizer
Region I:					
Land	24.4557	30.4799	-	23.4891	26.1159
Capital	1055.1531	0.1209	-	0.0222	0.0730
Labor	281.7666	0.0540	-	0.4395	0.2854
Region III:					
Land	10.0467	70.8108	40.1694	-	-
Capital	549.3611	0.0358	0.1033	-	-
Labor	158.4653	-0.0886	1.1389	-	-

In Table 5 and 6 one will see that the average product due to land of the new input resources is lower than the traditional practice. One might consider that the farm which applies fertilizer has a larger size and the fertility of land is lower. The production function of traditional practice engages a very high coefficient of land and the marginal productivity of land will be diminished as the size of farm in increased. The applications of new resource inputs which increase the marginal productivity of capital and labor will maintain the yield per rai of output while the marginal productivity of land drops drastically. In Table 5 and 6 indicates that the yield per rai of paddy of traditional practice is higher than the new resource input function evaluated at their respective geometric means. But when the traditional practice function is evaluated at the new resource inputs geometric mean the yield per rai of paddy of the new practice is higher than the traditional one as shown in Table 9.

Table 9. The average product calculated at high level of resource inputs of Region V and VI

Items	Geometric means	Traditional (average product)	Fertilizer (average product)
Region V:			
Land	22.2843	23.9545	24.0282
Capital	453.8259	1.1608	1.1798
Labor	287.7309	1.8362	1.8609
Region VI:			
Land	21.8448	20.318	22.03814
Capital	444.9917	1.004	1.0819
Labor	409.0537	1.093	1.1769

It is quite interesting to note that if the farmer can apply greater amounts of land, labor and capital; the marginal productivities of land, labor and capital derived from the production function of new resource inputs are higher than the marginal productivities of various resource inputs derived from the production function of traditional agriculture. However, in the area where the soil fertility is very high, the application of new resource inputs will increase the marginal productivities of capital and labor and also increase the average product per unit of land. Furthermore, in the area where the soil fertility is low, the applications of new resource inputs which increase the marginal productivity of land and labor will maintain the yield per acre of output while the marginal productivity of land drops drastically.

It is evident that the new form of capital increases the marginal productivity and average product. In the early stage of economic development, one might be interested in creating a new production function and of adjusting the existing production function. One would argue that since we have found the production function especially the production function for the fertilizer, we should trace it further to the isoquant and isocline. The writer agrees with this argument; however, the lack of the data concerning the weighted average to be estimated from different kinds of fertilizer application, both in price and in quantity, makes it impossible to estimate such in an appropriate fashion. Nevertheless, the potentiality of fertilizer used can be made properly and the supply function also can be derived from the field experimentations.

Since creating a new production function is of particular interest, the relative prices are of most importance. This can be most clearly explained in the following sections.

B. Farmers and their Capital and Product Markets

1. The desire for change of farmers

There is a desire for change on the part of farmers in Thailand and they will respond to market stimuli. The increased production of such crops as corn, kenaf, and cassava in recent years disprove the hypothesis that Thai farmers are bound by tradition, are satisfied, and will not change their production (Sitton 1962). Furthermore, it is evident in recent years, that somewhat uncoordinated developmental activities have opened up new vistas to a large proportion of Thai farmers, and made them want and expect further change. Road building, in particular, has opened up isolated regions. Roads are followed promptly by bus lines and trucking services. A previously sheltered population becomes more mobile, it visits the metropolis and is exposed to the delights of movies, soft drinks, flashlights and bicycles. These and other products of western origin next appear in local shops and the wellknown "demonstration effect" is at work (Ellsworth 1961). Thai farmers are ready to change from subsistence farming to commercial operations. They show evidence of responding quickly and dramatically to market stimuli. The problem arises that farmers are ready to change but they are still poor.

2. Marketing margins and channels

The relative importance of the processing-wholesaling margin of the marketing process is exaggerated. Let us examine the relative importance of the various assembling, processing, and distributing agencies for a few typical farm products. Table 10 and Table 11, present the distribution of the consumer's baht among those various agencies of the North-Eastern part of Thailand, reveal roughly the importance of other agencies as well as processor-distributors, which we have previously, in the theoretical part assumed to be the only intervening middlemen between farmer and consumer. Table 11, shows that apart from the provincial wholeseller and Bangkok slaughter house which occupy the largest margin to be taken largely by monopoly of hog, cattle and buffalo markets, the agency which bulks also large is doubtless the retailer. For example, of the consumer's pork baht, the retailer's margin is 20.29 percent as compared with 15.71 percent for Bangkok slaughter house and 15.70 percent for provincial wholeseller. The percentage received by the farmer is low; 48.3, 47.2, 49.0 and 48.5 percent for hog, cattle, buffalo and chicken respectively. These figures indicate the great upset of retailing margins to the farmer. The cutting and packing cost would not be considered high as in the advanced countries. The selling method is very simple, the butcher cuts the meat that the consumer wants and wraps it with a banana leaf. The same applies to margins taken by Bangkok slaughter house. It is becoming increasingly recognized that there may be important elements of imperfect competition in meat and pork marketing and processing where the competing firms are limited by some regulations. Perhaps, if the consumer needs more services concerning meat or pork cutting as well as packaging, the margin due to those services should be increased. However, if those services are actually not occurring, the "abnormal profit" would be in that margin.

It is necessary that the important livestock marketing in the North-East be improved. The North-East is one of the largest sources in supplying meat and pork to the Bangkok market. In general, one would say that farmers in the North-Eastern part are poorer than average. Besides the general agricultural situations, the marketing margins and channels are also unfavorable to farmer's. Under the local-and-central-market system, farmers do not have much choice in selling their products, because the current market news is so scarce, and the distances to the terminal markets are so great. In rice marketing, for example, the margins taken by the provincial rice miller and wholesaler are quite large, about 22.4 and 16.3 percent respectively (Table 10). As a comparison, in the central plain, the margins taken by the retailer, rice miller, wholesaler and farmer are about 12.1, 7.27, 8.51 and

72.2 percent respectively (Nakaswadi 1958). The margin taken by the retailer is about the same, however, the difference in margins among rice miller, wholesaler and proceeds to farmers, are quite large. Even though the transportation cost would be high in the North-East, the margin taken by rice miller and wholesaler should not be that high in the ordinary transaction. The less competition and the decentralized market in the North-East could be responsible for the above phenomena and also explains the marketing of other crops.

Table 10. Consumer's baht spent for selected farm crops: distribution to retailer, processor-wholeseller, assembling and transportation agencies and farmer in 1964, North-East of Thailand[a]

	rice	kenaf	Seed-lac	Tama-rind	Kapok	Water-mellon
Consumer's baht	100	100	100	100	100	100
Bangkok exporter	-	3.04	12.84	-	-	-
Bangkok exporter and wholesaler	-	-	-	-	59.64	61.20
Retailer in Bangkok	14.06	-	-	-	-	-
Bangkok wholesaler and retailer	-	-	-	59.46	-	-
Provincial rice miller	22.37	-	-	-	-	-
Provincial processor	-	-	28.97	-	-	-
Provincial belting plant	-	16.88	-	-	-	-
Provincial wholesaler	16.31	12.38	18.25	19.89	13.97	10.37
Proceeds to farmer	47.26	67.70	39.94	20.65	26.39	28.43

[a]Source: Thailand Ministry of Agriculture, (1964).

Table 11. Consumer's baht spent for selected livestock: distribution to retailer, processor-wholesaler, assembling and transportation agencies, and farmer in 1964, North-East of Thailand[a]

	Hog	Cattle	Buffalo	Chicken
Consumer's baht	100	100	100	100
Bangkok retailer	20.29	15.86	19.11	5.44
Bangkok slaughter house	15.71	12.39	10.78	
Bangkok wholesaler				16.10
Provincial wholesaler	15.70	24.59	21.14	30.00
Proceeds to farmer	48.30	47.16	48.97	48.46

[a]Source: Thailand Ministry of Agriculture (1964).

3. The indebtedness of farmers

The first concern of the majority of farmers in Thailand is to produce enough rice and other foodstuffs to meet their own families' requirements. After making provision for these needs they market surplus rice or attempt to grow a second cash crop such as kenaf, corn or others. For most of his production the farmer employs domestically supplied materials rather than purchase inputs. However, to a rapidly increasing extent, farmers do require some resources from the market. Not only because of a rapidly increasing number of farms which do not grow rice for home consumption, but also due to the effect of the international culturally cosmopolitan. To acquire these purchased commodities they must have cash or, when cash is unavailable, credit. A person needs credit whenever he desires goods for which he will not be able to pay until a future date. New loans only mean that the borrower is unable to pay at the moment for what he wants to buy. He is not insolvent unless his future income will be insufficient to repay the interest and principal on his loans.

The study of agricultural credit in Thailand found that about 68.1 percent of farm families are indebted (Thisyamondol, Arromdee and Long 1965). The total amount of credit outstanding is about nine billion baht. Most of the debt is concentrated in the Central Plain, where there is more commercial farming than in the rest of the country. The number and value of loans made by the different types of lenders in the four regions of the Kingdom are shown in Table 12. In the Central plain, commercial lenders of various types are the chief source of funds. In the other regions, relatives are the predominant lenders. In large, this is explained by the greater demand for credit by farmers in the Central plain. Farmers seek credit on the best terms they can get, that is, they have access to institutions that are the preferred source of funds. Secondly, farmers turn to relatives and friends who charge more than the institutions but less than the commercial lenders. Only when opportunities to obtain funds from other sources have been exhausted, do they seek loans from the local stores, merchants, landlords, etc. In the regions outside the Central Plain where the demand for credit is not great, the first two sources are able to supply a large portion of all credit needs. Table 12 also shows the interest rate charged by various lenders in the different regions of the country. Throughout the country, the Government agencies are the cheapest source of credit. Their 0.8 percent interest rate per month or ten percent per year is below that charged by all other lenders. However, those who are not members of a cooperative must rely upon private sources. Of these, relatives provide the least expensive credit and the various commercial sources the most costly. In all four regions of the country, rates charged by neighbors were higher than from relatives. Neighbors charged almost as much as did commercial lenders; 2.6 versus 2.9 percent. For all classes of lenders interest rates in the North and Northeast are higher than in the South and Central Plain. Rates in the South and Central Plain are roughly comparable by type of lender. The higher average rate in the Central Plain results from the larger fraction of loans coming from commercial sources. Again, in the North and Northeast, interest rates appear to be about the same with the various types of lenders. However, Northeasterners borrow so little, they are able to get a large fraction of all credit required from their relatives. This causes the average rate to be lower than in the North.

Furthermore, another point of interest is the repayment capacity of farmers. At first, it may appear that if a loan is profitable, it could be repaid without difficulty. However,

Table 12. Sources of credit by region and monthly rate of interest[a]

Type of lender	Central Plain		North		Northeast		South		Total		Monthly interest rate
	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	
Relative	17.8	22.6	44.8	47.0	50.0	58.5	40.2	43.0	39.9	32.0	1.8
Neighbor	14.0	16.7	24.1	19.9	12.1	4.3	15.1	12.9	15.7	15.0	2.6
Commercial lender	65.9	57.8	20.6	23.3	30.5	26.4	31.8	30.6	36.5	46.0	2.9
Local store	39.2	13.9	4.1	3.0	12.1	4.6	12.1	10.0	16.5		3.5
Crop buyer	8.2	7.9	5.2	10.0	9.1	6.5	13.7	13.8	8.6		2.9
Landlord	6.6	10.7	0.0	0.0	1.5	5.2	0.0	0.0	2.1		3.5
Money lender	8.0	14.3	7.8	8.9	3.3	7.5	3.0	1.5	5.4		3.3
Other	3.9	11.0	3.5	1.3	4.5	2.6	3.0	4.4	3.9		2.5
Institutional lender	2.5	3.0	10.3	9.8	7.6	10.8	12.9	13.7	7.9	5.0	0.8
Credit cooperative	1.4	2.0	10.3	9.8	7.6	10.8	12.1	12.9	7.5		0.8
Other government agency	0.9	1.0	0.0	0.0	0.0	0.0	0.8	0.8	0.4		0.8
Commercial bank	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	2.4

[a]Source: Thisyamondol, Arromdee and Long (1965).

if credit is used to the point where net income is at a maximum, where marginal income is just sufficient to cover marginal costs, the marginal net income will be nil. How, then, is the principal amount of the loan to be repaid? The answer depends partly upon the use made of the capital loaned. In other words, the type of assets purchased with borrowed funds influences the amount of indebtedness that can be carried. Assets which are paid for from gross income, in effect "pay for themselves". Loans for such purposes may be termed self-liquidating loans. Other assets must be paid for from net income. Loans made to acquire such assets are not self-liquidating (Murray and Nelson 1963). Loans for operating expenses might be considered as self-liquidating, however, Table 13 shows that operating expenses tended to increase as the farm size increased and occupied about 29 percent of total loans for all size farms. On the contrary, the non-self-liquidating loan, such as loans for consumption, occupied about 34 percent of the total loans and tended to decrease as the farm size increased. If we combine items one through five which are the self-liquidating and partially self-liquidating loans and compared these with the combination of items six through nine which are the non self-liquidating loans, the figures would come up half and half. This would answer the problem in Table 14, that farmers in the Central Plain can repay only 49.6% of the principal of their loans. Of this amount, less than half is spent on self-liquidating assets, these assets could not repay the total loan.

Farmer borrowers in the North have highest ability, in comparison with other regions, to repay both interest and principal. This is due to the fact that farming in the North is more intensified than farming elsewhere. Good irrigation systems better soil, and the prevalence of diversified farming, tend to increase farm incomes. The majority of the loan is an accumulation of interest on the basic principal. Farmers generally repay the interest first, then if money is available, they will repay their principal. Therefore, more are able to repay their interest, (81.9 percent) than to repay their principal (57.0 percent)(Table 14).

4. <u>Effects of the seasonal rhythm</u>

The necessity to borrow arises from the small or non-existent surplus, out of which saving can be made, and the seasonal nature of farm income. If incomes were adequate for consumption, and regular throughout the year, there would still be a demand for medium- or long-term credit, to provide fixed and semifixed capital. This would be for non-continuous expenses such as for purchase of traditional farm tools and equipment as well as fertilizers. The importance of the seasonal variation of income and its bearing on the demand for credit has been recognized in Thailand. The farmer in the Central Plain sells most of his rice surplus during the harvest-

Table 13. The classification of loans by purposes, Central Plain of Thailand, 1958[a]

Purpose of loans	Size of Farms (Rai) 1-20	21-40	41-60	61-80	81-100	above 100	Average
1. Pay operating expenses	26	31	30	30	27	34	29
2. Purchase of land	3	3	4	7	5	6	4
3. Purchase of farm implements	7	8	5	7	7	8	7
4. Improvement of land	1	-	-	-	1	1	1
5. Buy draft animals	10	9	9	9	6	10	9
6. Consumption	41	32	34	33	36	27	34
7. Repayment of old debts	4	9	10	3	9	4	8
8. Expenses for family ceremonies	3	3	2	3	1	2	2
9. Others	5	5	6	8	8	4	6
Total	100	100	100	100	100	100	100

[a]Source: Nakaswadi (1958).

Table 14. Ability to repay principal or interest[a]

Region	No. of borrowers	Ability to repay		Number of ability not to repay		Percentage of repayment		Percentage of not to repay	
		Prin.	Int.	Prin.	Int.	Prin.	Int.	Prin.	Int.
Central	232	115	180	117	52	49.6	77.6	50.4	22.4
North	72	56	69	16	3	77.8	95.8	22.2	4.2
Northeast	90	58	82	32	8	64.4	91.1	35.6	8.9
South	71	36	50	35	21	50.7	70.4	39.3	29.6
Total	465	265	381	200	84	57.0	81.9	43.0	18.1

[a]Source: Thisyamondol, Arromdee and Long (1965).

ing season (Table 15 and 16). This amounted to 22.6, 25.1 and 20.2 percent of crop year 1955-1956 and 21.2, 24.5 and 19.4 percent of crop year 1956-1957 in the months of January, February and March respectively (Nakaswadi 1958). Therefore, his cash income from crop sales is concentrated in one period of the year, the rice harvesting season. Throughout the remainder of the year he realized only a limited income from the sales of stored paddy or other farm products. The other major source of cash income is from working off the farm, especially as non-farm laborers during the dry season. To determine the farmer's need for seasonal credit we must also examine how cash funds are used during the year. Purchases of non-durable household items, food, soap, etc., are roughly constant throughout the year. The buying of more durable goods, clothes, pots and pans, household repairs, etc., is often concentrated in the dry season when the farmer not only has the time to shop but is also more likely to have cash available from crop sales and off-farm work. Expenditures on farm improvements are heaviest during this period. Therefore, during the harvest season farmers have a considerable excess of income over expenditures. The excess can be used either to repay old debts or build up a cash balance. Throughout the other seasons, farmers run deficits in the sense that outlays are greater than income. The deficits can be financed either by drawing on cash balances, or, when these are exhausted, by borrowing. The size of the income is very important in determining debt. In the Central Plain, most of the income is derived during the harvesting season from the rice crop. The rice surplus is not large, therefore, most of debt is concentrated in this region. Furthermore, during the harvesting season, when the farmer sells his crop, the price is usually the lowest of the year. This depresses the income more than it would be if the farmer sold his crop in another season. The seasonal price movements of several crops was estimated in Table 17. Usually the price of most farm products do not remain constant throughout the season, they follow a regular seasonal pattern. This is not necessarily evidence of an imperfection in the market with respect to time. Generally we might consider that most of agricultural products come on the market heaviest at harvest time when their cost of production plus costs of storage are lowest (since storage costs at harvest time are zero). These heavy sales depress prices until they reach the point where the seasonal rise in price thereafter corresponds roughly with differences in the costs of producing the product at different times of the year, or storing it (if it can be stored) from one part of the season to another. In Thailand, the need of money to repay a debt as well as to support the family is a factor that must be considered.

The seasonal series which are met in practice nearly always contain a trend component and nearly always the remaining component is serially correlated. It is probable that these three components will be interrelated in a complicated fashion, but it is nevertheless true, at least with economic data, that a simple additive model agrees sufficiently well for practical purposes. Often, it will be necessary to work in terms of the logarithms of the original observations for this to be so.

The basic model is;

$$y_t = p_t + s_t + u_t \qquad (3.B.1)$$

where p_t is the trend oomponent which will be describable by a polynomial in t of degree d, s_t is the seasonal component and u_t is a stationary residual with zero mean. By saying that u_t is stationary we mean that the serial covariances,

$$\gamma_s = \varepsilon(u_{t+s}\, u_t)$$

depend only s and not upon t. We assume that the unit time interval is one month. The s_t component may be written

$$s_t = \sum_{j=1}^{12} a_j s_{j,t} \qquad (3.B.2)$$

where $s_{j,t}$ is unity for t-j divisible by 12 and is zero otherwise. Thus a_j is the additive seasonal component for the j^{th} month of the year and if logarithms of the original data have been taken then antilog a_j will be the seasonal factor by which the figure for the j^{th} month of the year must be divided to give the seasonally corrected series. Of course the a_j are unknown and have to be estimated.

We may assume that

$$\sum_{1}^{12} a_j = o \tag{3.B.3}$$

Since we may achieve this, if it is not so, by subtracting a constant from s_t and adding it to p_t.

Though the formula (3.B.2) is the relevant one from the point of view of the application of the end results of the estimation procedure. A more relevant formula from the point of view of this estimation procedure is the equivalent formula

$$s_t = \sum_{k=1}^{6} (\alpha_k \text{ Cos } \lambda_k t + \beta_k \text{ Sin } \lambda_k t), \tag{3.B.4}$$

$$\lambda_k = \frac{2\Pi k}{12} \quad .$$

In this formula β_6 Sin $\lambda_6 t$ is identically zero and has been included only because its omission makes the notation more complex. The α_k and β_k are related to the a_j by

$$\left.\begin{aligned} \alpha_k &= \frac{1}{6} \sum_{j=1}^{12} a_j \text{ Cos } j\lambda_k \\ \beta_k &= \frac{1}{6} \sum_{j=1}^{12} a_j \text{ Sin } j\lambda_k \end{aligned}\right] \quad k \neq 6$$

$$\alpha_6 = \frac{1}{12} \sum_{j=1}^{12} a_j \text{ Cos } j\lambda_6$$

Hannan gives us a more convenient method to estimate seasonal movements (Hannan 1963). To eliminate the seasonal component from the "trend plus seasonal plus random" can be eliminated by the formula

$$y_t' = (I-A)y_t \qquad (3.B.5)$$

where y_t is empirical data of price by month, A is the moving average operator to eliminate p_t, I is the identity matrix.

To estimate a_j we will form u_j' by using the formula

$$u_j' = \frac{1}{m} \sum_{t=1}^{m} y'_{12t+j} \qquad j=1,...,12 \qquad (3.B.6)$$

where m is the number of years to be included in the model, and the same month of different years of y' will be estimated for 12 months to form u_j'. After u_j' are formed, adjust these to add to zero by subtracting their mean. Call the mean corrected set u_j. The u_j, to repeat, are the monthly means for the trend reduced series adjusted to add to zero, the trend reduction having been obtained by forming $(I-A)y_t$. Finally the seasonal index can be found by using the formula

$$\hat{a}_j = \sum_{k=1}^{12} u_k b_{k-j} \qquad (3.B.7)$$

where we define $b_k = b_{12+k}$ for $k \leq 0$ and b_k are also defined by

$$b_k = \frac{1}{12} \sum_{s=1}^{11} \frac{1}{1-h(\lambda_s)} e^{-is\lambda_k} \qquad k=1,\ldots,12$$

Both A operator and constant b were used in the calculation of Table 17 are the Spencer's 15 pt. formula. They are,

$$\text{A operator} = \frac{1}{320} [-3,-6,-5,3,21,46,67,74,67,46,21,3,-5,-6,-3]$$

$$b_i (i=0,\ldots,11) \text{ Constants} = [1.638,.539,.262,-.103,-.444,-.686,-.774,-.686,-.774,-.103,.262,.539]$$

The complex proof has been also shown by Hannan that the above method would be equivalent to formula (3.B.4).

The seasonal price movements of several crops which were estimated by the above method (Table 17). Prices of all crops are low during the harvesting season and high during the other seasons. From the point of view of farm income formation, the income of farmers who must sell their products during the harvesting period would be tremendously effected by seasonal price fluctuations.

Table 15. The monthly percentage of rice sold by farmers, Central Plain, Thailand[a]

Month	Year 1955-1956	Percent	Year 1956-1957
January	22.61		21.20
February	25.14		24.47
March	20.17		19.44
April	9.45		11.70
May	4.63		5.74
June	2.01		2.43
July	2.31		2.13
August	4.81		4.35
September	4.06		3.69
October	3.13		3.34
November	0.81		0.93
December	0.87		0.58
Total	100.00		100.00

[a]Source: Nakaswadi (1958).

Table 16. Crop calendar[a]

Crop	Month											
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Rice	p	p	p	H	H		H	H	H	H		
Corn	p	pH	p	H	pH	pH	H	H	H		p	
Castor beans	p	p			H	H	H	H	H	H	H	
Sesame	p	p	p	H	pH	pH	H	H	H	H		
Kenaf	p	p				H	H	H				
Peanuts	p	p	p		H	H	H	H				
Mung beans	p	p	p		p	p	H	H	H	H	H	
Cotton	p	p	p		p	p	H	H	H	H	H	H

p = planting
H = harvesting

[a]Source: Agricultural Economic Division, Ministry of Agriculture, Bangkok, Thailand. Private communication. 1966.

Table 17. Seasonal price index of certain crops in Thailand year 1959-1965[a]

Month	Paddy	Corn	Castor beans	Sesame	Kenaf	Peanuts	Mung beans	Cotton
May	99.87	113.81	100.83	104.84	96.96	101.89	100.46	100.21
June	101.83	109.89	101.84	104.35	98.18	96.15	99.36	100.63
July	104.48	100.97	104.02	98.76	98.13	97.47	103.66	100.59
Aug.	104.28	95.75	102.34	95.83	102.09	93.08	108.10	101.13
Sept.	104.65	87.15	97.98	94.56	98.59	92.40	108.88	102.62
Oct.	102.65	88.00	97.86	92.40	101.33	94.37	110.32	102.84
Nov.	103.69	93.58	98.04	95.34	96.09	96.65	96.29	100.84
Dec.	102.61	99.66	100.17	95.30	97.91	98.44	89.93	99.70
Jan.	93.70	103.98	103.23	101.96	104.93	106.08	91.47	97.52
Feb.	94.70	103.77	98.09	105.24	105.65	108.23	94.61	95.47
Mar.	93.96	102.56	97.49	103.86	104.43	108.97	98.34	99.12
Apr.	94.71	104.56	98.42	109.15	96.37	108.39	101.01	99.57

[a]Source: Estimated from the data received from the Division of Agricultural Economics, Ministry of Agriculture, Bangkok, Thailand (1966).

C. Size of Farm and Farm Business in Relation to Farm Income

The size of the farm business in relation to farm income is a very important aspect for farm development. The terms "size of farm" and "size of farm business" are often used interchangeably but are measured in many different ways. In so far as this dissertation is concerned, the size of the farm will be used to designate the amount of land in a farm unit and the size of farm business will refer to the combined inputs of land, labor and capital. Let us first consider the size of farm in relation to income.

As we know from previous analysis, farmers of all regions always grow paddy for home consumption and will sell their rice surplus in the open market. It would be advantageous to know the amount of rice production per farm and the disposition of rice within farm.

The Central Plain is the region that farmers have the largest portion of rice surplus for sale, constituting 64.2 percent of the total production (Table 18). The farmer in the other regions have a smaller portion of rice surplus for sale than the farmer in the Central Plain. The difference in rice surplus among regions would be largely due to the differences in the average size area cultivated for rice and the yield per rai. The average size of rice production by region is as follows: 26.1 rai in Central Plain; 16.3 rai in the Northeast; 13.4 rai in the North; and 8.7 rai in the South (Table 19). In the Central Plain; however, the picture is different, 97.2% of the total area of land, is devoted to rice production. Therefore, the income derived from farms would primarily come from the sale of rice. Evaluated at a high price of rice per kilogram say one baht, the income from rice will be 3,614 baht or about $172. This income is the gross income without deducting any expenses. If the net cash income is made, the income derived from rice surplus would be quite small for farmers to live with. Furthermore, farmers in the Central Plain who predominantly grow rice as the main source of income have only a small area of land left for other crops. This constituted only .76 percent of the total farm size and one crop a year, which is practically dominant, could not provide enough income for living especially for farmers who have a small size of farm. The above analysis would indicate why the farmer in the Central Plain has a large debt and less ability to repay loans.

Wealthier farmers might be those in the North. It has been mentioned earlier that diversification of farming and double cropping prevail in this region. The rice surplus amount more than half of total production can be sold. Income can also be derived from upland crops such as soybeans, mung beans, ground-nuts diversified with rice or planted in the other areas where about three rai left from rice cultivation.

Fruit trees are also grown in the rest of the area.

In general, farmers in the Northeast have a lower income as compared with other regions. Farmers have had to depend on natural collection of water in bottom land. This is a very uncertain method in much of the Northeast where rainfall density fluctuates considerably from year to year and where the concentration of precipitation in brief periods during the rainy season frequently produces flash floods that destroy large areas of planted paddy. In the Northeast, soils vary considerably from place to place. Much of the soil is composed almost entirely of silica sands and silts. There is very little inorganic material that can weather further to release any plant nutrients, and almost no clay, or organic matter, which can absorb and retain, any soluble plant nutrients that do exist. The latter are leached out quickly by heavy rains (Pendleton 1962). In these areas of poor soils, the yield per rai of rice is lowest as compared with other regions. The average rice surplus per farm family constituted 44.5 percent of total production or about 1,225.66 kilograms (Table 18). Evaluated at high price levels of one baht per kilogram the gross income from rice would be 1,225 baht or about $59. This is a very low figure for gross income throughout the year. Farmers try to grow upland crops such as kenaf, corn, and pulses. However, a wide price fluctuation, especially in the price of kenaf, cause the production to fluctuate widely from year to year. The non-rice area occupies 24.7 percent of the total farm size or about 5.3 rai (Table 19). This area will be available for upland crops and livestock. Due to the low income from rice surplus, farmers try to raise livestock as the other source of income. Hogs, cattle and buffaloes from the Northeast are one of the main sources of pork and meat supplied in Bangkok markets. Even though the farmer tries hard to raise his income, the income is still very low. A study of farm net cash income of three provinces in the Northeast - Roi-et, Mahasarakam and Kalasin, conducted by the Division of Agricultural Economics, Ministry of Agriculture, found that the net cash incomes of farmers were only 268.73 baht on the average in 1963. The improvement of farm income in this region must be considered urgent.

The rice surplus per farm family in the South is quite small, occupying only 23.9 percent of the total production or about 439.14 kilograms. Occasionally, rice from the Central Plain has to be shipped to the Southern part when the rice production in this region is damaged by drought, pests and diseases, and other cases. However, the income derived from non-rice areas such as rubber plantations and orchards constitutes a large part of family income. Non-farm work by some members of the farm family in the big rubber plantations or in tin mining has also contributed to the component of the family income. Therefore, the farm family income, in this area, would be high as compared with the farmer in other regions.

Table 20 shows the land tenure in each region separating into area owned by the operator and the area rented. At the present time, there is no serious study on tenure systems concerning leasing arrangements in Thailand. It might be due to the fact that the land area owned by the farmer's operator occupies a high percentage. The farm population associated with the total land area available would be considered as one of the other factors that determines the land area to be rented by farmers. According to the 1960 population census in Thailand, there were 4.6 million households in Thailand, of these, agricultural households occupied 74.6 percent. Proportionally, almost 75 percent of the total population lived on the farm. In the Northeast zone, the percentage of agricultural population was the highest, 88 percent, while the percentage of area owned by the farmer's operator was also the highest, 91.09 percent. In the Northern and Southern zones, the percentages were the same, 79 percent, while the percentages of area owned by the farmer's operator were 80.15 and 86.42 percent respectively. In the Central Plain where the land area owned by the farmer's operator was the lowest, 79.59 percent, with more urban areas located in this region, the percentage of agricultural population was down to 55 percent. Under the existing agricultural land available

Table 18. The average disposition of rice production of farmers

	Central plain	North	Northeast	South	Average
1. Product per farm[a]					
Kgs	5,629.33	4,038.20	2,757.04	1,840.06	3,490.52
%	100	100	100	100	100
2. Pay for rent[b]					
Kgs	493.69	292.78	57.35	47.84	230.03
%	8.77	7.25	2.08	2.61	6.59
3. Seeds[c]					
Kgs	242.27	124.16	151.59	81.28	152.52
%	4.30	3.07	5.49	4.41	4.36
4. Home consumption[d]					
Kgs	1,166.60	1,113.40	1,267.30	1,235.00	1,193.20
%	20.72	27.97	45.96	67.11	34.18
5. Other[e]					
Kgs	112.59	80.76	55.14	36.80	69.81
%	2.00	2.00	2.00	2.00	2.00
6. Sale[f]					
Kgs	3,614.17	2,427.10	1,225.66	439.14	1,844.96
%	64.21	59.71	44.47	23.88	52.87

[a]The product of rice per farm was estimated from Agricultural Census, 1963.

[b]Pay for rent was figured at 8.77, 7.25, 2.08 and 2.61 percent of total product estimated by the Division of Agricultural Economics, Ministry of Agriculture.

[c]Average 9.3 Kgs./rai of planted area of each region.

[d]Consumption was figured at 190 kgs./capita.

[e]2% of production was allowed for animal feed, charity and other of each region.

[f]Sale was the subtraction of items two to five from item one.

Table 19. The average size of farm, area for rice cultivation and the other*

Regions	Total farm size		Area for Rice cultivation		Other[a]	
	Rai	%	Rai	%	Rai	%
Central Plain	26.81	100	26.05	97.17	.76	2.83
North	16.14	100	13.35	82.71	2.79	17.29
Northeast	21.64	100	16.30	75.32	5.34	24.68
South	22.97	100	8.74	38.05	14.23	61.95
Average	21.68	100	16.40	75.65	5.28	24.35

[a]This item may be included farm homestead, land for upland crops and gardening, orchard, wood land as well as livestock yard.

*This table was estimated from Agricultural Census, 1963.

Table 20. The land tenure*

Region	Total land area		Area owned by operator		Area rented[a]		Other[b]	
	Rai	%	Rai	%	Rai	%	Rai	%
Central Plain	19,380,867	100	15,426,208	79.59	2,199,061	11.35	1,755,598	9.05
North	12,557,954	100	10,064,928	80.15	344,070	2.74	2,148,956	17.11
Northeast	26,419,099	100	24,066,328	91.09	16,121	.61	2,336,650	8.84
South	11,324,517	100	9,786,611	86.42	34,709	3.06	1,503,197	13.27
Total	69,682,437	100	59,284,075	85.08	2,653,961	3.80	7,744,401	11.11

[a]This item is the land rented on the basis of cash rent and share cropping.

[b]This item might be effected through clearing and occupancy of unclaimed land, use of land on free rent basis, squatting, use of land in exchange for services, or use of land in lieu of receiving payment on a morgage held on that land, persons enting land on both cash and share basis were also classified as other.

*This table was estimated from Agricultural Census, 1963.

and the existing heritance system, if the total movement of people out of agriculture cannot have large enough, the size of farm would be reduced and the more fragmentation of land and the more land to be rented by the farmer's operator would also occur. This is the really complex economic problem concerning the labor market, by using the cirterion that "labor of equivalent capacities should earn the same real marginal returns in all employment."

From the production function of previous analysis we know, in Thailand, land is the major input factor to boost output characterized by the high coefficient of land. In this section we also know that the existing size of farm cannot boost income for most farmers to live with. Now we will proceed to discuss another topic; how to increase farm income in Thailand.

The size of a farm business may be expanded extensively, intensively, or by a combination of both methods. The size of farm business can be increased up to the point at which the cost of the last unit added is equal to the value of the added product. The net management returns would be increased gradually from the point which they start, to the point of optimum size of farm business under the above criteria. For simplicity, the terms "net management returns" and "farm income" will be used interchangeably.

To increase farm income by the extensive expansion, which consists of adding more land, would be possible in Thailand's agriculture, but it needs more considerations. It was estimated by the National Economic Development Board, on the basis of land classification, that an additional 50 million rai could be brought under cultivation if there is a need for further expansion. Therefore, one would expect that the agricultural output will be increased by adding more land into cultivation. However, the increase in total agricultural output does not necessarily mean that the farm income will be increased. If the new land added to cultivation brings forth the enlarging of existing farm size; the farm income would expect to be increased. Nevertheless, the new land is forthcoming, but the existing farm size is not enlarged, the farm income could not be increased. It needs more careful study concerning the distribution of lands among farmers and the rate of growth of farm population to the extent that what would the direction be concerning the size of farm if the new land is brought into cultivation.

Intensive expansion may be accomplished by adding more labor or capital or both to each acre of land. The new form of capital might be very much concerned here. The productivity of new inputs and the factor/product price ratio will determine the amount of input used and the amount of output to be increased under the farm production function and size. Two forms of capital inputs, - fertilizer and machine, will be discussed here. To judge the magnitude of the inducement to farmers to use fertilizers, however, farm price of both fertilizers and crops should be applied for the conversion into value. In case of rice, at present price relationships between paddy and fertilizers, the input-output price ratio is unfavorable. For instance, in Taiwan, one pound of ammonium sulphate is worth one pound of rice. In Thailand, one pound of ammonium sulphate is worth 2.5 pounds of rice (Scoville and Thieme 1964). The results of field experiments and demonstrations done by the rice department indicate marked increase in rice yields from the use of chemical fertilizers. The average increases are: Northern zone, 36%; Central Plain zone, 64%; Northeastern zone, 93%; and Southern zone, 32%. But the unfavorable factor/product price ratio will cause the use of chemical fertilizers by farmers to be low. Thailand is one of some countries where the chemical fertilizer application per hectare is very low, averaging only 2 kilograms per hectare (Table 21). In the previous section concerning the farm production function and productivity, we see that the application of fertilizers will increase the productivity of capital and average product, but the increasing in productivity is not quite high. It may be due to the price of chemical fertilizer as compared with the price of rice, therefore, some farmers try to use animal manures instead of chemical fertilizers or apply both of them.

It is necessary for farmers to increase the yield per rai by applying chemical fertilizers, if the price ratio would be favorable to them. The Thai Government must be aware of this aspect. In the case of rice, the experiment on gradually reducing rice premiums would result in higher farm price of rice or a certain amount of rice premiums would be used as subsidies for cheap fertilizer sales, resulting in low production cost. Otherwise the rational producers will not use expensive chemical fertilizers.

To hire a tractor in ploughing farm land would increase the productivity of labor. This direction will be underway as long as the income of farmers is low and the investment on tractor for hired ploughing by crop dealers and big farmers is profitable. However, this technique will not help much to increase farm income. The intensification of farming which will increase farm income, and afterward farmers would have a chance to buy suitable power tillers of their own, would be the more reasonable direction to be considered under the existing circumstances.

When the term "small farm" is mentioned, it immediately brings to mind two problems: the limited supply of land and the seasonal surplus of labor as well as hidden unemployment. With the physical supply of land relatively fixed, the farmer cannot expand his farm size horizontally but he can expand it vertically. This means that land which was used for growing

Table 21. Consumption of chemical fertilizers in selected countries, 1961/62 (total content of N, p_2O_5, and k_2O)[a]

	Total fertilizer consumption (1,000 tons)	Fertilizer consumption per hectare (kg.)
Burma	5.1	0.3
Cambodia	0.1	0.04
Ceylon	65	42
China (Taiwan)	182	209
India	418	3
Indonesia	136	8
Korea, Republic of	316	151
Malaysia: Malaya	41	17
Sabah	1	7
Pakistan	79	3
Philippines	77	11
Thailand	20	2
Viet-Nam, Republic of	27	8

[a]Source: United Nations (1965).

only one crop a year should now be used for growing multiple crops. In addition to crops, other enterprises such as livestock raising, food preservation and cottage industries can also be properly combined. By doing so, the available land and labor resources will be fully utilized resulting in an increase of total output both per person and per unit of land, reducing the unit cost of production, and diversification of source of income. In other words, intensification is an effective means to enlarge the size of farm business from available but limited farm resources (Ong 1960).

The critical point in enlarging farm business is that, even agricultural extension people and farm economists as well as farmers who see the possibilities of enlarging farm business feel unable to do so because the inability to get sufficient capital to begin with. In general, we see that farm receipts are hardly enough to cover family expenses which often compel the farmer to live in indebtedness. With such a weak financial position, a loan is difficult to obtain even if the farmer is willing to pay higher interest rates. Therefore, to assist these farmers in financial distress, it is necessary to help them to formulate sound production plans with the more efficient use of labor at the primary stage of development. To help farmers make wise decisions in management practices, we begin with research. Conducting research today has become the responsibility of the government as both a financial burden and technical knowledge are beyond the means of the small farmers. Hence, the initial emphasis would be placed on the investigations that do not require large increases in the use of purchased inputs. This means emphasis upon the development and introduction of innovations such as improved crop rotations, optimum spacing and time of planting and a better seasonal distribution of the work load as well as the introduction of high yielding varieties. The above suggested techniques would increase farm income as well as increase the ability to repay loans of farmers. When the uncertainty in farming is reduced, the rate of interest in the farming area would also be reduced. An arrangement of cheap credit for farmers must be done by the government.

Experiences show that in the Northern zone of Thailand, particularly Chiengmai, where irrigation faciltiies are available, many farmers have practiced the multiple cropping system with rice as the main crop and other crops as supplementary crops. It has been reported that, under the double cropping system farm labor is better utilized (Nakaswasdi 1962). After the harvesting of rice, second crops such as tobacco, garlic, and onion are grown. The average acreage of rice per farm in the area surveyed was 12 rai while the average acreage of second crops was 3.52 rai, approximately 30 percent of the rice acreage. The reasons for the smaller area under second crops are: insufficient supply of water; high labor requirement for these intensive crops, and lack of markets.

In the high land where moisture is insufficient even to grow one crop of rice, the farmer could introduce two or more other crops such as corn and corn, corn and peanuts, corn and mung beans pluses and vegetables, or other combinations. In farm planning projects at Saraburi of the Central Plain, the settlers were much benefitted by adopting a three-crop system. They grew corn as the first crop from May to August, then mung beans or soy beans as the second crop from August to November, with castor beans intercropped between corn and beans as a third crop from June to March, (as reported by the Division of Agricultural Economics, Ministry of Agriculture in 1962).

A study in Chachengsoa province, reported that before adopting the diversified farming system, the average gross income per farm was only 7,659 baht. After adopting the diversified farming system, the average gross income increased to 8,155 baht the second year, to 9,507 baht the third year and to 11,456 baht the fourth year. The average net cash income per farm also increased from 442 baht in the first year to 1,865, 2,374, and 3,115 baht in the second, third and fourth years respectively (Nakaswasdi 1961).

As mentioned before as the farming becomes more diversified, the need for mechanization will follow, due to the resulting labor shortage. However, only low cost tractors or other farm tools will be forthcoming from the standpoint of existing farm business capacity. Furthermore, there is no doubt that the big push on the constructions of irrigation facilities and roads will strongly support the intensification of farming.

It is true that the increase of the farm output is not necessarily that the income of the farmer must be increased. In starting to formulate farm planning, the demand and price of various crops and livestock must be carefully investigated in each location and especially the export markets in the case of Thailand. The improvements of the existing market handling systems as well as the enlarged market for some crops will also support the diversification of farming as well as farm income. These things must go hand in hand, otherwise sound farm planning could not be accomplished.

IV. DISCUSSION

Through the stage of dynamic development, agriculture is internally a dynamic industry. The changes in the structure of agriculture will be basically due to three major sets of forces; namely, first: the national economic growth which has an important impact on relative prices of labor and capital, second: the advances in scientific knowledge as it relates to both the farming industry and those sectors which process inputs to be used in the agricultural production process, third: the improvements of market structure and marketing system as well as transportation.

Since we refer to agriculture as a dynamic industry, one might believe that agriculture in Thailand is moving ahead very slowly and, sometimes, it might seem to be a static industry. We will discuss the dynamic process of agriculture item by item in the following sections.

A. The Fruit of National Economic Growth on Relative Prices of Labor and Capital

Thailand's gross domestic product, i.e. the value of the production of the nation, is estimated to have doubled during the 1951-61 period. After allowing for price increases, the real rate of growth was 70 percent for the entire period, or about 5.5 percent annually. During the same period the annual growth of population has been slightly above 3 percent.

Consequently, real output per capita has increased on the average by almost 2.5 percent a year. The growth in this period has been predominantly in public utilities, construction and transport. Agriculture, which is the largest item, increased by 52 percent and manufacturing by only 50 percent.

The 1960 census shows that 74.6 percent of the population lived on farms, or 19.6 million. It is hoped that by 1970, the agricultural population might be reduced to 60 percent of the total, or 21.8 million. Even with optimistic anticipation, the population living on farms will be 21.8 million, 2.2 million more than that of 1960. As the population increases, the demand for food and fiber will be increased in similar fashion. Some commodities will decline on a per capita basis because they are foods consumers reject as their incomes go high. Furthermore, the change in the population resource structure, as a result of national economic growth will shift the relative resource prices. At the low stage of economic development, the price of labor is low while the price of capital item is high in relation to their relative abundance or scarcity. If the national economic growth brings forth the shift in the relative resource prices, the resource mix would move towards a capital intensive agriculture.

However, the change in the resource structure will be due basically to the development of industry. The development of Thai industry has been hindered mainly by the lack of sufficient electric power capacity. However, this problem is being partially met by the long-range big-push of the government investment on public utilities such as hydro-electric power and road constructions. Other principal bottle-necks to industrial development are the high speculative prices of industrial sites, shortage of skilled labor and management.

B. The Advancement in Scientific Knowledge in Agriculture

1. Within farming industry

Although the agricultural population might be reduced to 60 percent of the total in 1970, the population living on farms will be 21.8 million. This is 2.2 million more than that of 1960. Even with optimistic anticipation on the percentage reduction of farm population, the population living on farms will increase. Consequently, the size of the farm would be smaller than that of 1960. As mentioned earlier, the existing size of farm is quite small. If the size of farm tends to be smaller in the future, more intensification of farming is needed. We will not repeat our hypothesis concerning intensive cultivation here, but some more will be added here.

It seems worthwhile to examine the factors affecting the adoption of intensive cultivation. In general, the factors can be divided into two groups: (1) those largely controllable and (2) those largely uncontrollable by the farm operator and his family. Three main categories of resources controllable by the individual farmer are the quantities of land, labor and capital goods. Farmers can apply greater amounts of these resources in terms of physical units in order to expand their farm size. Another alternative to enlarge the size of farm business in terms of physical or value output is to accomplish better combination and/or better organization of the available resources which in turn, depend mainly on the operator farm management ability. However, achievement of agricultural programs and research works will have great influence on the operator's management ability through a well-developed agricultural extension education program. These factors of development of agricultural programs and technical innovation and improvement are largely uncontrollable by the individual farmer.

2. Factor inputs outside farming industry

Efficient farm production more and more requires the use of a complex bundle of capital items. The new forms of capital inputs such as chemical fertilizers, machineries, insectisides and fungicides are needed for agricultural development. These factor inputs are almost all imported from foreign countries and prices of these inputs are high relative to prices of domestic farm products. To encourage domestic and foreign enterprise to undertake these factor inputs industrial activities in the country are necessary. Otherwise, the subsidies for these factor inputs might be employed, if the more increase in output is needed.

C. The Improvements of Market Structure and Marketing System as Well as Transportation

The present marketing system in Thailand, the so-called middleman system, is understood by those countries having credit of a similar nature for producers and a certain number of middlemen. Under such a system merchants with much capital can use credit to exploit the farmers by buying their products using methods which give them various advantages over the farmers. Besides, over three million of farm households are similar to other businesses in the sense that they are generally profit motivated and respond to prices and adapt inputs and outputs accordingly. But they are dissimilar in the industrial sense in that they are unable to manage their supply to a given set of market prices. Under the imperfect competition, the price received by the farmer is lower than the market price, if the market is more competitive. From past experience, rice marketing in particular, has taught us that the oligopoly - oligopsony market can be developed into perfect competition if the number of independent crop dealer is increased. The promotion of local crop processing expansion would be also considered as a principal objective in agricultural development. The Government's main task is considered to be the creating of conditions conductive to investment in industry by private enterpreneurs, both domestic and foreign.

In the case of rice marketing, as the marketing structure is favorable to farmers, the government must be aware of the export premiums concerning the government revenue and the farmer's income. The previous mathematical extrapolation convinces us that the experiment on gradually reducing rice premiums would result in higher farm prices or rice, or a certain amount of rice premiums would be used as subsidies for cheap fertilizer sales resulting in low production cost.

Road building, in particular, has not only opened up the isolated regions, but also makes new facilities for farmers and reduces the transportation rate. The reduction of the transportation rate would bring more crops to market and also develop new crops to be introduced on the market. The construction of new roads might be more useful and contribute more to economic development if the spatial linear programming model is used to study the situation.

V. SUMMARY

The economy of Thailand is predominantly agricultural. Agriculture not only serves as the source of food and fibers sufficient for home consumption but is also considered the main source of foreign exchange earning. It is typical that the year by year investments of farmers are made on the historical experiences of their accustomed inputs. These inputs have low productivities. The marginal productivity of labor is also low because agriculture is characterized by an excess number of farm workers applied to the ancestor's pattern of farming. With the existing production process, the marginal productivity of land is higher than the marginal productivities of capital and labor indicated by mono-culture.

It has been shown that the size of farm is too small. The rate of interest is too high and most farmers have to sell their products at the harvesting time in order to pay debts as well as to receive cash for their family living. At the harvesting period the prices of products are the lowest of the year. As far as the farm production function is concerned, the farm output sold in the open market is quite small per farm family associated with the low price received, the income left after deducted for previous debt is quite low. The small part of their income to be used for the next investment is too small to invest in more productive inputs. The only thing the farmer can do is to invest in the conventional input.

To increase farm income by the extensive expansion which consists of adding more land, would be possible in Thailand's agriculture if the additional land available to be brought under cultivation brings forth the enlarging of existing farm size. The intensive expansion may also be accomplished by adding more capital. The introduction of new forms of capital such as chemical fertilizers and machines might be considered. However, the introduction of a new input; with a high production elasticity and low supply price is likely to change appreciably the resource mix as equilibrium amounts are approached in the case of factor-factor relationships. Also the factor/product price ratio will determine the amount of new input used in relation to the marginal product of the factor. In Thailand it has been estimated that the factor/product price ratio is unfavorable, resulting in the very low chemical fertilizer application per acre. Likewise, the imported tools and machinery are too large and indivisible in relation to the size of farm and credit available; hence, farmers seldom own the tractors. By now the hired plowing with big tractors seems to be a reasonable source in using it.

With a weak financial position, enlargement of farm business can be made by vertical expansion. This means that land which was used for growing only one crop a year should now be used for growing multiple crops wherever possible. In addition to crops, other enterprises such as livestock raising and others can also be properly combined. The hypothesis behind the above extrapolation springs from the low marginal productivity of labor, the small size of farm and the weak financial position of the farmer. If the labor used is diversified due to multiple crops, the marginal productivity of each labor used must be higher than the total labor used for the single crop. Therefore, the new production-consumption curve would be created. Under the new production-consumption curve, even with the same amount of funds invested as before, the income derived from the new curve will be higher. This hypothesis is very important and necessary for agricultural development in the early stage.

The investigation and development of the high production elasticity of new inputs with low supply prices are also very important. The improvements of the marketing structure, marketing handling system as well as the enlargement of markets for crops and livestock will also support the diversification of farming. No doubt, the big push on the construction of irrigation facilities and roads will strongly support the intensification of farming.

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VIII. APPENDIX

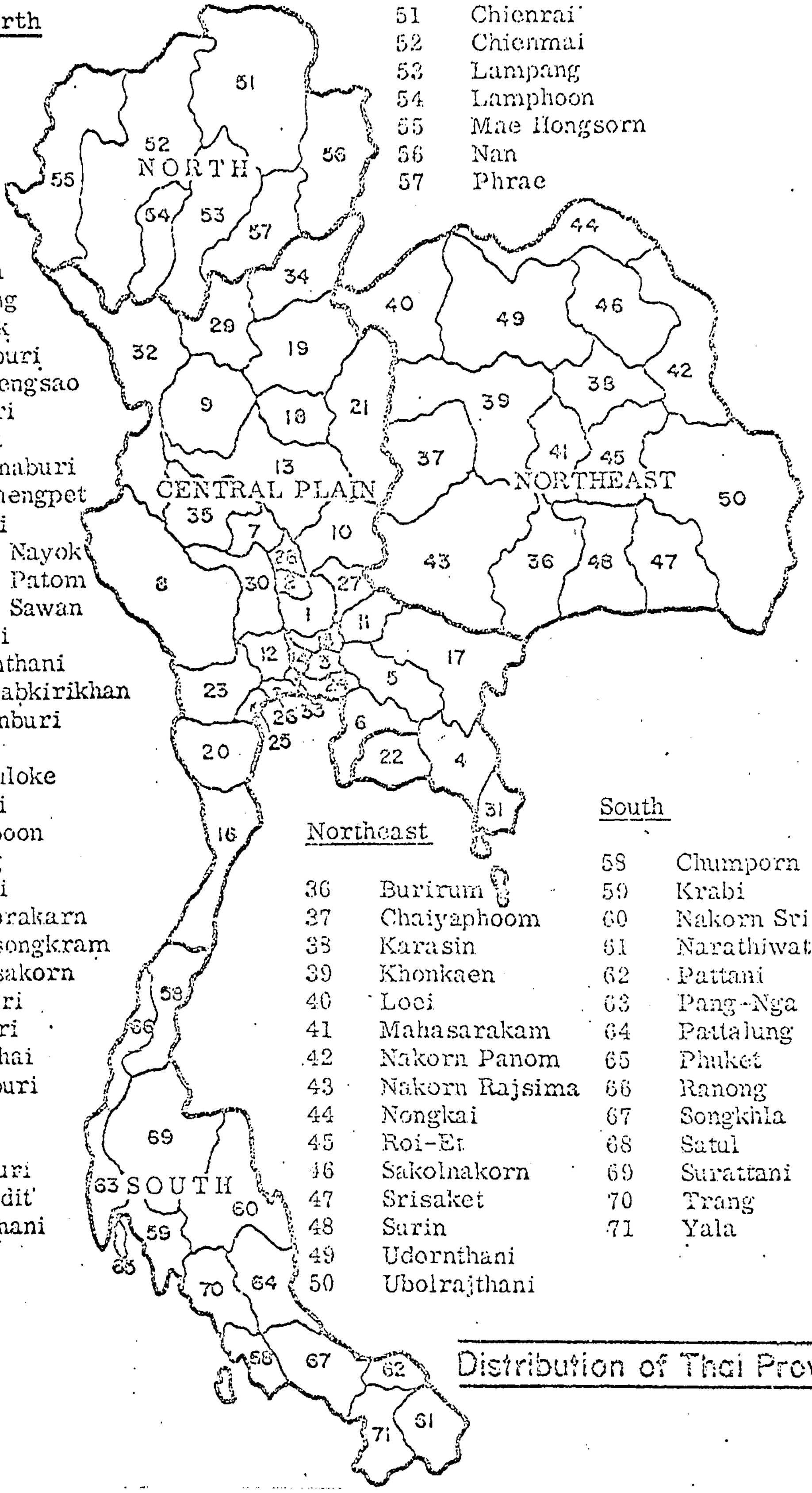
Figure 3. Map of Thailand

North

51	Chienrai
52	Chienmai
53	Lampang
54	Lamphoon
55	Mae Hongsorn
56	Nan
57	Phrae

Central Plain

1	Ayuthya
2	Angthong
3	Bangkok
4	Chantaburi
5	Chachoengsao
6	Cholburi
7	Chainat
8	Kanchanaburi
9	Kamphaengpet
10	Lopburi
11	Nakorn Nayok
12	Nakorn Patom
13	Nakorn Sawan
14	Nonburi
15	Pathumthani
16	Prachuabkirikhan
17	Prachinburi
18	Pichit
19	Pitsanuloke
20	Petburi
21	Pechaboon
22	Rayong
23	Rajburi
24	Samutprakarn
25	Samutsongkram
26	Samutsakorn
27	Saraburi
28	Singburi
29	Sukhothai
30	Supanburi
31	Trat
32	Tak
33	Thonburi
34	Uttaradit
35	Uthaithani



Northeast

36	Burirum
37	Chaiyaphoom
38	Karasin
39	Khonkaen
40	Loei
41	Mahasarakam
42	Nakorn Panom
43	Nakorn Rajsima
44	Nongkai
45	Roi-Et
46	Sakolnakorn
47	Srisaket
48	Surin
49	Udornthani
50	Ubolrajthani

South

58	Chumporn
59	Krabi
60	Nakorn Srithamrat
61	Narathiwat
62	Pattani
63	Pang-Nga
64	Pattalung
65	Phuket
66	Ranong
67	Songkhla
68	Satul
69	Surattani
70	Trang
71	Yala

Distribution of Thai Provinces

Table 22. Economically active population 11 years of age and over engaged in farming by sex in Thailand, 1960[a]

Occupation	Total		Male		Female	
	No.	%	No.	%	No.	%
Farming	11,185,222	81	5,464,230	77	5,720,992	86
Farmers and Farm managers			2,902,341		490,783	
Farm workers			2,561,889		5,230,209	
Non-farming	2,586,882	19	1,642,382	23	944,500	14
Total	13,772,104	100	7,106,612	100	6,665,492	100

[a]Source: Kulthongkham and Ong (1964).

Table 23. Distribution of gross domestic product in Thailand, 1953-1962 (baht: million)[a]

Year	Non-Agricultural sector	Agricultural Sector Others[b]	Agricultural Sector Rice	Total GNP	% of rice to total
1953	18,212	8,696	5,321	32,229	16.5
1954	19,215	8,119	4,710	32,044	14.7
1955	22,880	10,236	6,332	39,448	16.5
1956	24,503	9,456	7,130	41,089	17.4
1957	25,281	10,796	5,690	41,767	13.6
1958	25,524	10,977	5,859	42,360	13.8
1959	28,842	12,207	5,761	46,810	12.3
1960	32,411	13,553	7,150	53,114	13.5
1961	35,507	12,749	8,967	57,223	15.7
1962	39,288	13,391	8,838	61,517	14.4

[a]Source: Thailand Office of the Prime Minister (1963b).

[b]Others include agricultural crops (except rice), livestock, fisheries, and forestry.

Table 24. Percentage share of exports, 1951-1962[a]

Year	Rice	Rubber	Tin	Other	Total export value (US $Million)
1951	54.0	26.6	6.6	12.8	367
1952	65.7	15.2	6.9	12.2	329
1953	66.2	11.6	6.3	15.2	323
1954	51.4	15.5	6.3	26.8	283
1955	44.2	25.1	6.2	24.6	335
1956	41.3	22.1	7.3	29.3	335
1957	48.0	18.7	7.1	26.2	365
1958	46.1	20.6	3.9	29.4	309
1959	34.1	30.8	5.7	29.4	359
1960	29.8	29.9	4.2	36.1	408
1961	35.9	21.3	6.2	36.6	477
1962	34.3	22.0	7.2	36.5	461

[a]Source: Ungphakorn (1965).

Table 25. Gross domestic product of Thailand, 1951 and 1961[a] (in million baht at 1956 prices)

	1951	1961	Percentage increase during 1951-1961
Agriculture	13,731	20,099	52
Mining and quarrying	557	764	53
Manufacturing	3,949	5,721	50
Constructing	924	2,568	248
Electricity and water supply	43	169	307
Communication and transportation	1,203	3,857	246
Wholesale and retail trade	5,927	9,393	57
Banking and finance	1,565	2,494	64
Services	3,302	5,815	80
Total	31,199	50,881	70

[a]Source: Ungphakorn (1965).