AN ANALYSIS OF RESOURCES IN USE IN AGRICULTURAL PRODUCTION

(A Case Study of Korea)

by 6408

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TABLE OF CONTENTS

NAME OF THE TABLES

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I. INTRODUCTION

How to increase agricultural production both to feed a growing population and to feed growing industries is a common task, with which the world is concerned.

Particularly, people living in poor countries have been menaced by an impending crisis food shortage even though their eminent leaders were engaged in solving this problem.
While recognizing such problematic issues, this study will be discussed assuming that this status resulted from misallocation of resources used in agricultural production.

Theodore W. Schultz stressed that the rate at which farmers who settled into a traditional agriculture accept a new factor of production depends on its profitability, with due allowance for risk and uncertainty, and in this respect, the response is similar to that observed in modern agriculture.[1]

However, farmers in poor countries either are indifferent or respond perversely to innovation. They can only perform the iterative processes in farming which result in chronic poverty.[2]

He insists, however, that such conditions leave considerable leeway for responses to economic variables that in the economic equilibrium of traditional agriculture, these responses result in the efficient utilzation of existing factors of production.[3]

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[1] Theodore W. Schultz, Economic Crisis in the World Agriculture (University of Michgan Press, 1965) pp. 33-34

Stephen Enke discusses the fact that subsistence farmers may have fixed or relatively fixed money obligations, and therefore, only sell as much of their production as is necessary to obtain the desired money income.[4]
The relatively fixed desire for money income may exist in balance with relatively fixed monetary charges for rent, services, and inescapable small amounts for non-agricultural consumption goods, etc. Whatever production need not be sold to obtain the desired money income has a very high utility at the margin in on-farm consumption because of the inadequate food supplies which are viable to the subsistence producers. The subsistence producing unit, therefore, is to maximize its production.

One of the most important issues attempted to be found in this study may presumably be that the efficiencies of resources in use result in a subsistence level of production at which the farmer can not afford to get money income for alternative purposes.

The growth of the agricultural sector in the developing economy, of course, can result in better allocation of resources used in foodgrain production and raw materials supplied to industries. Only with the knowledge of how resources are allocated, effect of various specific policies on agriculture and overall growth should responsibly be examined.

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[2]Ibid, pp.35
[3]Ibid, pp.29-30, pp.47. pp.49-54
[4]Stephen Enke, Economics for Development ,(Prentice-Hall, New Jersey, 1963), pp.547-548

For further discussion, under this section, it was generally emphasized that agricultural production was apparently subject to resource allocation with regard to responsiveness of the elasticities of resources used in agricultural production.

The following is a brief introduction as to how this study was organized concerning the above-mentioned theoretical issues. Throughout this study, attention was focused on the analysis of the efficiencies of resources used in agricultural production per farm household in Korea, for the period 1962-1967.

In Chapter One, the historical background and characteristics of Korean agriculture will be discussed. Chapter Two is concerned with a multiple regression model to solve the problem. In Chapter Three, the marginal productivities of resources in use and the growth rate of the agricultural sector are presented. The summary is given in Chapter Four.

1. Historical Background of Korean Agriculture

Agriculture is Korea's most important economic activity. It provides a means of livelihood for more than 55 percent of the population (average 1960-1967) and is the source of approximately 42 percent of the national income (average 1960-1967).[1]

The farmers in Korea are so important that agriculture must be given high priority in planning for the development of Korea's economy. Korea has been engaged in a desperate struggle to evolve a viable economy from the ruins of her devasting war during 1950-1953. Her swollen population of nearly 30 millions of people includes millions of refugees from the north Korea.

With the help of the United States and the United Nations, Korea has been trying for nearly seventeen years to rebuild the war-torn country and to develop her economic potential sufficiently to provide an adequate livelihood for her millions of people.

The major emphasis of the economic activities of the rehabilitation effort has been in the direction of industrialization, this would seem to be both logical and necessary.

In the process, however, it appears that the economic well-being of the agricultural population was taken for granted, so that very little was done to correct the situation which

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[1] see table 3 and 15

resulted from falling prices and inadquate farm incomes.

The average farmer has been forced to dip into his limited capital and to build up a burdensome debt structure. Individually, and in competition with each other the farmers have been helpless to correct the situation. The farmer's plight might be dismissed as a part of the cost of building a new economy for Korea, if it were not for the fact that the same farmers comprise approximately 60 percent of Korea's potential market for industrial products.

Consequently, the low buying power of farmers had a repressive effect upon Korea's industry, which requires an effective market for its output in order to operate successfully.

Instead the Government followed an import policy which had the effect of substantially weakening the competitive position of Korean foodgrains in the domestic market.
The Government needs to launch immediately the most efficient plans to attain self-sustaining growth of the agricultural economy, the goal being better living standards for farmers. However, the role of agriculture in the Korean economy is gradually diminishing, although its contribution still accounts for about 40 percent of the national economic growth. Its importance, therefore, should not be under-estimated.

The characteristic of Korean agriculture is its concentrated production of foodgrains rather than of industrial raw materials.

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[2]see table 4 and 5.

Rice and barley compose approximately 82 percent of the quantity of foodgrains while other crops account for 18 percent.[2] However, 62 percent of farm income is composed of rice income. Thus agricultural management places its main emphasis on the cultivation of food crops. Because of this characteristic, the Korean economy is often referred to as a "Rice Economy".

The average growth rate of agriculture and forestry for the last 8 years, from 1960 to 1967, reached about 5.2 percent while that of GNP was about 3.8 percent.[3] The increase rate of agricultural growth is attributable almost entirely to the rate of increase in foodgrain production.[4]

If we review the growth trend of Korea's GNP for the last 8 years, we find that Korea was blessed with some bumper crops. However, with the poor harvest, the rate of increase of the GNP was below the average.[5]

In view of all facts, foodgrain production is important not only for satisfying the nation's demand for foodgrains but also for the economic growth of the nation as a whole. This condition is expected to persist in Korea as long as the Korean people continue to make strenuous efforts to achieve self-sufficiency in foodgrain production and unless a sharp increase in industrial production is achieved.

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[3]see table 3

[4]see table 3

[5]see table 6

2. The Characteristics of Korean Agriculture

Of a total land area of 220,847.86 square kilometers (= 54,549,209.84 acres) in the Korean peninsula, South Korea has about 44.6 percent or 98,477.48 square kilometers (=22,837,359.25 acres). As to the arable land, South Korea had only 5,712,781.87 acres in 1967. About 60 percent of the cultivated land (average from 1960 to 1967) consisted of rice paddy field. The remainder was classified as ordinary field for upland crops.[6]

On the basis of data for 1967, agriculture in Korea was conducted by 2,586,864 farm households with an average allocation of cultivated land amounting 2.2 acres. Included in this average were 459,658 farm households, 55.53 percent, who have less than 1.2 acres for their farm operation.[7] Since only a fraction of one percent of the farm households had more than 7.2 acres of cultivated land, it is obvious that Korean farms represent very small scale operations.

The farm population of Korea in 1967 was 16,078,086 persons, or 53.47 percent of the total population of 30,067,000.

The average farm households consist of 6.2 persons. On an occupational basis, agriculture provided employment for 6,776,000 persons or 79.5 percent of the total number of employed persons in the entire country.[8]

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[6] see table 1
[7] see table 2
[8] see table 1

In distribution of rewards for its productive effort, however, agriculture and forestry did not fare so well, particularly in the more recent years.

In 1960 agriculture and forestry together accounted for 90.54 bil. won,[9] or 40 percent of the total gross product of 226.41 bil. won for that year. The comparable figures for 1967 were 386.51 bil. won for the nation.[10] The agriculture and forestry were credited with only 34.1 percent of the GNP in 1967, computed on the basis of the 1967 prices.

One reason for the decline in the agricultural share of GNP was a relative decline in farm prices.

If the effect of changes in prices were removed from the picture by computing the 1967 commodities and services at 1965 prices, agriculture and forestry's contribution to the GNP would be raised to 35.8 percent. Irrespective of the level of prices used, agriculture and forestry with 65.6 percent[11] of population did not fare too well with only 34-36 percent of the distributive shares.[12]

These comparisions support the conclusions that the Korean farmer's trading position in the exchange of goods and services was weak, and that the situation was substantially

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[9] $1=278.25 won, at 1968 current official exchange rate, $1 sold to clients at 278.25 won by the Foreign Exchange Bank of Korea.

[10] see table 2

[11] refer to Korea Statistical Yearbook, pp.22 (the figure of 65.6 % is based on the population and housing census taken as of Dec. 1, 1960)

[12] see table 15

worsened by the decline in the prices of farm products as the period advanced.

As pointed out before, the general characteristics of Korean agriculture are a combination of small sized farms and large families. Thus causing the average Korean farmer pressure to maximize his output by intensifying his production efforts.

Over the period 1960 to 1967, when Korean population increased about 12.1 percent, there was only an 11.4 percent net increase in cultivated land.[13]

The factor which contributed to the increased output per unit of land appears to have been an improvement in the allocation of labor input to the same land area. Of the total paddy acreage, 58.86 percent (average 1960-1967) was used for single crop farming while the other 41.94 percent (average 1960-1967) was used for double crop farming, such as wheat and barley, etc.[14]

About 83 percent of all Korean farms are classified as rice paddy farms and more than 58 percent of all cultivated land area in Korea is devoted to rice production.[15]

Rice provides more than half of the money income for the average farm household, despite the fact that nearly 2/3 of the entire crop is not sold, but is retained by growers, for whom it is a primary foodgrain.[16]

In terms of physical output since the Liberation, Korea's agricultural production reached its lowest level in 1952. This was due in part to the effects of Korean War.

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[13] see table 13

Following 1952, agricultural production increased in varying degrees each year with the exception of 1956 when unfavorable weather brought a net decline in crop production of slightly more than 10 percent of the 1952 level. In subsequent years, however, agricultural production has made impressive gains.[17]

The gains in the physical output of agriculture in recent years have been due in large measure to the increased areas benefiting from an improvement of irrigation facilities.[18]

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[14]see table 1
[15]see table 1 and 4
[16]see table 5
[17]see table 13
[18]see table 7

II. MULTIPLE REGRESSION MODEL AS A TOOL OF ANALYSIS

In the previous chapter, we discussed the historical background of Korean agriculture and characteristics of it. In this section a multiple regression model as a tool of analysis for this study will be discussed.

The multiple regression model will be discussed with respect to problem setting and objective, choice of function, and identification of variables.[1]

However, this study is primarily concerned with analyzing the productivities of resources used in agricultural production by Korean farm households, and with determining the relative efficiencies of resource combinations for optimum farm operation.

1. Problem Setting and Objective

The method of this study will be to select a single production function based on the data of agricultural resource input and output for the selected period, 1962-1967.

The selection of this period is based only on the availability of data. Therefore, from the methodological view, this study should be extended as data becomes available. In handling the data, it was technically operated and rearranged using the cross-section method of collection data, which was able to handle thirty observations in sequence with a given period.

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[1]R.J. Vandenborre & W.O. McCarthy, "Determination of Optimal Input Levels in Cobb-Douglas Analysis", Jour. of Farm Econ., Nov. 1969, pp. 940-941 and F.H. Tyner & G.T. Luther, "Optimum Resource Allocation in U. S. Agriculture", Jour. of Farm Econ., Aug. 1966, pp. 613-631.

One of the major assumptions pertaining to this study is that the input-output relationship in agricultural production per farm household in Korea can be expressed through a single production function.

There may be some theoretical objections to setting this assumption. There is the problem of measurement of variables in comparable units and of heterogeneity in the composition of variables over time with different average sized farms.

Consequently, if and only if such a function can be fitted to the existing data, this function would be applicable to the further study concerning agricultural production per farm household and be extended to the relevant fields of study as a whole.

2. Choice of Function

As mentioned above, a single production function will be used to explain the generation of agricultural output per farm household in Korea from various resource inputs.

The function to be used in this study is identical to a Cobb-Douglas production function. It is linear in logarithms and can be written as follows:

$$Y = Y(S,\ L,\ F,\ I,\ T)$$

or

$$Y = A\ S^{a}L^{b}F^{c}I^{d}T^{e}$$

or

$$\log Y = \log A + a \log S + b \log L + c \log F + d \log I + e \log T$$

where, $a > 0$
$b > 0$
$c > 0$
$d > 0$
$e > 0$

The major advantages of this type of production function may be summarized as follows:

First, the coefficients in the logarithm equation are identical with the elasticities of production with respect to the different resource inputs. In other words, the coefficients, a, b, c, d, and e are the elasticities of production of the resource inputs, S, L, F, I, and T respectively.

Second, the equation makes it possible for the principle of diminishing returns to operate within the three different scales which can be defined for agricultural production activities. Therefore, no restrictions are applied to the sum of the coefficients of the independent variables, namely, a+b+c+d+e may be equal to 1 or may not be equal to one.

3. Identification of Variables

The dependent variable, Y, in the equation stands for the total agricultural output per farm household including the value of products not sold, which is summed up; crop income and non-crop income.

Crop income includes total income from rice, barley, wheat, beans, potatoes, and vegetables, etc., while non-crop income includes income from livestock, sericulture, processed products, and others, etc. Therefore, Y measures total value of agricultural output per farm household in terms of money value.

The independent variable, S in the equation represents arable land per farm household measured in area, which is classified into five different classes by the size of farm lands. Specifically, they are less than 5 danbo, 5-10 danbo, 10-15 danbo, and 20 danbo and over. (1 danbo=0.24506 acres)

The class intervals of arable land per farm household are given by the existing data and it is the only data source for arable land per farm household, available for computer work.

For simplicity, mid-point values were taken for each different size of arable lands per farm household, such as, 2.5 danbo, 7.5 danbo, 12.5 danbo, 17.5 danbo, and 22.5 danbo arable lands. The size of arable land determines the size of farm and scale of farming in Korea.[2]

The land resource use in agricultural production per farm household in Korea, is assumed, in this study, to be constant throughout the period.

The independent variable, L, stands for the labor hours used in agricultural production per farm household. The total labor hours used per farm household were computed by adding family labor hours, hired labor hours, exchanged labor hours, and cattle labor hours. Therefore, the labor input is the sum of hours of human and animal power.

The input of animal labor hours appeared not to be a significant factor in farming because they were only about 4 percent (average 1962-1967) of the total input of labor hours.[3]

The independent variable, F, concerned with chemical fertilizer consumption in agricultural production per farm household, represents money input at farmer's cost in chemical fertilizer consumption.

The independent variable, I, pertains to the irrigation charges per farm household which includes water in use for cultivation and improvements of irrigation facilities.

The last independent variable in this study, T, is the time trend variable. The purpose of using this variable is to adjust the price fluctuations for time. When price changes are not smooth, it is difficult to analyze the correlation among factors which are relevant to their changes.

For the sake of explanation, an example is needed that shows a specific commodity is more sensitive to price changes than others in a given short period. then we apply a technological variable like a time trend variable, to keep increasing or decreasing prices at a certain level in time.
Therefore, the independent variable, t, in this study, has no actual value in terms of money.

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[2] see table 12

[3] see table 16

III. INTERPRETATION OF THE MODEL

In the previous chapter, the function and variables concerned with this study, were defined. In this chapter, the method approaching the problem will be discussed.

To solve the equation as shown in the previous chapter, Stepwise Program was used. Stepwise is an IBM-contributed, KSU-revised program written to perform a stepwise multiple regression on a set of variables, which are entered as input by observations. Output includes correlation coefficients, the constant terms, T value, beta coefficients, and several other useful statistics.

In order to develop this program, a transformation subroutine was provided by the writer, and also in order to select the seven regression equations, seven selection cards, which tell the different combinations of resources in use in agricultural production, were used.

1. Regression Equations

As a solution of the model, the multiple regression of Y on different combinations of resources used have been worked out in logarithms for the value of the variables.

One of the major purposes of using this multiple regression method in analysis of the equation is to find the most efficient combination of different resources used to produce a given output.

In order to explain how much Y would be dependent on independent variables, a simplex correlation coefficient table which illustrates the scale of farming per farm household in Korea, was made.[4]

Judging from the simplex correlation coefficients, Y is highly correlated with S and I but less correlated with L, F, and T. If we look into the correlations among independent variables, S is highly correlated with L and I but F is less correlated with any other variables.

This status would be interpreted as follows:

The agricultural production per farm household in Korea was very much concerned with the use of land and irrigation.

The consumption of chemical fertilizer per farm household, however, appeared to be inefficient, which could have resulted from surplus supplies of chemical fertilizers, distributed through authorized channels controlled by the Government intervention, with a monopolistic price set by the Government.

The labor resource used in agricultural production per farm household appeared not to have a strong effect on farm income.

This could result from the existing redundant farm labor in relation to the small amount of arable land per farm household.

Given the situations mentioned above, under this section, the different combinations of resources in use will be studied

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[4]see table 8

to find the most efficient combination which results in the optimum farming method.[5]

In combination 1, the regression of Y on S, L, and T only, has been taken into account. In combination 2, the regression of Y on S, F, and T only has been taken into account, and so on as shown in Table 9.

Among these various combinations of different independent variables with respect to the dependent variable, the most efficient and desirable combinations have to be selected for the purpose of this study.

It is hard, however, to tell which combination is the most desirable and efficient by judging only from the table. If there are one or more selectable combinations among the seven combinations, we may not know the statistical value to positively prove it. Therefore, we are forced to use the MULTREG FORTRAN IV PROGRAM, which comprises the Durbin-Watson statistic and the auto-correlation coefficients.

This MULTREG computer program was also revised by the Department of Statistics and Computer Science at Kansas State Unversity.

In computer processing, the JCL transformation has been worked out by the writer.

As the result of the Durbin-Watson Test, it appears that regression equations 2, 5, and 7 show an acceptable relationship, while regression equations 1, 3, 4, and 6 illustrate

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[5]see table 9

that the test is inconclusive and more observations are needed.

Consequently, from the computer analysis, the regression equations 2, 5, and 7 proved to be the most desirable combinations of different resource inputs. From this result, our main concern is to select one regression equation for further study.

By judging from the values of the coefficients, multiple regression, standard error estimate, Durbin-Watson statistic, and auto-correlation, regression equation 5 gives a more precise fit to the data than the other two selected equations.

The selected regression equation 5 is as follow:

$$\log Y = 39{,}963.6 \cdot S^{0.3822} L^{0.2752} I^{0.1491} T^{0.2887}$$

In addition to this regression equation, we need to compare regression equation 5 with regression equation 7 for the future discussion.

$$\log Y = 36{,}972.7 \cdot S^{0.3827} L^{0.2729} I^{0.1486} F^{0.0025} T^{0.2882}$$

These two equations have almost the same value in coefficients.

The regression equation 7 will be further applied to analyze the marginal productivites and growth rates in the agricutural sector.

2. Productivities of Resources Input

By using the selected regression equation and taking the values of regression coefficients in the production equation, we can obtain the productivities of resources used in agricultural output.

As already pointed out, the coefficients in the regression equation can measure the elasticities of production per farm household in Korea, with respect to each independent variables.

If we take for example the selected regression equation 5, a one percent increase in arable land per farm household, other variables remaining unchanged, results in a 0.40 percent increase in net farm income per farm household.

Similarly, a one percent increase in labor input per farm household, results in an increase of 0.26 percent in net farm income per farm household, while a one per cent increase in irrigation charge per farm household will raise net farm income per farm household by 0.34 percent.[6] The same relationship will apply to decreases in values of variables.

The independent variable, T, as mentioned above, will not be considered in computing the growth rate and marginal productivities because it has no actual money value.

There are several significant meanings to be drawn from the analysis of Table 9:

First, among the values of the coefficients shown in the regression equations, the coefficient of arable land has the highest value and labor hours and irrigation charges follow

[6]The figures in these comparisons were computed by taking geometric mean value with respect to each independent variable and dividing this mean value by dependent variable calculated in the same way, considering all different classes of farm sizes and the period concerned.

in order. Therefore, from the standpoint of elasticities of production, arable land, labor hours, irrigation charges, and fertilizer consumption are in order from highest to lowest.

The scale of human resources may change if there is a change in quality following the technological development. However, the elasticity of labor hours appears comparatively higher than that of irrigation. The low value of the marginal productivity of labor hours in agricultural production per farm household in Korea appears to have resulted from the misallocation of resources used in agricultural production.[7]

The expenditure on irrigation per farm household casts a significant meaning with respect to the arable land.

Second, the fertilizer cost per farm household, in co-operation with the production equation of one or more variables, does not appear to increase the value of the net output per farm household. Besides, the value of the coefficients attached to this variable appears not to be significant at all and can not be relied upon to explain net agricultural output increase in Korean farming.

However, the main concern of this study is to present the most efficient and optimum way to maximize the net agricultural output per farm household in Korea.
In this regard, the marginal productivities of the different resources have been considered.

The efficiency of each resource as determined from the

[7]see table 12

elasticities of the coefficients for the different variables have been previously mentioned. In order to deduce anything about additional input, we have to base our findings on the marginal efficiencies of the resources used per farm household.

This is concerned with marginal productivities of the different resources, which can be computed from the regression equation by taking the partial derivative with respect to each input variable on the output variable respectively.

The data used in the computation of these marginal productivities, have been revised by taking the geometric mean value with respect to five different classes of farm size.[8]

The same method was used in calculating other independent variables. (refer to notation 8)

As mentioned in the previous section, in order to compute the marginal productivities of resources in use, regression equation 7 was selected. (refer to Section 2, Chapter II)

The method of computation marginal productivities with respect to regression equation 7 was presented under notation 9.[9]

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[8] $G = \sqrt[n]{L_1 L_2 L_3 L_4 L_5 L_6}$

$$\log G = \frac{1}{n} (\log L_1 + \log L_2 + \log L_3 + \log L_4 + \log L_5 + \log L_6)$$

where, G = geometric mean
n = 6
L = labor hours used

The figures in Table 12 show how much the net agricultural income will increase as the input of each resource is increased by one unit, such as one danbo in arable land, one unit cost of fertilizer consumption, one unit cost of irrigation charges, and one unit of labor hour input per farm household in Korea respectively.[10]

It appears from these figures that the marginal productivity of one danbo of arable land per farm household is higher than that of one unit of any resource input, at large, while that of one unit cost of chemical fertilizer consumption has no value at all in Korean farming.

If we look into these situations in more detail, referring to Table 12 which illustrates some meaningful suggestions to improve Korean farming efficiency, we can summarize some important findings as follows:

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[9] $Y=A\cdot S^a\cdot L^b\cdot F^c\cdot I^d\cdot T^e$

$$\frac{\partial Y}{\partial S} = a\cdot\frac{\bar{Y}}{\bar{S}}$$

$$\frac{\partial Y}{\partial L} = b\cdot\frac{\bar{Y}}{\bar{L}}$$

$$\frac{\partial Y}{\partial F} = c\cdot\frac{\bar{Y}}{\bar{F}}$$

$$\frac{\partial Y}{\partial I} = c\cdot\frac{\bar{Y}}{\bar{I}}$$

where, $\bar{Y}$, $\bar{S}$, $\bar{L}$, $\bar{F}$, and $\bar{I}$ stand for geometric means, respectively. $\partial Y/\partial S$, $\partial Y/\partial L$, $\partial Y/\partial F$, and $\partial Y/\partial I$ stand for marginal productivities of S, L, F, and I respectively.

[10] See Table 11.

First, in the smallest class of less than 5 danbo size of farm households, which comprise about 40 percent of the total farm households, it shows that the marginal productivity of chemical fertilizer consumption in farming appears almost zero.[11]

Second, in the class of 5-10 danbo size of farmhouseholds which comprise about 32 percent of the total farm households, it shows that the marginal productivity of land that of irrigation are apparently decreasing but that of labor shows a slight increase in its value compared to the first case.

Third, in the class of 10-15 danbo size of farm households which comprise about 22 percent of the total farm households, it shows that the marginal productivity of land and that of irrigation is lower in comparision with the above two cases but the value of that of irrigation is decreasing continuously.

Fourth, in the class of 15-20 danbo size of farm households which comprise about 5 percent of the total farm households, the table shows that almost the same results as the third case.

Fifth, in the class of 20 and over danbo size of farm households wich comprise with approximately 1 percent of the total farm households, it shows that the marginal productivity of land is still decreasing, while that of labor is continuously increasing. However, the marginal productivity of irrigation is also apparently decreasing.

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[11] see table 12

As far as the marginal productivity of chemical fertilizer is concerned, its value of use appears almost zero through all different sizes of arable land per farm household.. Therefore, this factor would not contribute to raising farm income at all.

However, the use of chemical fertilizer needs to be reexamined in light of an efficient farm management program in each Korean farm household. Fertilizer price policy also should be reexamined.

We can draw some significant issues concerned with the scale of farming from the analysis of resource inputs:

As the arable land per farm household increases, the marginal productivity of land decreases, and that of labor increases.

The marginal productivity of irrigation charge per farm household apparently decreases as the arable land increases, while that of chemical fertilizer consumption remains constant at almost zero.

In relation to chemical fertilizer consumption in farming, the marginal productivity of that resource, as shown in Table 12, implies two meaningful issues:

First, the chemical fertilizer supply schedule is organized arbitrarily regardless of farmers' responsiveness to the supply of chemical fertilizer.

Second, the supply price of chemical fertilizer is decided by the Government without considering farmer's profit.

Instead of this, we have to discuss the productivity of

irrigation charges per farm household.
Even though the irrigation cost input is in a functional relation to agricultural output,[12] the marginal productivity of irrigation charges per farm household, as already pointed out, is decreasing as the size of arable land per farm household increases.

The marginal productivity of irrigation cost per farm household is irrelevant to the Government's long-run irrigation and land reclamation projects. But it is relevant to the individual farmers' utility charges for the use of water resources in farming, which are managed and administered by the Government controlled Irrigation and Land Reclamation Association.

The figures of marginal productivity of irrigation charges per farm household, as shown in Table 12, mean that the more arable land a farmer owns, the more he pays in utility fees for irrigation purposes to the Irrigation and Land Reclamation Association regardless of benefits received.

The farm households having small areas of arable land, have been comparatively benefited due to the small scale of arable land in case of drought.

Thus, problematic issues on irrigation projects will be summarized as follows:

The Government should establish a fully-examined long-run irrigation project in favor of building permanent

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[12] see table 7

reservoirs which result in drought-free arable land as a whole.

The Government should re-examine the facts that the farm households with larger amounts of arable land are not benefited as much as their irrigation charges increased.

As shown in this analysis, the increases in irrigation cost per farm household did not result in a proportionate increase in farm income per farm household because its marginal productivity was decreasing.

We have discussed in this section the relative efficiencies and marginal productivities of the different resources used for agricultural output per farm household in Korea.

These findings should be used in making decisions which result in maximum output of foodgrains in an effort to make the nation self-sufficient as a whole this area.

3. Growth Rate of the Agricultural Sector in Korea

A selected regression equation that has been derived from the set of regression equations is to be used in estimation of the annual growth rate of agricultural output per farm household of Korea.

This rate can be calculated from the production equation regarded as showing the most efficient combination of resources in use. Therefore, we prefer regression equation 7 due partly to the combination of all resource inputs and partly to its value judged from a statistical point of view.

Thus, using regression equation 7 and taking the total derivative with respect to time t, we can obtain the result desired.

$$Y = A \cdot S^{a} \cdot L^{b} \cdot F^{c} \cdot I^{d} \cdot T^{e}$$

$$\frac{dY}{dt} = a \cdot A \cdot S^{a-1} \cdot \frac{dS}{dt} \cdot L^{b} F^{c} I^{d} T^{e} + b\ A\ S\ L^{b-1} \frac{dL}{dt} F^{c} I^{d} T^{e}$$

$$+ c\ A\ F^{c-1} \frac{dF}{dt} S^{a} L^{b} I^{d} T^{e} + d\ A\ I^{d-1} \frac{dI}{dt} S^{a} L^{b} F^{c} T^{e}$$

$$+ e\ A\ T^{e-1} \frac{dT}{dt} S^{a} L^{b} F^{c} I^{d}$$

If we devide both sides by Y, we obtain the following equation:

$$\frac{dY}{dt} \Big/ Y = a \frac{dS}{dt} \Big/ S + b \frac{dI}{dt} \Big/ I + c \frac{dF}{dt} \Big/ F + d \frac{dI}{dt} \Big/ I + e \frac{dT}{dt} \Big/ T.$$

Therefore, $\frac{dY}{dt} / Y$ stands for the growth rate of agricultural output per farm household, while $\frac{dS}{dt} / S$, $\frac{dL}{dt} / L$, $\frac{dF}{dt} / F$, and $\frac{dI}{dt} / I$ stand for the rates of growth of resource inputs S, L, F, and I respectively, and we can disregard $\frac{dT}{dt}$ T, because it has no actual value.

Thus, the annual rate of growth, Y, can be computed with the help of the results we derived from equation 7, by multiplying the rate of growth of each of the resource inputs, S,L,F, and I, corresponding to the coefficients a, b, c, and d the elasticities of production and adding them up.

Finally we obtain the following equation to be used for this purpose:

$$\frac{dY}{dt} \Big/ Y = 0.3827 \frac{dL}{dt} \Big/ L + 0.2759 \frac{dS}{dt} \Big/ S + 0.0025 \frac{dF}{dt} \Big/ F$$

$$+ 0.2882 \frac{dI}{dt} \Big/ I$$

This equation is to apply to different sizes of farm households.

Table 14 shows that the gross agricultural production per farm household in Korea with forestry excluded increased by 3.97 percent annually during the period 1962-1967.

If we look into this result in more detail, we can generalize that the percentage changes in labor hours increased very slightly through all sizes of farm households, regardless of influence on percentage changes in agricultural production per farm household.

However, the percentage changes in expenditure on chemical fertilizer consumption apparently increased without significant changes in agricultural production per farm household. The percentage changes in irrigation charges per farm household significantly affect agricultural production.

Large scale farm households are more influenced than small scale ones by those percentage changes.[13]

It is obvious that the improvement of irrigation facilities and the expansion of arable lands can not be over emphasized as far as agricultural production of Korea concerned. However, irrigation charges must be reasonable and levied in accordance with benefits derived by the farmer.

However, if the present growth rate in agricultural production, as shown in Table 14, is maintained and the growth rate of population can be kept below it, it is obvious that there is no need for an alarmist's view of the state of the foodgrains in Korea.[14]

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[13]see table 15
14Ibid

In conclusion, a case study has been made in this analysis to fit a production function with linearity in logarithms to agricultural production per farm household in Korea.

It appears that the significant resources contributing to agricultural production on the established sizes of farm classes in Korea, are arable land, labor hours, chemical fertilizer cost and irrigation charges.

The marginal productivities of these resources have been computed. These figures show that the marginal productivity of one unit of arable land per farm household is higher than that of one unit of labor hours, one unit cost of chemical fertilizer consumption, and one unit cost of irrigation charges per farm households in Korea according to farm sizes.

The annual growth rate of agricultural output per farm household was 3.698 percent compared to a population growth rate of 1.995 percent per year.[15]

Some important decisions may be derived from the analysis attempted in this study.

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[15] see table 15

IV. SUMMARY

The final goal of a farmer under conditions of abundant labor supply is to be blessed with maximum returns on his land. This basic a priori assumption is concerned with a major factor that of production organization.

This study was undertaken having as its main objective; the analysis of the resource allocation in agricultural production using multiple regression equations.

The mathematical technique of multiple regression used in the analysis of resource allocation was subjected to computer processes using revised computer programming manuals of the Computer Center at Kansas State University.

The main findings of this study may be summarized as follows:

First, in the agricultural production per farm household in Korea, the resources, chemical fertilizer and labor hours inputs appeared least efficient. Throughout the study, five different size groups showed arable land to have the highest marginal productivity.

Second, the labor hours input in agricultural production per farm household appeared constant during the period of 1962-1967, and did not have any effect on agricultural production per farm household.

Third, the expenditure on chemical fertilizer consumption per farm household was increasing significantly year by year, but its contribution to agricultural production appeared to be of no value at all.

Fourth, the irrigation cost input in agricultural activities per farm household was apparently increasing and simultaneously its contribution to agricultural production was significant with respect to small areas of arable land. At this moment, the expansion of arable land by means of irrigation and improvement of existing irrigation facilities seemed to be the only solution that results in maximum output on land per farm household.

Fifth, the growth rate of agricultural production per farm household was increasing compared to the growth rate of the population during the period of 1962-1967.

Table 1. Number of farm households and population and area of arable land

Year	No. of farm households (A) unit=1,000	No. of farm population (B) unit=1,000	A/B unit=person	Area of arable land unit=1,000 jung		Percentage of arable land	
				Paddy-field	Ordinary field	Paddy (%)	Ordinary (%)
1960	2,350	14,559	5.99	1,216	825	59.6	40.4
1961	2,327	14,509	6.23	1,221	829	60.0	40.0
1962	2,469	15,067	6.11	1,233	847	59.3	40.7
1963	2,416	15,266	6.33	1,238	859	59.1	40.9
1964	2,450	15,553	6.35	1,273	917	58.1	41.9
1965	2,507	15,812	6.31	1,297	978	57.0	43.0
1966	2,450	15,781	6.21	1,298	1,014	56.1	43.9
1967	2,587	16,078	6.21	1,301	1,030	55.8	44.2

Source: Korea Statistical Yearbook, Economic Planning Board (EPB) 1963, 1964, and 1968

Notes:

1. 1 jung= 2.4506 acres
2. Farm household indicates a household whose family is engaged in crop production, sericulture, livestock, etc., regardless of the size of arable land

Table 2. The percentages of farm households and arable lands by the sizes of farming scale.

Year	Total arable land unit=1,000 (jung)	Less than 5 danbo		5-10 danbo		10-15 danbo		15-20 danbo		20 and over danbo	
		house (%)	land (%)	house (%)	land (%)	house (%)	land (%)	house (%)	land (%)	house (%)	land (%)
1960	2,027	43.1	16.6	30.1	27.9	20.7	37.0	6.0	17.3	0.3	1.2
1961	2,039	40.7	15.7	31.8	28.7	21.1	37.1	6.1	17.4	0.3	1.1
1962	2,066	41.0	15.9	32.5	29.6	20.5	36.4	6.0	17.2	0.3	1.3
1963	2,080	41.8	16.1	31.9	28.9	20.6	36.6	5.8	16.8	0.4	1.6
1964	2,178	40.0	15.0	31.7	28.3	21.5	36.7	6.0	17.0	0.6	2.7
1965	2,260	35.9	12.4	31.5	27.6	25.7	40.5	5.6	15.0	1.2	5.1
1966	2,281	35.2	12.0	32.0	26.9	25.9	40.4	5.4	14.7	1.4	6.0
1967	2,297	35.5	11.8	32.1	27.0	25.7	40.3	5.2	14.2	1.5	6.7

Source: Korea Statistical Yearbook, EPB, 1963, 1964 and 1968

note; figures in the above table are as of the end of year stated.
1 danbo = 0.1 junbo = 0.24506 acres.

Table 3. Contribution to GNP of agriculture and other leading industries

(in bil. won)

	1960		1961		1962		1963		1964		1965		1966	
	Value-added	%	Value-added	%	Value-added	%	Value-added	%	Value-added	%	Value-added	%	Value-added	%
					at current factor cost									
1. Agriculture & Forestry	90.5	40.0	118.4	42.9	126.7	39.7	204.6	45.0	319.0	48.5	310.3	41.3	370.6	39.2
2. Mining	5.2	2.3	5.5	2.0	7.0	2.2	8.3	1.8	12.3	1.9	14.5	2.0	16.5	1.7
3. Manufacturing	27.3	12.0	34.0	12.4	40.4	12.7	61.9	13.6	97.6	14.8	129.0	17.2	161.5	17.1
4. Construction	8.0	3.5	9.5	3.4	11.5	3.6	14.5	3.2	20.0	3.0	27.3	3.6	37.5	4.0
5. Electricity & Water	1.6	0.7	3.0	1.0	3.9	1.2	4.3	0.9	5.6	0.9	8.6	1.1	11.9	1.2
6. Transportation	10.3	4.6	12.9	4.7	15.7	4.9	18.2	4.0	22.0	3.3	29.8	4.0	46.3	4.9
7. Wholesale & Retail trade	21.7	9.6	24.8	9.0	33.2	10.4	50.4	11.1	71.7	10.9	98.2	13.1	128.7	13.6
8. Banking	3.4	1.5	3.8	1.3	4.8	1.5	6.2	1.4	8.2	1.2	9.8	1.3	12.6	1.3
9. Ownership of dwellings	16.0	7.1	16.3	5.9	17.9	5.6	21.0	4.6	24.6	3.7	27.2	3.6	32.4	3.4
10. Public admin. & Defence	17.4	7.7	20.4	7.4	26.5	8.3	28.1	6.2	33.6	5.1	39.9	5.3	53.8	5.7
11. Services	24.9	11.0	27.4	10.0	31.4	9.9	37.2	8.2	44.2	6.7	56.4	7.5	74.7	7.9
Total	226.4		276.1		319.0		454.6		658.7		751.1		946.4	

continued.

cont.

Table 3. Contribution to GNP of agriculture and other industries

(in bil. won)

	1967	
	Value-added	%
	at current factor cost	
1. Agriculture & Forestry	386.5	34.1
2. Mining	20.7	1.8
3. Manufacturing	212.6	18.7
4. Construction	51.0	4.5
5. Electricity & Water	16.1	1.4
6. Transportation	65.2	5.8
7. Wholesale & Retail trade	153.7	13.5
8. Banking	19.6	1.7
9. Ownership of Dwellings	41.2	3.6
10. Public Admin. & Defence	67.8	6.0
11. Services	100.6	8.9
Total	1,134.50	100.0

Source: Statistical Year-Book of Korea, EPB, 1963, 1964, and 1968

Table 3. Contribution to GNP of Agriculture and other leading industries

(in bil. won)

	1960		1961		1962		1963	
	Value added	%	Value added	%	Value added	%	Value added	%
	at 1965 constant factor cost							
1. Agriculture & Forestry	242.9	44.3	267.4	46.5	251.3	42.5	269.3	41.7
2. Mining	8.2	1.5	8.8	1.5	10.8	1.8	11.8	1.8
3. Manufacturing	72.8	13.4	74.8	13.0	86.0	14.5	100.6	15.6
4. Construction	14.2	2.6	15.8	2.8	18.0	3.1	20.4	3.2
5. Electricity	4.2	0.7	4.3	0.8	5.2	0.9	5.9	0.2
6. Transportation	16.6	3.0	16.6	3.9	18.6	3.4	21.8	3.4
7. Wholesale & Retail Trade	78.2	14.2	76.7	14.3	85.2	14.4	93.2	14.5
8. Banking	7.2	1.4	7.3	1.3	8.5	1.4	8.7	1.4
9. Ownership of Dwelling	24.0	4.4	24.6	4.3	25.2	4.3	25.8	4.0
10. Public Admin. & Defence	36.1	6.6	35.7	6.2	37.0	6.3	38.2	5.9
11. Services	48.5	8.0	42.8	8.4	45.5	7.7	49.3	7.6
T otal	548.6	100.0	574.9	100.0	591.1	100.0	645.4	100.0

continued.

Table 3. Contribution to GNP of Agricultural and other leading industries

(bil. won)

	1964		1965		1966		1967	
	Value added	%	Value added	%	Value added	%	Value added	%
	at 1965 contrast factor cost							
1. Agriculture & Forestry	312.9	44.6	310.3	41.3	344.4	40.7	323.5	35.8
2. Mining	13.3	1.9	14.5	2.0	15.6	1.8	17.5	1.9
3. Manufacturing	105.5	15.0	129.0	17.2	149.7	17.7	182.2	20.3
4. Construction	21.6	3.1	27.3	3.6	34.4	4.1	38.0	4.2
5. Electricity	7.1	1.0	8.6	1.1	10.2	1.2	12.9	1.4
6. Transportation	25.2	3.6	29.8	4.0	34.9	4.1	41.9	4.6
7. Wholesale & Retail Trade	90.6	12.9	98.2	13.1	114.4	13.6	133.7	14.8
8. Banking	9.3	1.3	9.8	1.3	10.6	1.3	12.5	1.4
9. Ownership of Dwelling	26.6	3.8	27.2	3.6	28.1	3.3	29.3	3.2
10. Public Admin. & Defence	38.9	5.5	39.9	5.3	42.7	5.0	45.5	5.0
11. Services	51.3	7.3	56.4	7.5	60.9	7.3	66.7	7.4
Total	702.0	100.0	751.1	100.0	846.5	100.0	904.8	100.0

Source: Statistical Yearbook of Korea, 1963, 1964, and 1965, EPB
Note: It excludes from GNP at current market prices indirect taxes and net factor income received from abroad and plus subsidies.

Table 4. Number of farm households by management of farming

Year	Total (unit= 1,000)	Kinds of Farming (unit=1,000 jung)									
		Paddy field	%	Dry field	%	Fruits field	%	Vegetab -le firld	%	Special crop field	%
1960	2,350	1,948	82.9	362.1	15.4	7.8	0.3	13.2	0.6	2.8	0.11
1961	2,327	1,930	83.0	356.5	15.3	8.3	0.4	13.4	0.6	3.2	0.13
1962	2,469	2,019	81.7	403.2	16.3	9.2	0.4	14.4	0.6	4.4	0.17
1963	2,416	1,966	81.4	405.0	16.8	9.1	0.4	12.4	0.5	3.9	0.16
1964	2,450	1,970	80.4	428.8	17.5	9.9	0.4	13,4	0.5	5.0	0.16
1965	2,507	1,898	75.7	549.1	21.9	11.8	0.5	13.3	0.5	3.9	0.19
1966	2,540	1,868	73.5	593.5	23.4	12.3	0.5	13.6	0.5	6.7	0.26
1967	2,587	1,814	70.1	615.8	23.8	13.3	0.5	13.6	0.5	7.7	0.29

Source; The Statistical Yearbook of Korea, EPB, 1963, 1964, and 1968

Note; The management of farm land is classified in accordance with major income and confined to one management per house hold.

Table 5. Farm income per farm household (percentages)

Year	Percentages of farm income by management of farming									
	Rice	Wheat	Miscell.	Beans	Potatoes	Vegetab.	Spec. crop	Fruits	By prod.	Others
1962	60.47	16.67	1.86	2.83	2.89	5.83	2.01	0.60	2.69	0.17
1963	58.09	18.17	2.11	2.69	3.39	6.22	1.68	0.36	3.16	0.14
1964	65.22	15.44	2.40	3.57	3.82	4.87	1.53	0.65	2.45	0.04
1965	63.68	14.81	1.83	3.49	4.10	5.01	4.44	0.62	1.90	0.12
1966	64.04	15.59	1.73	3.08	3.99	5.83	2.83	0.98	2.18	0.04
1967	62.65	15.16	1.87	3.85	3.71	7.04	2.63	1.24	2.28	0.06

Source; Statitical Yearbook of Korea, 1963, 1964 & 1968

Statistics of Agricultural Production, FAO, Rome, 1952-1968

Note; $ 1 = 320.29 won at 1970 (January) , official exchange rate sold to clients by The Foreign Exhange Bank of Korea

Table 6. Indices of Crop Production, Wholesale prices and GNP

1960=100

	1960	1961	1962	1963	1964	1965	1966	1967
Crop prod.	100	112.5	102.8	130.4	134.0	133.8	143.5	129.6
Wholesale	100	113.3	123.9	149.3	201.1	221.2	240.7	256.2
GNP	100	121.1	141.1	201.3	291.1	332.3	418.5	501.7

Source; Korea Statistical Yearbook, EPB, 1963, 1964, & 1968

Note Indices of GNP were computed on the basis of at current factor cost.

Table 7. Irrigation and land reclamation work

units; area in jung
yield in M/T

Year	Number of Districts	Benefited Area	Increased Yield	Indices of Benefited Area 1960=100	Indices of Increased Yield 1960=100
1958	56	14,427.8	19,004.5	204.4	180.5
1959	45	9,493.3	13,292.8	134.49	126.25
1960	45	7,058.5	10,528.8	100	100
1961	200	76,190.2	97,775.6	1,079.41	928.64
1962	75	34,756.9	43,827.6	492.42	416.26
1963	76	51,857.9	57,448.2	734.68	545.62
1964	73	43,416.2	46,654.2	615.09	443.11
1965	87	40,442.2	46,216.2	572.98	438.95
1966	96	42,169.7	62,779.2	597.43	596.26

Source : Korea Statistical Yearbook, 1963, 1964, and 1968

Note : This table covers newly established irrigation associations, extention work for irrigation and land reclamation.

Table 8. Simplex correlation coefficients of resources in use in agricultural production per farm householf of Korea

Items of variables	Y	S	L	F	I	T
Y	1.00000					
S	0.91347	1.00000				
L	0.87867	0.97093	1.00000			
F	0.73908	0.67114	0.67400	1.00000		
I	0.97175	0.91100	0.87892	0.74339	1.00000	
T	0.36246	0.00000	0.06270	0.30217	0.33919	1.00000

Note ; The figures in this table were computed by computer machine.

For the indentification of variables, refer to Table 11.

Table 9. Combinations of independent variables on dependent variable Y.

Independent variables (coeffs.)		(1) S+L+T	(2) S+F+T	(3) S+I+T	(4) S+L+F+T	(5) S+L+I+T	(6) S+F+I+T	(7) S+L+F+I+T
S	(a)	0.5004	0.6847	0.4914	0.5012	0.3822	0.4890	0.3827
L	(b)	0.3744			0.3614	0.2752		0.2729
F	(c)		0.0374		0.0129		0.0178	0.0025
I	(d)			0.1836		0.1491	0.1780	0.1486
T	(e)	0.3756	0.3480	0.2573	0.3713	0.2887	0.2553	0.2882
T values;								
S	(a)	4.4100	17.5701	4.7517	4.3339	2.9254	4.6360	2.8593
L	(b)	1.8373			1.6781	1.3359		1.2653
F	(c)		0.6773		0.2323		0.3341	0.0463
I	(d)			2.1159		1.6699	0.2929	1.6792
T	(e)	10.7354	8.9320	4.4153	9.2489	4.6533	0.2579	4.4725
log A		4.2612	4.4917	5.2283	4.2510	4.6017	5.1697	4.5985
A		18,245.8	91,540.0	169,153.0	17,824.8	39,963.6	147,800.0	36,972.7
Multiple coefficients		0.98475	0.98531	0.98306	0.98479	0.98630	0.98538	0.98630
Standard error estimate		0.11187	0.11788	o.10983	0.11369	0.1o821	0.11176	0.11044

Note; the figures in this table were computed by computer machine. refer to Table 11 for the identification of variables.

Table 10. The Durbin-Watson Statistic(=d)

Regression Equations	# of independent Variables	Auto-correlation Coefficients
1	d=1.5107	0.2173
2	d=1.6341	0.1348
3	d=1.3541	0.3157
4	d=1.4828	0.2336
5	d=1.8499	0.0700
6	d=1.3460	0.3202
7	d=1.8489	0.0705

# of independent variables (=k')	Upper Boundaries (=dl)	Lower Boundaries (=du)
k'=3	1.12	1.54
k'=4	1.05	1.63
k'=5	0.98	1.73

Notes ; if $d > du$, then hypothesis accepted,
if $d < dl$, then hypothesis rejected,
if $dl < d < du$, then the test is inconclusive, and we have to take more observations.

Table 11. Input-Output Data for Computer Work

(per farm household)

Year	Y	S	L	F	I	T	No. of observations
1962	321.8	2.5	15.3	35.0	1.6	1	1
1963	406.1	2.5	17.3	41.7	1.9	2	2
1964	531.8	2.5	11.2	23.5	2.3	3	3
1965	529.3	2,5	15.8	37.5	2.9	4	4
1966	551.1	2.5	15.1	38.4	3.4	5	5
1967	619,5	2.5	12.6	34.7	3.7	6	6
1962	578.8	7.5	24.5	61.4	5.3	1	7
1963	774.4	7.5	25.6	69.5	4.8	2	8
1964	894.7	7.5	16.7	44.7	6.3	3	9
1965	910.0	7.5	23.8	72.6	6.7	4	10
1966	1,021.7	7.5	23.3	72.7	8.8	5	11
1967	1,086.7	7.5	21.7	67.3	12.7	6	12
1962	816.7	12.5	31.1	79.1	8.9	1	13
1963	1,169.6	12.5	33.0	94.3	9.4	2	14
1964	1,403.6	12.5	28.9	65.9	13.8	3	15
1965	1,406.9	12.5	32.4	110.6	13.9	4	16
1966	1,508.8	12.5	31.6	112.6	17.6	5	17
1967	1,727.1	12.5	30.0	105.1	29.1	6	18
1962	1,181.1	17.5	38.6	95.5	13.9	1	19
1963	1,437.9	17.5	41.7	113.0	11.9	2	20
1964	1,913.6	17.5	34.9	97.6	15.2	3	21
1965	1,896.3	17.5	40.3	139.3	19.8	4	22
1966	2,006.6	17.5	40.9	145.6	30.1	5	23
1967	2,174.4	17.5	37.0	141.7	39.2	6	24
1962	1,534.2	22.5	50.5	119.0	22.1	1	25
1963	2,053.1	22.5	49.6	132.4	17.4	2	26
1964	2,748.2	22.5	44.5	118.2	33.0	3	27
1965	2,690.1	22.5	50.0	213.9	39.9	4	28
1966	2,864.3	22.5	50.2	141.7	53.8	5	29
1967	3,108.7	22.5	48.1	197.7	63.6	6	30

Notes; Y=net agricultural output in money value per farm household. unit=loo won. $1=278.75 won.
S=arable land per farm household. unit=danbo, 1 danbo=0.24506 acres.
L=labor hours in-put in agricultural output. unit=100 hours
F=fertilizer cost input per farm household. unit=100 won
I=irrigation charges per farm household. unit=100 won.
T=time trend. 1962=1

Source; Korea Statistical Yearbook, 1963, 1964,& 1968.

Table 12. Marginal productivities of each combination of resources input on output per farm household

Size of Farm arable land	Resources input	Combination of Resource Inputs (2)	(5)	(7)
2.5 danbo	Land, danbo	135.10	75.44	75.51
	Fertilizer, won	0.52		0.04
	Labor, hours		9.32	9.25
	Irrigation, won		27.96	27.87
7.5 danbo	Land, danbo	80.08	44.70	44.76
	Fertilizer, won	0.51		0.03
	Labor, hours		10.67	10.58
	Irrigation, won		19.58	19.51
12.5 danbo	Land, danbo	73.33	40.93	40.99
	Fertilizer, won	0.53		0.04
	Labor, hours		11.82	11.72
	Irrigation, won		12.92	12.88
17.5 danbo	Land, danbo	69.67	38.61	38.66
	Fertilizer, won	0.54		0.04
	Labor, hours		12.49	12.39
	Irrigation, won		12.16	12.12
22.5 danbo	Land, danbo	61.27	32.43	32.34
	Fertilizer, won	0.61		0.04
	Labor, hours		15.08	14.96
	Irrigation, won		9.72	9.68

Notes; combination (2)= Land and Fertilizer,
combination (5)= Land, Labor, and Irrigation,
combination (7)= Land, Fertilizer, Labor, and Irrigation.

Table 13. The ratios of chemical fertilizer consumption and indices of crop production

Year	Arable land (unit=1,000 jung) (A)	Crop Production (unit=M/T) (B)	Chemical Fertilizer Cons.(unit= 1,000 M/T) (C)	B/A unit=kg	C/A unit=kg
1956	2,868	4,310	587	160	20.5
1957	2,785	4,744	557	172	20.0
1958	2,695	5,189	437	193	16.2
1959	2,704	5,359	380	198	14.0
1960	2,727	5,271	326	193	12.0
1961	2,764	5,933	958	215	34.7
1962	2,828	5,423	(203**)	192	(7.2**)
1963	2,916	5,741	1,058	197	56.3
1964	3,069	7,066	923	231	29.3
1965	3,248	7,006	1,033	216	31.8
1966	3,116	7,568	1,075	243	34.5

1956=100

Year	Indices of B/A	Indices of C/A
1956	100	100
1957	108	98
1958	121	79
1959	124	69
1960	121	58
1961	134	169
1962	120	(35**)
1963	123	275
1964	144	143
1965	135	155
1966	152	169

Source; Korea Statistical Yearbook, EPB, 1963, 1964.and 1968.

Note; ** marks represent the chemical fertilizer consumption from Aug. 1,to Dec. 31, 1962, therefore, we may disregard of the figures corrsponding to ** marks.

Table 14. Annual rate of growth of resources input and gross agricultural output per farm household by the size of farm land

Size of farm land	Items of resources input	Growth rate Resos. input(%)	Agri. ouput(%)
less than 5.0 danbo (2,5)	Arable land, area	0.0	0.0
	Labor hours	0.4	0.11
	Fertilizer cost	7.4	0.02
	Irrigation charges	18.4	2.73
5.0-10.0 danbo (7.5)	Arable land, area	0.0	0.0
	Labor hours	0.17	0.05
	Fertilizer cost	7.86	0.02
	Irrigation charges	20.90	3.11
10.0-15.0 danbo (12,5)	Arable land, area	0.0	0.0
	Labor hours	0.36	0.11
	Fertilizer cost	10.4	0.03
	Irrigation charges	28.0	4.16
15.0-20.0 danbo (17.5)	Arable land, area	0.0	0.0
	Labor hours	0.16	0.04
	Fertilizer cost	9.7	0.02
	Irrigation Charges	30.2	4.49
20.0 and over danbo (22.5)	Arable land, area	0.0	0.0
	Labor hours	0.19	0.68
	Fertilizer cost	19.4	0.05
	Irrigation charges	28.4	4.22
	Average		3.97

Source; refer to table 11.
Note ; the figures in the above table were computed by taking total derivative with respect to time t on the selected regression equation (7).

Table 15. The growth rate of population

Year	Total Pop. (A)	Farm Pop. (B)	B/A (%)	Indices of A	Indices of B
	unit=1,000	unit=1000		1960=100	1960=100
1960	24,989	14,559	57.7	100	100
1961	25,700	14,599	56.9	103	104
1962	26,432	15,097	56.3	106	104
1963	27,184	15,266	55.9	109	105
1964	27,985	15,553	55.7	112	107
1965	28,670	15,812	55.6	115	109
1966	29,209	15,781	54.3	117	108
1967	30,067	16,018	50.4	120	110

Source; Korea Statistical Yearbook, EPB, 1963, 1964, 1968

Annual growth rate of total population=2.00 %
Annual growth rate of farm population=1.57%

Computation;

$$\frac{X_n}{X_o} = r^n$$

$$r = \sqrt[n]{\frac{X_n}{X_o}}$$

$$\log r = \frac{1}{n} \log \frac{X_n}{X_o}$$

where, n=numberof years
r=annual growth rate
X_o=number of pop. at the base year.
X_n=number of pop. at the latest year.

r_T=1.99587 %

r_F=1.57433 %

Table 16. Farm Labor (Average per farm household)

unit =hours

Year	Human labor hours				Cattle labor	
	Family	Hired	Echange	Total	Own	Borrow
1962	1,414.80	551.67	209.93	2,176.10	63.34	40.77
1963	1,942.35	517.26	202.71	2,212.32	67.42	41.80
1964	1,503.26	449.26	163.94	2,116.46	60.31	40.36
1965	1,862.67	555.56	166.31	2,584.54	64.56	44.34
1966	1,809.84	565.52	181.22	2,556.58	63.66	42.74
1967	1,713.03	512.37	192.84	2,418.24	61.13	44.45
Average	1,708.19	525.23	185.33	2,418.75	63.40	42.41

unit=hours

Year	hours Total	(Cattle/Human) %
1962	101.11	4.65
1963	109.22	4.93
1964	100.67	4.75
1965	108.90	4.21
1966	106.40	4.16
1967	105.78	4.37
Average	105.81	4.38

Source; Korea Statistical Yearbook, EPB. 1963,1964, 1968

Notes; Hired labor hours include yearly and daily hired labor hours.
Work Cattles are cows, oxen and horses.

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AN ANALYSIS OF RESOURCES IN USE
IN AGRICULTURAL PRODUCTION

by

DOYLE JEON

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ABSTRACT

One of the most important and useful techniques in decision-making is to apply mathematical approaches to the analysis of systems.

The main objective of this study was to analyze the relative efficiency of resources used in agricultural production which concerned output maximization in utilization of limited resources and to obtain some information for further decision-making that should be identical not only to farmers but also to the country as a whole. The production activities are continuously faced with decision-making related to efficiency.

As a farmer, he can only produce as much as is possible by using of his given quantitative and qualitative capabilities, while as a decision-maker, the Government tries to utilize its maximum capacities to benefit the country as a whole.

The harmony of these two activities may improve welfare of the society, therefore, this harmonization can not be overemphasized.

In order to find which combinations of resources to use in agricultural production, a mathematical technique was used by using a multiple regression model which depicts the correlations of each resource in use.

As for the independent variable inputs in this model, land and irrigation appeared more highly correlated than any other combinations of variable inputs.

This can be interpreted that a decision-maker, the Government should establish a reasonable and desirable scheme in the direction of expansion of arable land and improvement of irrigation facilities. This is the only way to maximize output with a scarcity of arable land.

In addition to this, another important finding concerned chemical fertilizer consumption.

The production process and distribution channels of chemical fertilizers were partly government-controlled and partly monopolized by the Government.

As shown in this study, chemical fertilizer consumption on production activities, such as rice, barley, etc., has already reached its margin. Therefore, the Government may choose either one or two alternatives as follows:

First, it should reconsider, or stop distributing chemical fertilizers to the farmers through the rice exchange program.

Second, it should introduce or disseminate new varieties, such as corn, sorghum, wheat, etc., which are responsive to chemical fertilizer and give high productivity.

Throughout this study, what was mainly emphasized was the need to improve and strenthen the administrative management of production and distribution processes and to point out that the misallocation of resources and the negligence of the Government in agricultural sectors should be corrected, somehow, in favor of a better living and an abundant society.