GROWTH AND TECHNICAL CHANGE
IN KOREAN AGRICULTURE

by

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DECLARATION

Except where otherwise indicated, this sub-thesis is my own work.

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ABSTRACT

The principal task facing the Korean economy is to further increase total farm output to meet the requirements for farm products.

This study attempts to find economic means of carrying out a further increase in the total farm output.

In order to carry out this work, this study attempts to survey the sources of the past growth in total farm output with reference to the measurement of technical change and factor input-output relationships based on the aggregate production function.

An attempt is made to formulate five aggregate production function models involving various factor inputs, and to provide empirical estimates of their paramenters. The various factor inputs are measured as land, labour and other input.

In particular, an attempt is made to estimate the magnitude of unbiased technical change and to establish the role of technical change as a source of the growth in total farm output. The quality of land is measured through the relative proportions of upland and paddy field and irrigated land input; and also the quality of labour input through the schooling level of farm labour forces. These quality adjustments of land and labour input are used in an attempt to explain apparent technical change.

From the empirical results estimated by the aggregate production function models, it is evident that an unexplained residual or output augmenting technical change remains as an important source of the past growth in total farm output, though apparent technical change occurs through the effects of education on labour input and through the improvement in the irrigated land input.

Apart from technical change, total farm output increased through the intensive use of farm supplies and equipment, as measured by the 'Other Input', and also by land development through the improvement in irrigated land and expansion of upland reclamation.

On the other hand, it appears that the continuing decrease in labour input has an adverse effect on the growth in total farm output.

Some implications can be drawn from the empirical results of this study. It is expected that under the constrained land resources and a continually decreasing labour input due to the urbanization and the industrialization, further increases in total farm output can only be achieved by the use of more and new farm supplies and equipment, so as to substitute for primary land and the decreasing labour input. Technical change can also be encouraged by improving the quality of labour input through education, by improvements in irrigated land, and by output augmenting factors.

Alternatively, further increase in total farm output can probably be achieved by a unified economic policy, to regulate the allocation of labour input and non-farm inputs between sectors so that the opportunity costs of each factor of production in both sectors are equal.

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CHAPTER 1

INTRODUCTION

The Republic of Korea (R.O.K.) is a semi-industrial country with a total land area of about 98.5 thousand km^2 and a total population of about 32.4 million in 1972. During the period of this study (1956-71), the Korean economy passed from a period of post-war reconstruction to that of the First and Second Economic Plans (Tae, Won-Son, 1972, pp. 28-30).

During the post-war reconstruction period (1953-56), the Korean economy was forced to rely upon foreign aid. However, with the gradual reduction of this foreign aid, Korea launched the First and Second Five Year Economic Development Plans (1962-71) with the goal of economic self-sufficiency through industrialisation.

The First and Second Five Year Economic Development Plans (1962-71) succeeded in achieving an average annual growth rate of 9.9 per cent; during the First Plan from 1962 to 1966, the economy grew at an average annual rate of 8.3 per cent, while during the Second Plan from 1966-71, the average annual growth rate accelerated to 11.4 per cent (Table 1.1).

As a result, during the period of this study, the Korean economy grew at an average annual rate of 7.8 per cent. On the other hand, the Korean agricultural sector, which had been lagging behind the non-farm sector, remained at an average annual growth rate of 3.5 per cent for the period 1956 to 1971. In particular, during the First and Second Five Year Economic Plan (1962-71), the agricultural sector showed a relatively low growth rate of 3.7 per cent compared to that of the G.N.P. (Table 1.1).

TABLE 1.1

RATE OF GROWTH AND PERCENTAGE SHARES OF GNP BY INDUSTRIAL GROUPS, SELECTED PERIODS
(At 1965 constant market prices)

Period	GNP	Agr. Forestry & Fishing		Mining & Manufacturing		Social Overhead Capital & Other Services	
		Growth Rate	Shares	Growth Rate	Shares	Growth Rate	Shares
	%	%	%	%	%	%	%
1956-61	4.4	3.2	44.2[a]	9.8	12.8[a]	4.3	43.0[a]
1962-66	8.3	5.5	39.7[a]	14.8	16.7[a]	8.9	43.6[a]
1967-71	11.4	2.0	32.8[a]	20.9	22.3[a]	13.2	44.9[a]
1962-71	9.9	3.7	24.2[b]	17.9	29.9[b]	11.1	45.9[b]
1956-71	7.8	3.5	-	14.8	-	8.5	-

Source: BOK (1972, pp. 48-49).

Notes: a. Initial year's share.
b. Percentage share of 1971.

This high growth rate in the Korean economy has been achieved primarily by rapid industrialization, especially by the mining and manufacturing sectors. As a result, the relative share of the agricultural sector in the economy declined from 44.2 per cent in 1956 to 24.2 per cent in 1971, while the non-farm sector increased rapidly (Table 1.1).

This change in the industrial structure of the Korean economy is caused by the strategy of giving priority to industrialization.

However, from the result of these highly differential rates of growth between farm sector and non-farm sector, it is strongly argued that agricultural development should be a precondition for a further economic growth.

The reasons for increase in total farm output are; firstly, that the Korean agricultural sector does not produce enough food crops to meet domestic demand; and secondly, that balanced growth between farm sector and non-farm sector can contribute to acceleration of Korean economic development. Moreover, increased farm production can make it possible to avoid reliance on imported farm products and to improve the balance of payments (Tae, Won-Son, 1973, pp. 107-147).

Whatever the reasons may be, the necessity for increasing total farm output is evident from the fact that the Korean economy relies heavily on imported farm products: such products include grains, special crops and livestock (BARS, M.A.F., 1972, pp. 401-403). The Korean economy imported 96 thousand metric tons of major food crops in 1956, and 2.9 million metric tons in 1971.

In fact, despite the growth rate of 3.5 per cent in agricultural sector, the increase in imported farm products is due mainly to the population growth rate of 2.3 per cent and increase in the national income without much change in the pattern of food consumption during the period 1956-71.

However, increase in total farm output is the major task of this economic policy to meet the requirements of farm products and to reduce the reliance on imported farm products.

In this study, an attempt is made to find out economic ways of performing further increase in total farm output with reference to the input-output relationship and technical change in farming.

Importance of technical change in Korean farming

The Korean farm is characterized by 'cash orientation with a supplementary subsistence economy',[1] under small scale farming, being subject to a monsoon climate.

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1. On the average, about 44.1 per cent of food crops and about 51.6 per cent of non-food crops were sold to the market. If the stage of economic activity for development planning is defined on the basis of money income, the Korean farms would fall into the second of Fisk's three stages - a cash orientation with supplementary subsistence economy. See E.K. Fisk, (1973, p. 6).

Farm resources in Korean farming are mostly employed in the production of food crops such as rice, barley and wheat. These food crops are a major source of total farm output (Chapter 3). Thus, the farm resources used for total farm output have closely associated with the condition of food crop production which has been predominately influenced by the unfavourable monsoon climate. Thus Korean farming is seasonal, a fact that results in an inefficient use of farm labour and land resources in off season.

Moreover, the Korean farm operates under the constraint of the supply of land and a continually decreasing farm labour force caused by the rapid urbanization and industrialization of the country (Chapters 4 and 5).

Under the generally unfavourable conditions for farm production, increase in total farm output may involve an intensive application of chemical fertilizers and pesticides and more use of farm machinery and implements in order to improve land productivity and efficiency of labour use, or may follow from improving and extending farm land, i.e. through the expansion of an irrigated paddy field and upland reclamation.

Alternatively, there may be a development of farming skill and knowledge due to the improvement in quality of labour input, or by means of reorganization in the production procedure through the reallocation of farm resource use through the more efficient use of labour and land inputs.

This means, from the economic point of view, that farmers can increase total farm output through the improvement in factor inputs and reallocation of farm resource use, and further increase total farm output through the achievement of higher productivity of farm resources by means of technical change, assuming that technical change means changes in the ways of producing farm output. Thus technical change is an accelerator of further growth in total farm output.

If we accept these concepts, total farm output can increase in the following ways:

a. the quality of land and labour input can be improved;

b. new and increased farm supplies and equipment can be employed;

c. idle farm resources can be utilized; and

d. technical change can occur.

Much of the academic research on technical change has involved the non-farm sectors of western economies, mainly because of the development of the theory in these countries. Therefore, some difficult problems may occur when the western methods of empirical analysis are applied to the Korean economy, particulary in the case of the farm sector.

The dissemination of technical change depends on the nature and characteristics of the Korean farm sectors. Hence, the impact of technical change on Korean farming may be quite different from that in a western economy.

Fundamentally, the economic theory of technical change provides an acceptable basis for this study. The main problem lies in adapting the empirical models, rather than the theory of technical change itself. It is difficult to formulate a model that fully takes account of the characteristics of the Korean agricultural setting.

This study formulates models of technical change for Korean agriculture and provides empirical estimates of their parameters. The results of this study are used to determine the causes of growth in total farm output and especially to measure technical change.

This study can help to provide a framework for formulating agricultural policy and for improving the allocation of farm resources use.

Lastly it can indicate problems that are in need of further research.

To summarise, the main objectives of this study are as follows:

a. to measure the past growth in total farm output;

b. to measure changes in factor inputs;

c. to measure technical change in Korean farming and to determind its nature; and

d. to determine sources of growth in total farm output.

Outline of the study

Aside from this introduction and the conclusions, this study is arranged in six chapters. In Chapter 2, there is a discussion of the concept of technical change, and of the role of factor quality improvement. In Chapter 3 the nature and past growth in Korean farm output are discussed and quantified, with emphasis on the growth of total farm output. In Chapters 4, 5 and 6, changes in factor inputs are discussed and measured with the main focus on the quality adjustment of factor inputs. In Chapter 7, estimates of technical change are derived and then the nature of technical change is discussed.

This study covers Korean agricultural growth from 1956 to 1971. The base year of 1956[2] was the end of the economic reconstruction period of the Korean economy after the Korean War, and it was the initial stage of economic stability in Korean economy. For the whole period, it is attempted to determine the 'technical change' of Korean agriculture by the concepts and the methods which are developed in western economic literature.

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2 Tae, Won-Son, (1972, pp. 28-30).

CHAPTER 2

A LOGICAL APPROACH TO THE MEASUREMENT OF TECHNICAL CHANGE

2.1 Concept

A number of recent works by western economists [3] have established the concept and measurement of technical change (or total productivity) as a source of growth in output. In the literature surveyed, the most commonly used measurement of the rate of technical change is the index of total productivity.

The total productivity index or the rate of technical change is constructed as the ratio of a total output index to a total input index, both using as weights constant base period prices:

$$A = Q/(\alpha L + \beta K),$$

where: Q, L, and K indicate, respectively, total output, labour and capital inputs; α and β are weights of factor inputs.

On the other hand, from the point of view of single resource use, the index of the partial productivity is constructed as a ratio of output per unit of factor inputs, indicating the average products of land, Q/R; labour, Q/L; and capital, Q/K, respectively. Such partial productivity is often measured in order to observe the efficiency of resource use. But the index neglects inter-factor substitution, since it takes no account of other factors contributing to output.

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3 Abramovitz, M. (1956 , 1962); Kendrick, J.W. (1956, 1961); Fabricant, S. (1959); Ruttan, V.W. (1956): Solow, R. (1957); Denison, E.F. (1962, 1964); Griliches, Z. (1960, 1963, 1964, 1970); Nadiri, (1970); Stigler, G. (1961); Jorgenson, D. and Griliches, Z. (1967).

In this respect, a more meaningful measure is the index of total productivity or technical change. Empirical works have stressed many ways of measuring technical change or total productivity, but two main conceptions of technical change or total productivity can be distinguished.[4] One is based on the arithmetic index and the other is based upon the geometric index. In order to determine an appropriate concept for the measurement of technical change on the production function, the two different concepts are reviewed briefly.

Kendrick, J.W. (1961) used the arithmetic index to construct an index of total productivity ($\dot{A}/A$) introducing a distribution equation. He assumed a linear homogeneous production function to derive the following form:

$$Q = L\frac{\partial Q}{\partial L} + K\frac{\partial Q}{\partial K} = wL + \gamma K$$

$$\dot{A}/A = \frac{Q_t/wL_t + K_t)}{Q_o/wL_o + \gamma K_o)} = \frac{Q_t/Q_o}{(wL_t + \gamma K_t)/(wL_o + \gamma K_o)}$$

= Index of Output/Index of Total Input

where Q, L and K are the output, labour and capital, respectively. The subscripts t and o identify the compared period and the base period, respectively. w and γ indicate the average wage rate and the average return to capital, respectively. In this approach, the weights of factor inputs are changing over time (Kendrick, 1956).

Solow, R. (1957) defines a geometric index for the measurement of technical change ($\dot{A}/A$), based on the Cobb-Douglas production function. The production function used was a Cobb-Douglas constant returns to scale function with an exponential time trend, showing the relationship at time t

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4 Nadiri, (1970); Stigler, G. (1961); Griliches, Z. (1963).

between output, $Q(t)$; capital input, $K(t)$; and labour input, $L(t)$; $Q(t) = \exp(at)\ K(t)^{\propto} L(t)^{\beta}$. More generally, he defined technical change 'as a short hand expression for any kind of shifts in the production function',[5] and he assumed neutral technical change. For that special case, the general production function:

$Q = F(K,L;t)$, takes the following form:

$$Q = A(t)f(K,L) \qquad (2.1)$$

or in a logarithmic regression model:

$$\text{Log } Q = A(t) + \propto_1 \log K + \beta_1 \log L \qquad (2.2)$$

Differentiating equation (2.1) with respect to time and dividing by Q, he obtains:

$$\dot{Q}/Q = \dot{A}/A + A\ \partial f/\partial k\ \ \dot{K}/Q + A\partial f/\partial L\ \ \dot{L}/Q \qquad (2.3)$$

thence, he derives the following form:

$$\dot{A}/A = \dot{Q}/Q - (\propto_2 \dot{K}/K + \beta_2 \dot{L}/L) \qquad (2.4)$$

$$\beta = 1 - \propto$$

where $\propto_2 = \gamma Q/\gamma K\ .\ K/Q$ (relative share of capital)

$\beta_2 = \gamma Q/\gamma L\ .\ L/Q$ (relative share of labour)

Dots indicate time derivatives.

He also assumes that factors are paid their marginal products and that F is homogeneous degree one.

In particular, from the general production function, $Q = F(K,L;t)$, if $\dot{F}/F$ is constant in time, then $A(t) = \ell^{at}$ or in a discrete approximation

$$A(t) = (1+a)^t \qquad (2.5)$$

(Solow, 1957). Hence $\dot{A}/A = a$ is defined as the rate of technical change during the given period, and 'a' is the average annual rate of change in total output per unit of total factor inputs. The basic appraoch of this study clearly follows Solow's concept.

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5 Solow, R. (1957, p. 312).

The main reasons for this choice are based on the economic theory of production; a necessary condition for efficient allocation of resource use to obtain the maximizing output is the equality between the values of the marginal products of factor inputs and the factor prices. Solow's geometric index is identified with the concept of marginal productivity. Hence, the concept of technical change used in this study is based on the geometric index by using Cobb-Douglas model in Solow's form.

2.2 Quality adjustment of factor inputs and regression models

The aggregate agricultural production function in this study introduces three factor inputs based on the concept of Solow's model and takes the following form:

$$Q_t = A(t)\ F(R_t, N_t, C_t) \tag{2.6}$$

or in a logarithmic regression form:

$$\text{Log } Q_t = A(t) + \alpha \text{ Log } R_t + \beta \text{ Log } N_t + \gamma \text{ Log } C_t \tag{2.7}$$

$$\alpha = 1 - \beta - \gamma$$

where Q_t = total farm output

R_t = land input in terms of natural units

N_t = labour input in terms of natural units

C_t = other inputs in terms of natural units

t = time variable to allow for technical change

Next, following equations (2.3) and (2.4)

$$\dot{Q}/Q = \dot{A}/A + \alpha \dot{R}/R + \beta \dot{N}/N + \gamma \dot{C}/C \tag{2.8}$$

It should be noted that the restriction, $\alpha = 1 - \beta - \gamma$ must be introduced in order to ensure homogeneity of degree one in the production function.

Then $\dot{A}/A = \dot{Q}/Q - [\alpha \; \dot{R}/R + \beta \; \dot{N}/N + \gamma \; \dot{C}/C]$ (2.9)

where $\alpha = \partial Q/\partial R \; . \; R/Q$ (relative share of land)

$\beta = \partial Q/\partial N \; . \; N/Q$ (relative share of labour)

$\gamma = \partial Q/\partial C \; . \; C/Q$ (relative share of other input)

From the equation (2.9) it is clear that the rate of technical change ($\dot{A}/A$) cannot be measured directly. Rather, factor shares of land, labour and other input are measured first and the measure of technical change is then calculated as a residual term. In this regard the magnitude of the technical change and its stability over time are closely associated with the choice of measurement of land, labour and other input, together with any adjustment for quality changes, which are not included in the definition of the land, labour and other input.

In addition, all variables other than land, labour and other input are omitted from the production function and may affect the estimated magnitude of technical change.

For it is evident that when the rate of technical change is defined as a residual, any misspecification or error in estimating the parameters of the aggregate production function becomes confounded with technical change in an indistinct and meaningless catch-all measure. In this case, its resulting coefficient of technical change will be biased (Nadiri, 1970).

In this study, it is first supposed that the three factors included in the production function do indeed capture all important inputs into Korean agriculture. Next, every effort is made to ensure that they are measured correctly. In particular, attempts are made to adjust for changes in the quality of factor inputs.

Quality adjustment of labour input

The problem of quality adjustment of labour has been tackled by Denison (1964) and (1962), and Griliches, Z. (1963 and 1970), and Jorgenson,D. and Griliches, Z. (1967).

Griliches stresses that changes in output involve changes in both the quantities and the qualities of factor inputs, and he emphasizes both capital and labour embodiment. Denison, on the other hand, proposes that technical change is embodied in the improvement in the educational quality of labour input. But, in practice, both authors emphasise that the improvement in the educational quality of labour input is the main embodiment of technical change. They then measure quality of labour input by means of the educational level of the labour force. Thus, in the final analysis, their methods reduce to making a quality adjustment of the labour input.

Griliches' approach (1970) categorizes total labour according to the number of years schooling completed. From these different categories of labour he constructs an aggregate labour input, using the relative shares in total labour compensation as weights. Next, he estimates an aggregate production function, separating its labour input (L) into the unweighted number of workers (N) and the quality of labour forces (E). The functional form, $Q = AK^{\alpha} L^{\beta}$ becomes $Q = AK^{\alpha} E^{\beta} N^{\beta}$

where Q = output

K = capital input

L = correct labour input, (L = E . N)

E = quality of labour input

He then argues that 'E' is equivalent to the 'Labour augmenting technical change'.[6]

One problem with this approach is that it makes no allowance for ability, or the inherent characteristics of the labour forces. It is possible that the school-earnings relation reflects these influences (Nadiri, 1970).

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6 Griliches, Z. (1970, p. 81).

On the other hand, Denison's approach is based on the age-sex composition and educational quality of the labour force; relative earnings are used as measure of the marginal productivity of the various types of labour and as weights in constructing the aggregate labour input. He assumes that only 60 per cent of the wage differentials between labour of different levels of school education reflects the effects of more education upon the productive ability; 'the remaining 40 per cent results from the greater natural ability and energy to continue their education, and that of other variables that are associated with, but not the result of, the amount of education.'[7] It is reasonable to assume that part of the observed differentials are actually associated with factors other than the educational differences. But it is impossible to measure how much of the differential is due to education.

In this study, as in Denison's work, labour quality is adjusted by the use of the schooling level of the labour force. But the method of measurement of educational quality of labour input is closer to that of Griliches. It is assumed that the wage differentials between workers of various educational levels in the long run truly reflect the difference in their marginal products. Therefore the relative wage rates are used to construct a quality adjusted measure of aggregate labour input.

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7 Denison, E.H. (1964, p. 16).

Quality adjustment of land input

Mosher, A.T. (1965) stresses that 'increased agricultural production comes from new techniques or methods put into practice on farms,'[8] and suggested that 'it is simply not possible to get much increase by using the same old plant and animal materials and the same old soil in the same old ways'.[9] He argues that the 'technology' of farming includes the enterprise combinations by which farmers seek to make the best use of their labour and land by using the chemical inputs and mechanical inputs, along with the improvement in quality of land. This means that farm supplies and equipment do not embody all the technical change in farming.

Nadiri (1970) argues that all quality adjustments of factor inputs are not necessarily synonymous with the embodiment effect of technical change, and that a distinction should be made between the quality correction and the embodiment effect. He also argues that embodiment of technical change in capital could produce purely labour augmenting technical change and that all technical changes are not embodied in capital goods.

However is is impossible in this study to distinguish empirically between the embodiment and augmentation effects or between the augmentation effects and quality changes. Therefore it is necessary to simplify these concepts by assuming that the augmentation effect is wholly captured by improvements in the quality of factor inputs. The question arises whether a deterioration in quality should be called 'an augmentation effect'. Since technical change is by definition positive, it seems better to leave deteriorations in quality out of the augmentation effect. The distinction

8 and 9 Moshen, A.T. (1965, p. 75).

between these various effects are particularly relevant in measuring changes in land input.

In the case of other input, embodied technical change is assumed to produce land augmenting technical change due to the improvement of infertile land input and to the resulting increase in the efficiency of labour use in farming. On the other hand, part of the technical change embodied in other inputs is inoperative unless there are improvements in the quality of labour input. This study attempts to make a quality adjustment of land input, first by introducing the change in relative proportions of upland and paddy fields and secondly, through the changes in the relative proportions of irrigated land and non-irrigated land (Chapter 4).

The quality adjustment of land input due to the pattern of land use is based on relative earnings, which are used as measures of the marginal productivity of upland and paddy fields and as weights in constructing the aggregate land input. The quality adjustment of land input due to the irrigated and non-irrigated land input, is achieved by using their relative earnings as weights in constructing aggregate land input (Chapter 4). The upland/paddy split, or 'pattern of land use', is considered to be purely a quality correction of the land input, but changes in irrigated land input are better defined as manifestations of technical change. This is because the increasing proportion of upland has led to a decline in the average quality of land input, while irrigation leads to an improvement in quality, which can be associated with an augmentation effect of technical change.

It remains to consider improvement in quality in other input. It is difficult to obtain explicit indices of quality change for these inputs and in any case, the examples given above suggest that technical change embodied in other inputs acts by augmenting either land or labour efficiency.

In farming, land augmenting technical change represents an extreme example of the embodiment effect of technical change in other inputs such as chemical inputs and mechanical inputs. That is, the principle manifestation of land augmenting technical change occurs as a result of improving infertile land input by employing chemical fertilizers and farm manure, along with the use of power machines, especially when improved farming skills and knowledge combine chemical fertilizers with farm manure.

There is some evidence for this in Korean farming. For example, the Soil Division and the Rice Experiment Station of the Office of Rural Development have studied the effect of fertilizer quality improvement on the yield of rice (ORD, 1963). It is concluded that there is a positive effect of fertilizer quality on the yield of rice if the chemical fertilizer is applied with deep plowing and the application of farm manure (compost). To take another example, the technical change embodied in chemical inputs is only effective when combined with improved farming skill, early culture and compost (Park, 1966, pp. 34-42). Or again, farm mechanization of rice paddy fields in small farming in Korea has resulted in higher labour requirements per hectare while also improving the efficiency of labour use (Kim, 1970).

Hence, increased use of purchased inputs such as chemicals and machines can effect technical change substantially. But for its application to be effective, it requires the additional application of complementary inputs. Hence the effect of the technical change associated with the new input results, in the statistical analysis, in the embodiment of technical change in the primary input categories of land and labour. Thus, the quality adjustment of new inputs is not included directly in this study.

Regression models

Five models of the production function are introduced in this study. Model I is based on the natural factor inputs, while Models II, III, IV and V include the quality adjustments of factor inputs as mentioned above. These models are derived, based on the concept of the production function in Solow's form. Models II, III, IV and V can be seen as extensions of Model I to include quality adjustment of factor inputs.

In Model I output is explained by the factor inputs employed in farming, unweighted for quality change, along with an exponential time trend, that is, in terms of physical factor inputs in natural units with no embodied technical change.

Model II is described as an adjusted land input due to the structural change in land use in terms of quality correction in land input, along with the same variables of labour and other input as in Model I, using an exponential time trend.

Model III adds the quality adjustment of land input due to the irrigated land to the structural change in land use of Model II, and the same variables of labour and other input as in Model I, along with the time trend.

Model IV also adjusts labour input for changes in quality, along with the introduction of the land input, adjusted as in Model II, and the other input as in Model I, using an exponential time trend.

Model V is formulated from the adjusted labour input of Model IV, the adjusted land input of Model III, and other input in natural units as in Model I, using a time trend.

These models are represented as follows:

<u>Model I</u>: $Q_t = A(t).F(R_t,N_t,C_t)$ (2.6)

or $\text{Log } Q_t = A(t) + \alpha \log R_t + \beta \log N_t + \gamma \log C_t$ (2.7)

$$\alpha = 1 - \beta - \gamma$$

<u>Model II</u>: $Q_t = A(t).F(S_t,N_t,C_t)$ (2.10)

or $\text{Log } Q_t = A(t) + \alpha \log S_t + \beta \log N_t + \gamma \log C_t$ (2.11)

$$\alpha = 1 - \beta - \gamma$$

<u>Model III</u>: $Q_t = A(t).F(K_t,N_t,C_t)$ (2.12)

or $\text{Log } Q_t = A(t) + \alpha \log K_t + \beta \log N_t + \gamma \log C_t$ (2.13)

$$\alpha = 1 - \beta - \gamma$$

<u>Model IV</u>: $Q_t = A(t).F(S_t,L_t,C_t)$ (2.14)

or $\text{Log } Q_t = A(t) + \alpha \log S_t + \beta \log L_t + \gamma \log C_t$ (2.15)

$$\alpha = 1 - \beta - \gamma$$

<u>Model V</u>: $Q_t = A(t).F(K_t,L_t,C_t)$ (2.16)

or $\text{Log } Q_t = A(t) + \alpha \log K_t + \beta \log L_t + \gamma \log C_t$ (2.17)

$$\alpha = 1 - \beta - \gamma$$

where:

1) Q_t, R_t, N_t and C_t indicate total farm output, quantity of land input, labour input and other input, respectively.

2) $S_t = \gamma_t \times R_t$ S_t = adjusted land input and
γ_t = quality adjustment of land use (Chapter 4).

3) $K_t = D_t \times S_t$ K_t = adjusted land input
D_t = quality adjustment of land input due to the irrigated land based on the γ_t in Model II (Chapter 4).

4) $L_t = E_t \times N_t$ L_t = adjusted labour input
E_t = quality of labour input (Chapter 5).

5) α, β and γ indicate relative shares of each factor input, and t indicates time.

It must be emphasized that the rate of technical change implied by these models rests on the following assumptions:

a. the aggregate production function is a log-linear form, homogeneous of degree one (later this assumption is tested);

b. technical change is neutral, and factors are paid their marginal products; and

c. the growth of total output is determined by the changes in factor input and technical change.

CHAPTER 3

FARM OUTPUT AND ITS GROWTH IN KOREAN AGRICULTURE

Measures of farm output

There are two ways of measuring farm output, a) gross farm output, and b) net farm output. Gross farm output is estimated excluding items such as intermediate products (seeds, feeds and by-products) from the gross farm production, while net farm output is calculated by the subtraction of all production expenses from the gross farm ouptut (net farm output = gross farm output - farm expenditure).[10] Net farm output is essentially a measure of farm income (M.A.F. 1, p. 72, p. 75).

Since this study focuses mainly on the sources of growth in total farm output with a view to increasing farm output, gross farm output is used as the measurement of the farm output.

The major part of the official statistical information on gross farm output is published by the Bureau of Agricultural Research and Statistics, Ministry of Agriculture and Forestry, (BARS, M.A.F.) and the National Agricultural Cooperative Federation (N.A.C.F.). The gross farm output data are mainly taken from the Report on the Results of Farm Household Economic Survey and Production Cost of Agricultural Products[11] and the Year Book of Agriculture and Forestry Statistics[12] published by BARS, M.A.F., and also from the Agricultural Year Book[13] compiled by the N.A.C.F.

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10 Farm expenditures consist of material and animals, wages, rent and irrigation and other agricultural expenditures. See M.A.F. (1, 1972, p. 55 and pp. 72-73).

11 Published since 1962.

12 Published since 1950.

13 Compiled since 1958.

These three statistical publications are the major official data sources for Korean agriculture. Other relevant data are taken from the Economic Statistics Year Book,[14] published by the Bank of Korea (B.O.K.).

In Korea, data on the quantity or output of farm production is surveyed through two channels. One is based on the administrative reporting system through the administrative districts, and the other is a sample survey, providing output estimates based on farm household units, conducted by the M.A.F. (1) since 1962, and by the N.A.C.F. and the B.O.K. before 1961.

The latter survey was carried out in order to measure various aspects of the farm structure with a view to improving farm management practices, and providing data needed for formulating and researching agricultural development and policy (M.A.F. (1), 1972, p. 19).

In this study, the gross agricultural output data are taken from this latter source, surveyed on the basis of the farm household unit, in order to analyse the input-output relationships.

For the measurement of the farm output series in real terms, it is necessary to aggregate the heterogeneous physical output units into a single measure. In order to do this, prices of farm output at the farm level, are used as deflators. The prices of farm products at the farm levels have been surveyed and reported by the N.A.C.F.[15]. We can therefore construct and aggregate the index of the gross farm output series in real terms based on the Laspeyre's quantity index[16]

$$Q_t = \sum_{j=1}^{n} Q_{jt} P_{j0} / \sum_{j=1}^{n} Q_{j0} P_{j0} \qquad (3.1)$$

14 Published since 1956.

15 It should be noted N.A.C. F. was the Bank of Agriculture before 1961.

16 Thomas H. Wannacott and Ronald J. Wannacott (1972, pp. 538-543).

where Q_{j0} and Q_{jt} indicate output produced in the base period and the compared period, respectively (j = 1, 2, 3, ...n). P_{jo} indicates their prices in the base periods (1964-66 = 100). This equation (3.1) is designed to eliminate price changes, leaving an index of physical output produced.

The indices of the gross agricultural output in real terms are calculated on the basis of 1964-66 = 100. On estimating an unbiased gross agricultural output at constant price on the basis of 1964-66 = 100, it is assumed that the relative price structure of farm products during the base period selected was sufficiently representative of the whole period. In order to examine this assumption, the gross agricultural output index is constructed with a base of 1959-61 = 100 as weights and a deflated index. The two indices are shown in Table 3.1, indicating a similar trend in growth of the gross agricultural output.

TABLE 3.1

COMPARISON WITH THE FARM OUTPUT INDEX FOR THE BASE YEAR, SELECTED YEARS, 1956-1971

		1956 = 100 as the base of
Period	1959-1961 = 100	1964-1966 = 100
	per cent	
1958	109.9	107.1
1960	106.2	104.3
1962	118.6	118.3
1964	125.3	127.4
1966	130.5	132.2
1968	137.7	138.3
1971	150.1	157.3

Sources: M.A.F. (1), and N.A.C.F. (1) and Appendix 1.

This study is based on a 1964-66 index. The constructed gross farm output index is shown in Appendix A2 and Table 3.4 of the later section.

Past growth in farm output

As mentioned in the discussion of the characteristics of Korean agriculture in Chapter 1, the Korean farm's resources are mostly employed for food grain production, and the farm organization has the dominant characteristics of a mono-culture farming system. In this regard, the farm output has shown wide fluctuations from year to year as a result of variations in rainfall. In particular, this has been largely associated with fluctuations in food crop production (Figure 3.1). If we abstract from these fluctuations, farm output has shown a continued upward trend. However, the average annual growth rate from 1956-71 was just under 3.18 per cent a year, but the data for individual pairs of years during the period show wide fluctuations in the growth rate from 3.30 per cent to 14.40 per cent (Table 3.2).

TABLE 3.2

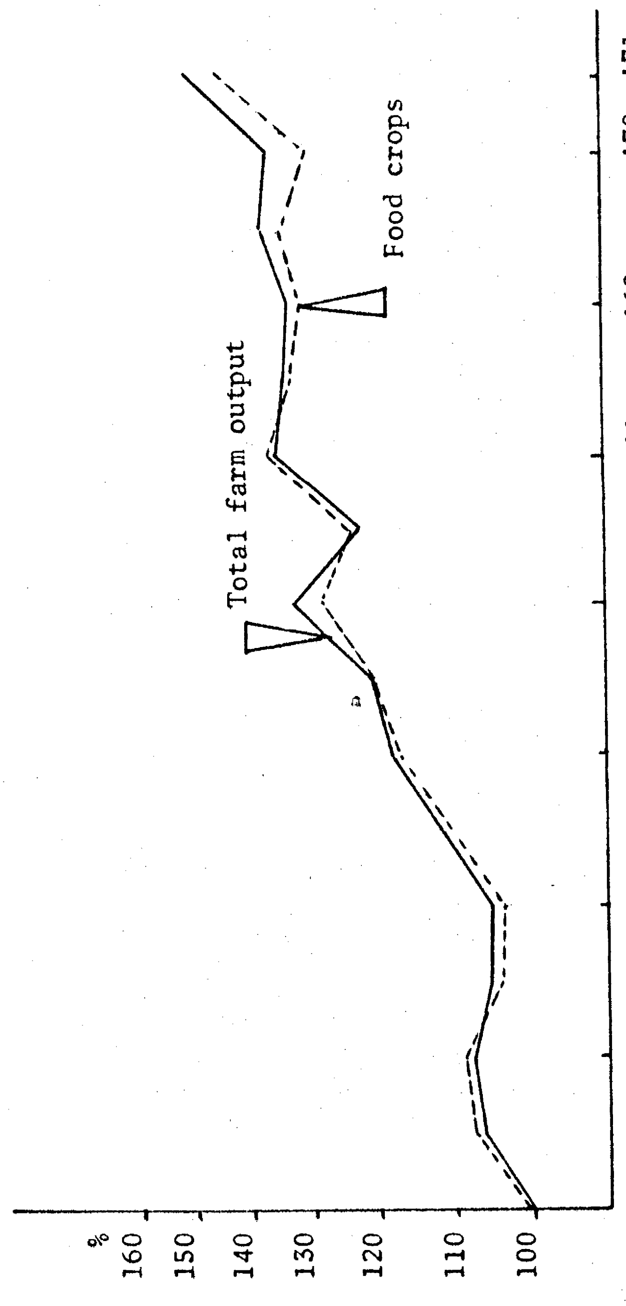
INDEX NUMBERS AND GROWTH RATE OF FARM OUTPUT, 1956-1971

Period	Index	Growth Rate (per cent)	Period	Index	Growth Rate
1956	100.0		1964	127.4	5.03
1957	106.0	6.00	1965	123.2	-3.30
1958	107.1	1.04	1966	132.2	7.31
1959	104.8	-2.15	1967	128.5	-2.80
1960	104.3	- .48	1968	127.9	- .47
1961	112.2	7.57	1969	138.3	8.13
1962	118.8	5.97	1970	137.5	- .58
1963	121.3	2.02	1971	157.3	14.40
Average Annual Growth Rate (per cent) : 3.18					

Source: Appendix A1.

FIGURE 3.1

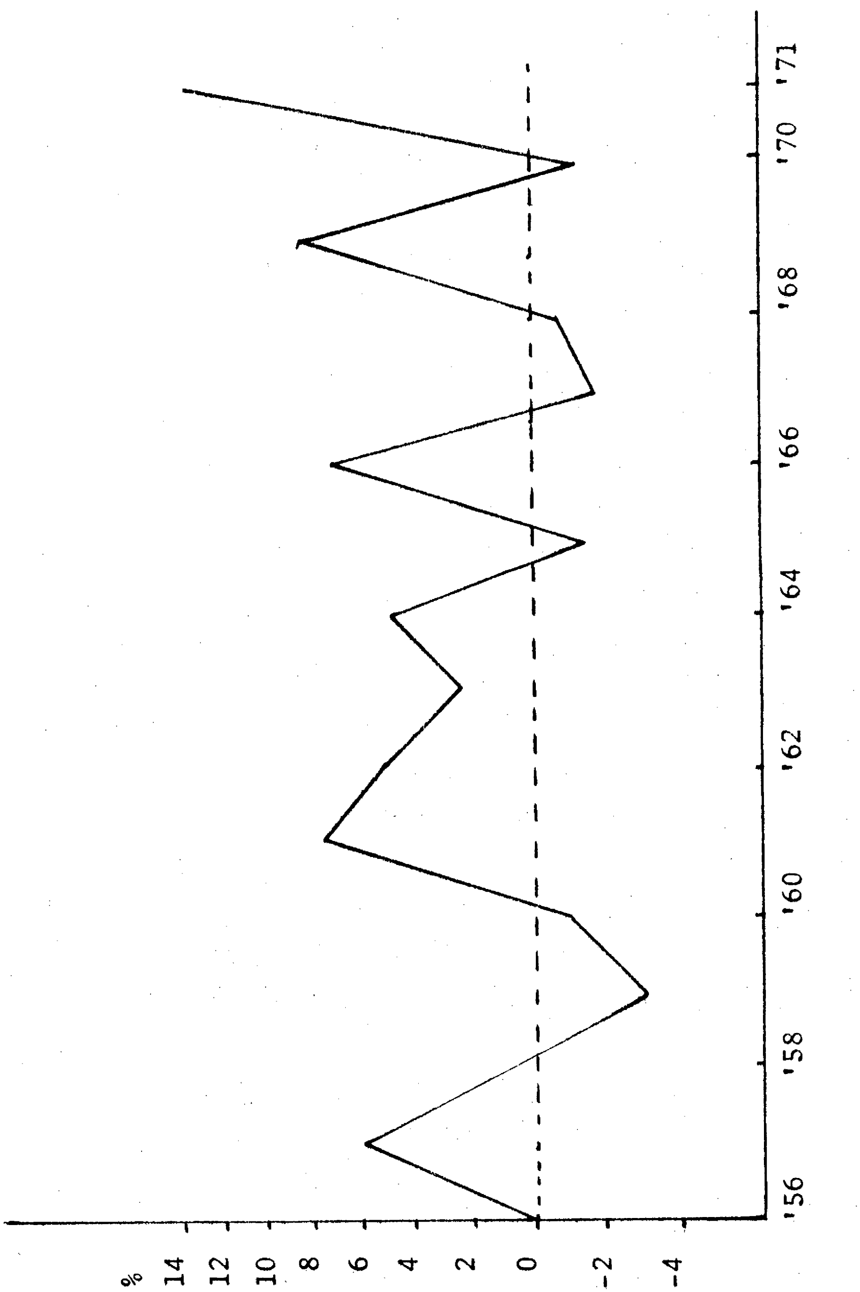
TRENDS IN TOTAL FARM OUTPUT AND FOOD CROPS



Source: Appendix A2

FIGURE 3.2

ANNUAL GROWTH RATE IN TOTAL FARM OUTPUT, 1956-1971, 1956 = 100



Source: Table 3.2

This irregularity of changes in the growth rate indicates only that the year to year fluctuations have been dominated by changes in food crop production due to favourable or unfavourable weather conditions, as shown also in the trends between foodcrops and total farm output in Figure 3.1. In order to eliminate the influence of weather on the sources of growth in total farm output, the time period chosen should be sufficiently long, that is at least over seven years, mainly because since 1955, the worst foodcrop harvests have occurred in a seven year cycle (M.A.F. 2, p. 134). In this study, the time span considered is chosen to be from 1956 to 1971. This is more or less arbitrary except that this period lies during the economic stabilization period and is long enough to minimize the effect of statistical error.

Differential growth rate between two periods

Average annual growth rate of total farm output increased by 3.18 per cent from 1956 to 1971, but the growth rate differs between the two time periods, on either side of the turning point of 1963 in patterns in land use and employment of labour input in farming (Table 3.3) (Chapters 4 and 5); in the period from 1956 to 1963 total farm output grew at an annual rate of 2.94 per cent, while between 1963 and 1971 it grew at 3.30 per cent.

Accepting that total farm output in the two periods is accurately measured, this differential growth rate between two periods suggests that from a turning point in 1963, one or more of the following occurred. Either resources use employed in farming is reallocated or used for farm production more efficiently, or a structural change in farm production occurred, or more and new farm inputs are employed or else some combination of these. These sources of differential growth rate between two time periods are discussed in the following chapter and concluded in Chapter 7.

TABLE 3.3

AVERAGE ANNUAL GROWTH RATE OF FARM OUTPUT, SELECTED PERIODS, 1956-1971

Periods	Index	Growth Rate
		(per cent)
1956-62	100.0 to 118.9	2.94
1963-71	121.3 to 157.3	3.30
1956-71	100.0 to 157.3	3.18

Source: Based on Table 3.2

Composition of farm output

Attention is now turned to the role of food crops and non-food crops of gross farm output. As the Korean economy develops, the needs of farmers for cash to purchase goods and services for household consumption and for farm production tends to increase. In order to earn more cash income, the Korean farms have to sell more farm products on the market by increasing farm production or by producing farm products which meet favourable demand conditions. To some extent total farm output has been increased by replacing farm resources.

Upland has been newly developed due to the land development project since 1962 (see Chapter 4). There have also been special projects to increase farm income (Nong Tuk Sa Up) since 1968, based on the upland developed to employ idle farm resources such as infertile upland to utilize idle labour input in slack farming seasons (Whang and Min, 1969). However, as mentioned above, the index of commodity groups classified by consumption pattern indicates high growth rates of non-food crops during the industrialization period of 1962-71, as shown in Tavle 3.4. The most noteworthy increases in non-food crops were in sericulture and special crops. The increase in these crops was mainly due to the special projects recommending those crops for infertile newly developed upland, along with other suitable crops to be grown on infertile upland for an increasing total farm output (Nong Tuk Sa Up).

On the other hand, increases in livestock items, vegetables and fruits were based on the special projects for increasing farm output since 1967, and favourable demand conditions on the market (Nong Tuk Sa Up).

TABLE 3.4

TRENDS IN INDICES OF FOOD CROPS AND NON-FOOD CROPS, SELECTED YEARS, 1956-1971
(1956 = 100, based on the 1964-66 = 100 price weights)

Year	Foodcrops	Vegetables & fruits	Livestock, meat & poultry	Special Crops	Sericulture	Others
			(per cent)			
1958	107.6	114.5	95.7	116.3	128.2	85.2
1962	117.5	105.9	171.2	139.3	111.2	130.5
1967	125.8	134.0	135.2	193.9	268.1	139.1
1971	145.6	164.7	201.3	490.5	1251.1	182.9

Source: Appendix A2

But it should be noted that the relative proportions of these non-food crops forms the smallest share of the total farm output, despite the increase in their shares (Table 3.5). That is, from 1956 to 1971, sericulture, special crops and livestock items increased at 1.3 per cent, 3.3 per cent and 0.7 per cent, respectively.

As a result, even though the food crops increased at a relatively low growth rate, and the percentage share of food crops in total farm output declined about 6.3 per cent between 1956 and 1971, the percentage share of food crops in total farm output has still remained highest at about 78 per cent (Table 3.5).

However, the structural change in farm output, but such diversification of farm production has proceeded slowly relatively (Table 3.5).

TABLE 3.5

RELATIVE IMPORTANCE OF FOOD CROPS AND NON-FOOD CROPS, SELECTED YEARS, 1956-1971

Year	Foodcrops	Vegetables & fruits	Livestock, meat & poultry	Special Crops	Sericulture	Others
			(per cent)			
1956	84.3	7.5	2.5	1.5	.2	4.1
1958	84.7	8.0	2.2	1.7	.2	3.2
1962	83.3	6.6	3.6	1.8	.2	4.5
1967	82.5	7.8	2.6	2.3	.4	4.4
1971	78.0	7.8	3.2	4.8	1.5	4.7

Source: Appendix A4.

Note: In the case of the sum of over 100 or under 100 results from rounding.

To summarize, total farm output has increased at an average annual rate of 3.18 per cent without much change in the composition of total farm output, in spite of the operation of the law of diminishing returns in agriculture due to the constrained land resources. But the growth of the non-food crops has increased faster than that of the food crops.

CHAPTER 4

LAND INPUT IN KOREAN AGRICULTURE

Changes in pattern of land use

In Korean agriculture, a farm is defined as an area of more than 1 hectare on which a farm family is engaged in farm work or on which a farm organization operates farm production (M.A.F. 1, p. 20).

In Korean farming, availability of farm land has been a primary limiting factor of farm production. Of the total land area of Korea, farm land was estimated at about 20.2 per cent in 1956 and 23.1 per cent in 1971, or some 2,008,500 cheongbo in 1956 and 2,290,200 cheongbo in 1971. The rest of the total area was mountainous and hilly (Table 4.1).

TABLE 4.1

UTILIZATION STATUS OF NATIONAL LAND AREA, SELECTED YEARS, 1956 to 1971

Year	Total area	Farmland	Distribution of total area		
			Farmland	Forest	Other
	(1000 cheongbo)[a]		(per cent)		
1965	9925.1	2008.5	20.2	67.8	12.0
1962	9925.1	2079.9	21.0	68.6	10.4
1968	9929.5	2338.1	23.6	67.3	9.1
1971	9929.5	2290.2	23.1	67.1	9.8

Source: M.A.F. 2, pp. 22-23.

Note: A cheongbo is equal to 0.99 hectares.

This small share of farm land was occupied by 2,200,500 farm households in 1956 and 2,481,500 farm households in 1971 (M.A.F. 2, 1960 and 1972).

This suggests that Korean agriculture has been operated under small-scale farms of around 0.92 cheongbo. Despite this small farm size per farm household, with population growth[17] and rapid urbanization, farm land already cultivated must be distributed to new farmers within the agricultural sector. In addition, the pattern of land use in the economy has been changing, due to rapid urbanization with road development, industrial sites, housing estates and leisure farms, especially since 1962 (Whang, 1972). Fertile land already cultivated is increasingly being used for the purposes of the non-farm sector such as industrial sites and housing estates (Park, 1968, pp. 11-12). Thus, the small farm land per farm household used for farm production is not only an increasingly scarce resource for farm production, but also indicates a downgrading in the quality of arable farm land.

Land development projects

In order to improve the supply of farm land, two main land development projects have been carried out during the period of this study. One is a project of farm land expansion based on upland reclamation work, and the other is a project devoted to improving the quality of land already under cultivation, by means of irrigation improvement and land consolidation. Both of the projects require public investment and long-term financing, along with the administrative support of central government and the technical support of the agricultural institutions.

Thus, unless the projects are assured of positive results in terms of economic feasibility, the public investment for them is not only a waste of alternative national budgeting, but also farm resources at the farm level will be operated with low marginal productivity.

17 During the period 1956-71, the annual growth rate of total population was 2.48 per cent, and the annual average growth rate of farm households was 0.07 per cent (E.P.B. 1972).

In the 1960s economists looked closely at land development projects with a view to making a priority decision on whether to improve or expand the land base for farm production. However, the upland reclamation project was placed at a higher level of priority than the expansion of irrigation improvement projects already conducted since 1956. This was mainly because emphasis was placed on increasing the area of farm land, to substitute for land taken up by the non-farm sector. This project has been carried out progressively since 1962 under the land reclamation law. As a result, the relative share of upland has increased since 1962 and reached its limit in the period after 1968 (Table 4.2).

TABLE 4.2
CHANGES IN TOTAL FARM LAND AND UPLAND,
SELECTED YEARS, 1956 to 1971

Year	Farmland to total area	Upland to farm land
	(per cent)	
1956	20.2	40.3
1958	20.4	40.4
1960	20.6	40.4
1962	21.0	40.7
1964	22.1	41.9
1968	23.6	44.4
1971	23.1	44.3

Source: M.A.F. 2, 1972, pp. 22-23.

Table 4.2 shows that when farm land's share of total area increased from 20.2 per cent in 1956 to 23.6 per cent in 1968, the relative share of upland in the total farm land increased from 40.3 per cent in 1956 to 44.4 per cent in 1968; especially between 1962 and 1968, after which it decreased slightly. The main constraint on the expansion of the land reclamation project was based on economic profitability rather than technical conditions. This is particularly important as a limiting factor of resource use in the individual farm unit.

Through the work of this writer's field survey, involving land use of upland reclamation, in 1968 (Whang, 1970, p.109) it was seen that not only was further expansion of upland constrained by economic feasibility, but also that there was a lack of land suited to family farm operations. This fact is also seen in the work of Park (1968, pp. 256-257 and pp. 28-36). That is, silkworm cocoon production per hectare of land already cultivated was 2.5 times higher than that of upland newly developed. The unit cost of land reclamation was estimated to be 1.5-2.0 times lower than that of the irrigated land project. But even after the third year of development, only about 17.7 per cent of the new land could be cultivated, and then its productivity was half that of the existing land.

In this stiuation, it is clearly advisable that the land development plan should be redirected in favour of the land improvement projects such as irrigation, land consolidation and water development projects, but with the main focus on the expansion of irrigated land. The land improvement projects, including improvement of irrigation, reservoirs, weirs and small irrigation ponds, have been developed since 1956 (A.D.C., 1964 and 1972). But until 1967 these projects were only carried out at the local level. Since 1967, they have been transformed into the Agricultural Water Resources Development Project, operating on a regional level in order to assure a stable farm production base. This resulted mainly from the effects of the two consecutive years of poor crops brought about by drought in 1967 and 1968, and the project is based mainly on the paddy field.

The land improvement projects increased irrigated land at an annual compounded rate of 3.23 per cent between 1956 and 1971. This improvement in irrigation increased two-crop paddy fields at an annual rate of 3.21 per cent (Table 4.3). It resulted in an expansion of total cultivated land at an average annual rate of 1.07 per cent and a consequent increase in the land utilization rate at an annual rate of 0.19 per cent (Table 4.3).

TABLE 4.3

LAND IMPROVEMENT AND LAND UTILIZATION[a]
SELECTED YEARS, 1956 to 1971

Year	Total farm land (A)	Total cultivated land (B)	Utilization rate (B/A)	Two-crop paddy fields	Irrigated land
	(1000 cheongbo)		(per cent)		(1000 cheongbo)
1956	2008.5	2833.1	141.1	394.5	543.1
1958	2029.1	2907.7	143.3	402.4	580.1
1961	2049.5	3084.0	150.5	447.2	618.8
1968	2338.2	3552.5	151.9	641.3	736.5
1971	2290.2	3324.8	145.2	634.1	875.0
		ANNUAL GROWTH RATE (%)			
1956/ 1971	.88	1.07	.19	3.21	3.23

Source: M.A.F.2, 1957 and 1972.

Note: a. Land utilization is described in Korean statistical terminology as: Total cultivated land/Total farm land.

Moreover the Regional Water Resources Development Project increased the rate of irrigated paddy to total paddy land from 56.7 per cent in 1968 to 68.6 per cent in 1971 (Table 4.4), resulting in the rapid expansion of two-crop paddy fields. As a result, the land improvement projects such as irrigation and water resource development improved the ratio of irrigated land to total paddy field land from 45.3 per cent in 1956 to 68.6 per cent in 1971, at an annual compounded rate of 2.81 per cent. The ratio of two-crop land to total paddy field increased from 32.9 per cent to 49.7 per cent in 1971, at an annual rate of 2.79 per cent (Table 4.4).

TABLE 4.4

INDICES OF LAND IMPROVEMENT, SELECTED YEARS, 1956 to 1971

Year	Irrigated land to total cultivated land	Irrigated land to total paddy land	Two-crop land to total paddy land
		(per cent)	
1956	27.0	45.3	32.9
1958	28.6	48.0	33.3
1965	31.1	54.6	46.1
1968	31.5	56.7	49.3
1971	38.2	68.6	49.7
	ANNUAL GROWTH RATE (%)		
1956-1971	2.34	2.81	2.79

Source: M.A.F. 2, 1957 and 1972; and Appendix A5.

Improvement in land quality: irrigated land

From the point of view of agronomy, improvement in quality of land input can take various forms such as soil conservation, water control, soil improvement and soil rotation systems based on the soil characteristics and the nature of the land itself. In this study, the increase in irrigated land input and the resulting expansion of two-crop paddy fields are observable phenomena taken as the indicators of improvement in the land quality. But it is questionable whether these terms may be introduced as measures of land quality itself.

In Korean agriculture, the two-crop paddy field is made possible by natural conditions such as hours of sunshine, temperature of the soil surface, evaporation and precipitation. Part of the increase is attributable to the improvement in farming knowledge and skill of farmers. The irrigation facilities are, of course, an accelerating factor for two-crop production in the paddy field, but they are not a determining factor for two-crop production owing to the influence of natural conditions.

For example, according to the statistical data for regional paddy fields (M.A.F. 2, 1972), the southern province of the agricultural area has introduced the two-crop paddy field system on more than 70 per cent of the land, and the middle province of the agricultural area has introduced it at the level of 30 or 40 per cent, while the northeastern and north western provinces have introduced it on only about 4 or 5 per cent of the land, and these differences are principally due to climate.

In this regard, the expansion of two-crop paddy fields based on the improvement of irrigated land input is not necessarily an indication of land quality. But land productivity can be improved by increasing the irrigated land input, along with the adoption of new farming skills and knowledge, within the constraints of climate conditions; and from this standpoint land quality can be measured through the irrigated land input. (The measurement of quality of land input is dealt with in a later section.)

Land quality correction: pattern of land use

As mentioned earlier, the expansion of farm land is based on the expansion of upland. The newly developed upland is infertile land compared with the land already cultivated. Moreover, about 98.1 per cent of this upland can achieve the same productivity as of upland already cultivated after around three or four years (Park, 1968, p. 135).

According to the statistical yearbook of M.A.F. (2, 1972), the productivity of crop production in upland areas is shown to be lower than that of paddy fields. For example, the average yield of rice per tanbo (about .01 of a hectare) of paddy land was 328 kg in 1964, 283 kg in 1965 and 316 kg in 1966, while the average yield of upland crops per tanbo was 166 kg in 1964, 176 kg in 1965 and 207 kg in 1966 in naked barley. Thus upland productivity is far lower than the paddy productivity even if their price per bag is assumed to be equivalent. In fact, the prices of upland crops are far lower than those of paddy crops.

TABLE 4.5

LAND UTILIZATION OF UPLAND RECLAMATION

After upland reclamation	Number of farms	Upland (A)	Total cultivated upland (B)	Rate of upland utilization (B/A)
	(household)		(cheongbo)	(per cent)
First year	295	864.9	398.4	46.1
Second year	828	799.9	762.4	95.3
Third year	581	611.8	600.0	98.1

Source: Park, Jin Whan, 1968, p. 135.

In this regard the structural change in the pattern of land use due to the expansion of newly developed upland brought about a relatively lower productivity of land input. Thus, this change in the pattern of land use had no augmenting effect through improvement in quality of land input (cf. Chapter 2). That is, it is not included in the concept of technical change through changes in pattern of land use. From this point of view, a measure of land input adjusted by the structural change in pattern of land use is described as a quality correction, rather than as the improvement in quality of land input. (The measurement of this land input is dealt with in the following section.)

Measurement of land input

For the analysis of the input-output relation based on the production function models in Chapter 2, land input on the individual farm unit is measured by the physical land area (Table 4.6). As mentioned above, the increase in supply of upland resulted in a decrease in the relative share of paddy field from 66.4 per cent in 1956 to 60.4 per cent in 1971 (Table 4.6).

This change in relative proportions of upland and paddy field caused a downgrading in quality of land input and a consequent relative decrease in the adjusted land input through the relative earning of upland and

TABLE 4.6

RELATIVE COMPOSITION OF PADDY FIELD AND UPLAND TO THE TOTAL LAND INPUT, SELECTED YEARS, 1956 to 1971

Year	Land input	Relative composition in	
		Paddy	Upland
	(per cent)	(per cent)	
1956	100.0	66.4	33.6
1962	98.4	63.9	36.1
1968	110.2	61.2	38.8
1971	109.8	60.4	39.6

Source: Appendix A6

paddy field, despite the increase in physical land input due to the upland reclamation (Table 4.7). For the measurement of quality adjustment of land input, the physical land input (R) is broken down into upland (U_t) and paddy fields (P_t) as follows:

$$R_t = U_t + P_t \qquad (4.1)$$

In constructing an aggregate land input from the different categories of upland and paddy field, their relative earnings are introduced, to be weighted based on the relative proportions of upland and paddy field:

From the equation (4.1),

$$\gamma_t = \alpha \frac{U_t}{R_t} + \beta \frac{P_t}{R_t} \qquad (4.2)$$

Hence, land input adjusted by the quality of land input is measured as follows:

$$S_t = R_t \cdot \gamma_t \qquad (4.3)$$

Where: S_t = adjusted land input

R_t = physical land input

U_t = upland

P_t = paddy field

γ = quality of land input

α and β are relative earnings of upland and paddy fields, respectively.

For computational purposes, it is convenient that the factor share of upland input is introduced as a standard unit, so the ratio of the factor share of paddy field over that of upland is formulated as follows:

$$Ti = \beta / \alpha \qquad (4.4)$$

Hence, the equation (4.2) is transformed by the use of equation (4.4) as the following form:

$$\gamma_t = Ti\ P_t/R_t + U_t / R_t \qquad (4.5)$$

Hence, $S_t = R_t \cdot \gamma_t$ (4.3)

Table 4.7 provides the average earnings of upland and paddy field, and presents the quality of land and adjusted land input.

TABLE 4.7

QUALITY OF LAND INPUT AND ADJUSTED LAND INPUT, SELECTED YEARS, 1956 to 1971

Year	Land input (R)	Quality of land (γ)	Adjusted land (S) *
		(per cent)	
1956	100.0	100.0	100.0
1962	98.4	97.9	96.3
1968	110.2	95.7	105.5
1971	109.8	95.1	104.4

* S indicates land input of Model IV in Chapter 7.

* $\gamma = \alpha\ U/R + \beta\ P/R$ (equation 4.2).

α and β are estimated by F.E.S. records data of M.A.F.(1), surveyed from 1200 farms, based on 1964-66.

	Average earnings per 1 unit of land	Numeral (Index)	Index (β/α)
Upland (α)	1.92	100.0	1
Paddy field (β)	5.40	281.3	2.813

Source: M.A.F. 2, 1964-1967.

Here we should note that the pattern of land use due to the relative proportions of upland and paddy field is considered to give an adjustment for quality of land input, mainly because it is an adjustment of homogenous land input as mentioned in Chapter 2.

Attention is now turned to making a quality adjustment in land input based on irrigated and non-irrigated paddy field. As shown in Table 4.4, the ratio of irrigated land to paddy field increased from 45.3 per cent in 1956 to 68.6 per cent in 1971.

In order to make an adjustment for quality changes due to irrigation, the adjusted land input is broken down from the point of view of paddy field. That is, paddy field in the equation (4.2) is separated into irrigated and non-irrigated land input:

$$Z_t = \frac{U_t}{R_t} + \beta \left[\left(a \frac{D_{1t}}{P_t} + b \frac{D_{2t}}{P_t} \right) (P_t / R_t) \right] \tag{4.6}$$

or for computational purposes, from the equation (4.5) and (4.6)

$$Z_t = \frac{U_t}{R_t} + Ti \left[\left(Hi \frac{D_{1t}}{P_t} + \frac{D_{2t}}{P_t} \right) (P_t / R_t) \right], \text{ where } Hi = a/b$$

$$\text{if } Hi \frac{D_{1t}}{P_t} + \frac{D_{2t}}{P_t} \text{ denote to } q_t, \tag{4.7}$$

$$Z_t = \frac{U_t}{R_t} + Ti \left(q_t \cdot \frac{P_t}{R_t} \right) \tag{4.8}$$

Then, land input adjusted by the quality of irrigated land input based on the quality correction of land input is as follows:

$$K_t = R_t \cdot Z_t \tag{4.9}$$

where $Ti = \beta / \alpha$ (see equation (4.4))

$Hi = a/b$

D_{1t} and D_{2t} indicate relative proportions of irrigated land and non-irrigated land input in paddy fields, respectively.

t = time variable

a and b are relative earnings of D_1 and D_2: the other descriptions follow equation (4.3).

Thus, the land input adjusted by equation (4.9) based on the equation (4.6 means that a quality adjustment of land input is weighted by relative earnings, based on the relative proportions of irrigated and non-irrigated land input comprising aggregate land input. Their relative earnings are based on the work of Professor Kim (1971, October, p. 23), in which he estimated average earnings of irrigated and non-irrigated land to formulate an irrigation improvement project:

	Rate of increasing yield (per cent)	per cheongto* (a/b)
Non-irrigated paddy field (b)	86.75	1.0
Irrigated paddy field (a)	108.59	1.2518

* Average yield of rice during the period 1960 to 1971.

These relative earnings are used to weight the relative proportions of irrigated and non-irrigated land comprising aggregate paddy land input of equation (4.7).

TABLE 4.8

RELATIVE COMPOSITIONS OF IRRIGATED LAND AND NON-IRRIGATED LAND TO PADDY FIELD AND ADJUSTED PADDY FIELD TO TOTAL LAND, SELECTED YEARS, 1956 to 1971

Year	Relative composition in Irrigated land (D_1/P_t)	Relative composition in Non-irrigated land (D_2/P_t)	Quality of paddy a (q_t)	Relative composition in paddy to total land b (P_t/R_t)	Adjusted relative composition in paddy field c $(q) \cdot (P_t/R_t)$
	(per cent)				
1956	45.3	54.7	1.000	66.4	66.4
1962	52.4	47.6	1.016	63.9	64.9
1968	56.7	43.3	1.026	61.2	62.8
1971	68.6	31.4	1.053	60.4	63.6

Source: Appendix A7

Notes: a. $q_t = D_{1t}/P_t + b\ D_{2t}/P_t$ or $q = Hi\ D_{1t}/P_t - D_{2t}/P_t$ (see equation 4.6).

b. See Table 4.6.

d. Column a . column b, i.e., the ratio of adjusted paddy field to total land input.

Table 4.8 provides the basic data on the relative proportions of irrigated and non-irrigated paddy fields and presents an adjusted paddy field to total land input. Table 4.9 presents an adjusted land input through the quality adjustment of irrigated land input and the changes in pattern of land use due to the relative proportions of upland and paddy field as in Table 4.6.

TABLE 4.9

ADJUSTED LAND INPUT BY THE IRRIGATED LAND INPUT AND STRUCTURAL CHANGES IN LAND USE, SELECTED YEARS, 1956-1971

Year	Land input (R_t) a	Adjusted land input (S_t) b	Adjusted land input (K_t) c	(Z_t) d
1956	100.0	100.0	100.0	1.000
1962	98.4	96.3	97.6	.992
1968	110.2	105.5	107.7	.977
1971	109.8	104.4	108.9	.992

Source: Appendix A8

Notes: a. See Table 4.7

b. See Table 4.7

c. $K_t = R_t \cdot Z_t$ (equation 4.9)

d. $Z_t = U_t/R_t + Ti(q_t \cdot \frac{P_t}{R_t})$ (equation 4.8)

The land input R_t, S_t and K_t as shown in Table 4.9 are used for each production function model in Chapter 7.

CHAPTER 5

LABOUR INPUT IN KOREAN AGRICULTURE

In the Korean economy, persons employed in farming accounted for about 47.4 per cent of the total 9,708 thousand persons employed by all Korean industry in 1971 (E.P.B., 1973, p. 97). About 2.92 persons out of total family members (5.92 persons) per farm household in 1971 were employed in farming, and farm land per farm worker was estimated at about 0.34 ha in 1971, which had greatly increased from the 0.26 ha in 1956. These facts indicate that the Korean farm is operated by family labour, and farm labour is the least scarce resource used for farm production. Thus, the Korean farm is characterized by a high labour - land ratio, even though farm land per farm worker has increased, and it is described as a family labour farming system.

However, in this family labour farming, farm production is determined by how many hours are worked rather than by how many farm persons are engaged in farming (Lee, 1964, p. 13) and Kim, 1967, pp. 59-62). In this study, the measure of labour input entering into the production function models in Chapter 7 attempts to take account of labour hours related to the total farm output regardless of the number of persons employed in farming.

5.1 Changes in quantity of labour input

Structure of farm labour

The total labour input employed in farming is based on the family labour input, and the residual labour input is provided by hired labour (Table 5.1).

TABLE 5.1

FAMILY LABOUR HOURS AND HIRED LABOUR HOURS WORKED IN FARMING, SELECTED YEARS, 1956-1971

Year	Family labour hours[a] to total labour hours	Hired labour hours to total labour hours
	(per cent)	
1956	80.4	19.6
1958	78.4	21.6
1964	78.8	21.2
1968	80.1	19.9
1971	84.5	15.5

Source: M.A.F. (1), 1958, 1959 and 1971.

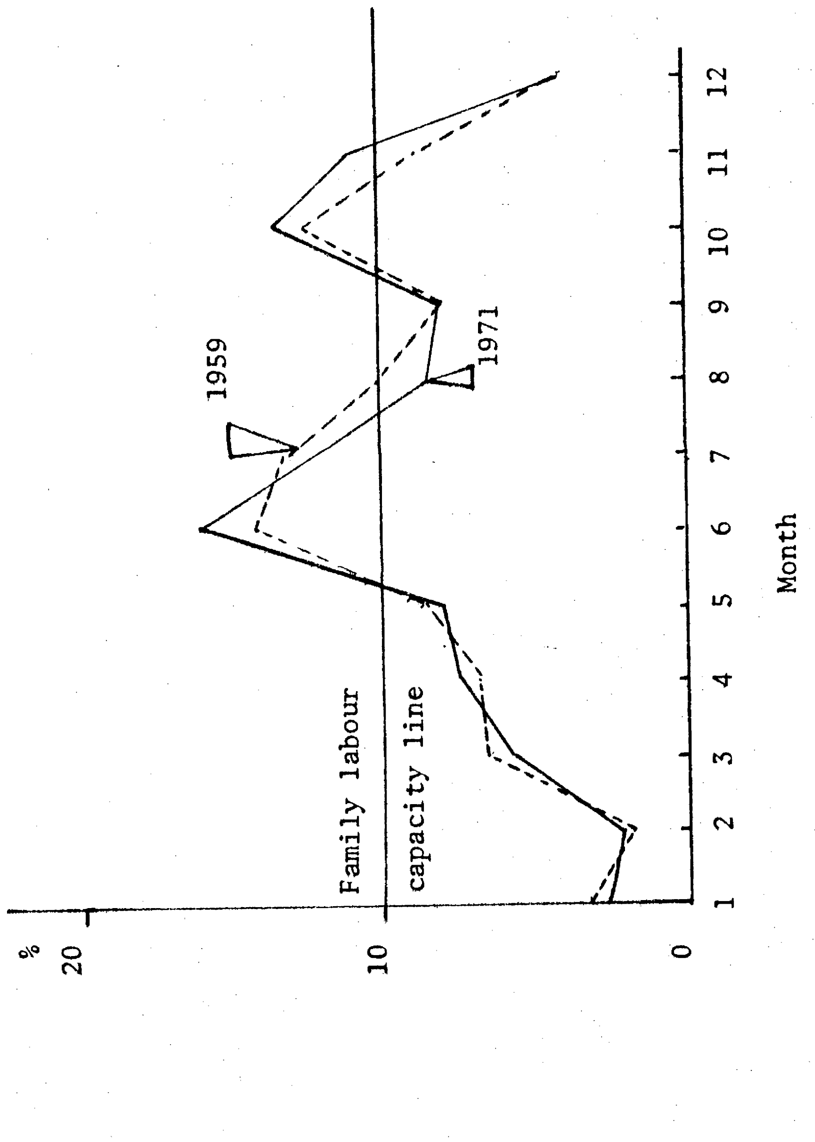
Note: a. Exchange Labour is included in Family Labour.

In the family labour farming, the use of hired labour input on the farms can be explained by two reasons. Firstly, full use of family labour throughout the year is difficult, because crop production requires an intensive farming season of planting, ploughing and harvesting, and an idle farming season to prepare for farm production. Therefore, in the labour peak season for farm production, the hired labour is employed because of the additional output given by timely operations by hired labour. The second reason is that the leisure of operators and family labour in the large farm size can be exchanged with the expense for hired labour, but this reason is only relevant fact for the large farm of more than 3.0 cheongbo.

During the labour peak seasons, the Korean farmers are not only employed in farming as a full time job, but also have an extremely heavy work load, exceeding the family labour capacity in the most intensive labour seasons such as June, July, October or November, when most Korean farms employ hired labour (Figure 5.1).

FIGURE 5.1

MONTHLY LABOUR INPUT OF AVERAGE FARM HOUSEHOLD IN KOREA

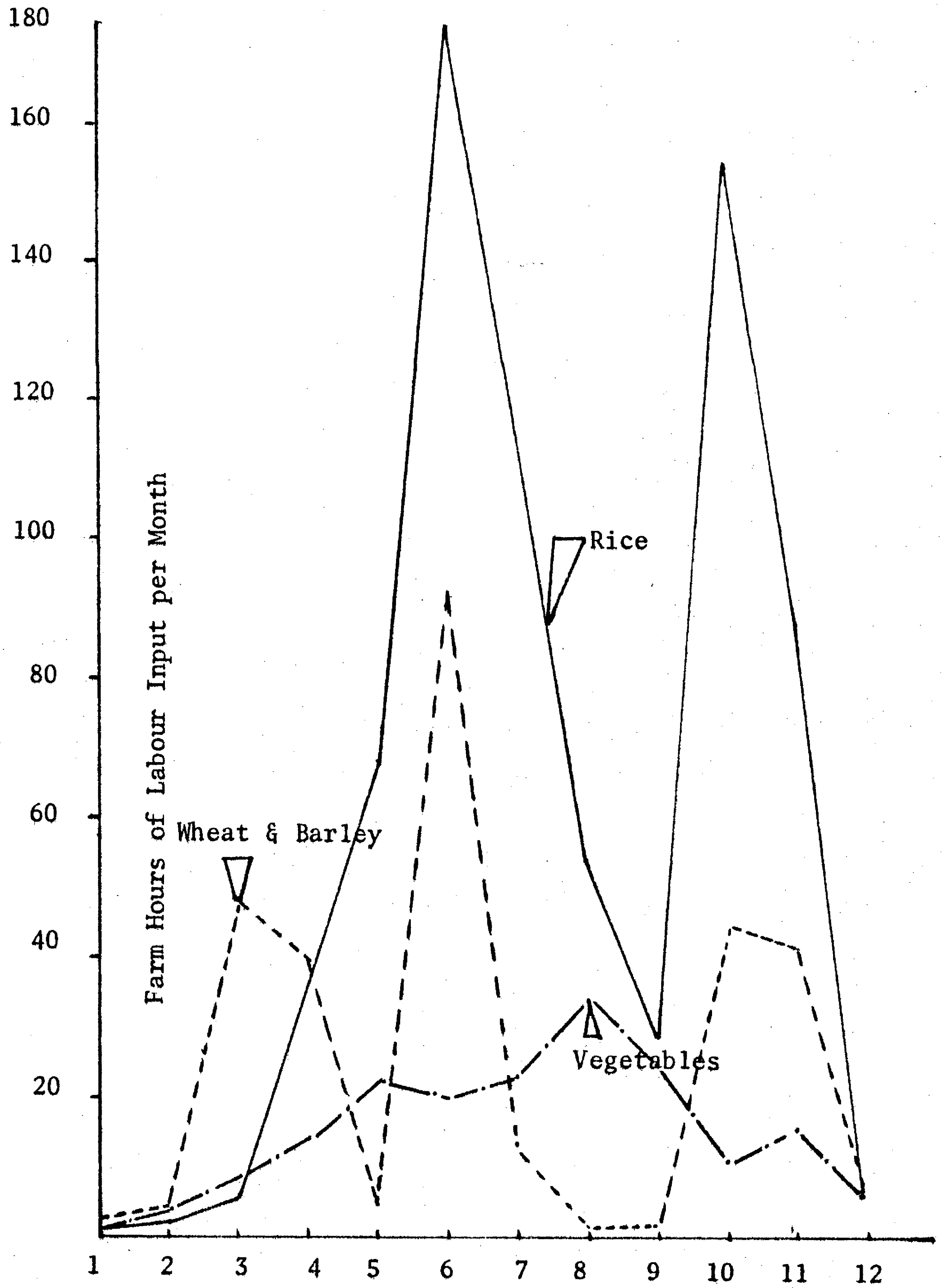


Source: M.A.F. (1), 1960 and 1972.

The seasonal fluctuation of labour requirements is especially higher in rice production than any other crops, as shown in Figure 5.2; June for planting and October for harvesting. Thus, in order to perform the necessary operations for rice production at the proper time, the hired labour is temporarily employed.

FIGURE 5.2

MONTHLY LABOUR INPUT PER FARM FOR RICE, VEGETABLES, WHEAT AND BARLEY, 1971



Source: M.A.F. (1), 1972, p. 222.

Most hired labour employed in farming comes from small farms under 0.5 ha and true farm labourers in rural areas; about 83.1 per cent of the total hired labour hours is comprised by temporary farm workers obtained from the small farm category, and the remainder consists of farm labourers hired annually in rural areas (M.A.F., (1), 1972, p. 214 and 217).

In Korean agriculture in the idle seasons of farm production, these hired labour forces and family labour capacity also are idle farm resources. Thus many hired labourers are excluded during the idle farm seasons, and these will take any opportunity to be employed, at either farm or non-farm work.

Changes in farm labour input

In recent years, these hired farm workers, together with the surplus family farm workers, have migrated out from the farm sector, particularly since the formulation of the First-Second Five Year Economic Plan from the starting point of 1962. This is due to the fact that the successful growth of the non-farm sector has increased its employment capacity, and has pulled out relatively cheap labour forces from the farm sector, especially since 1964 (Table 5.2). Thus, since 1964, outmigration of farm labour forces is caused by the effect of pulling out from non-farm sector, while before 1964, by the effect of pushing out from the agricultural sector (Kim and Whang, 1970, pp. 17-21, 31-32).

TABLE 5.2

COMPOSITION OF PERSONS EMPLOYED BY SECTORS, SELECTED YEARS, 1963-1971

Year	Farm workers employed by farm sector	Non-farm workers employed by non-farm sector
	(per cent)	
1963	60.7	39.3
1964	59.8	40.2
1968	50.1	49.9
1971	47.4	52.6

Source: E.P.B. 1972, p. 97.

However, in this study total labour hours employed in farming have decreased at an annual compounded rate of 1.69 per cent from about 2,370 hours in 1956 to about 1,833 hours in 1971. Especially since 1964, total labour hours have declined at an annual rate of 2.03 per cent (Table 5.3).

TABLE 5.3

TOTAL LABOUR HOURS EMPLOYED IN FARMING PER FARM HOUSEHOLD, SELECTED YEARS, 1956-1971

Year	Total labour*			Index of total labour hours		
	Hours	Rate of change a.	%	Per cent	Rate of change	%
1956	2370			100.0		
		-1.39			-10.7	
1964	2117		-1.69	89.3		-22.7
		-2.03			-12.0	
1971	1833			77.3		

* It was calculated by weighting for the differences in age and sex:

Age	Male	Female
10-14	.3	.2
15-16	.6	.6
17-19	.8	.6
20-55	1.0	.8
56-60	.8	.6
61-65	.6	.6
66 and over	.3	.2

Note: a. Annual compounded rate (%).

Source: M.A.F. (1), 1962 and 1972.

Actually the reasons for the decrease in total labour hours employed in farming are involved and combined of many different factors resulting from the structure of the socio-economic background. But for the purpose of this study, if we look only at the quantitative factors of composing farm labour input within the farm sector, the main factors emerge clearly from the structure of the farm labour input. Much of the decrease in total labour hours is due to the outflow of the hired labour hours employed in farming since 1964 (Table 5.4).

TABLE 5.4

ANNUAL CHANGES IN RELATIVE COMPOSITION OF FARM LABOUR HOURS BY SOURCES OF FARM LABOUR, SELECTED YEARS

Period	Family labour hours to total labour	Hired labour hours* to total labour
	(per cent)	
1956-58	- .83	3.40
1958-64	-1.31	- .26
1964-68	.65	-1.23
1968-71	1.43	-5.52

Source: M.A.F. (1), 1958 and 1972. N.A.C.F. (1), 1958.

* Exchange labour input is excluded.

For more detailed discussion, percentage changes in total labour hours are distributed to monthly labour input by sources of farm labour hours worked in farming between 1964 and 1971 (Table 5.5).

TABLE 5.5

PERCENTAGE CHANGE IN PROPORTIONS OF MONTHLY LABOUR INPUT, 1964 to 1971

Sources of farm labour	Labour peak seasons				Labour idle seasons		
Month:	6	7	10	11	12	1	2
Family labour	- 6.8	- 3.0	- 7.4	- 8.0	- 3.2	-16.8	- 5.9
Hired labour	-10.3	-56.5	-26.8	-20.8	-63.2	-58.9	-47.2
Total labour	- 1.9	-21.5	-11.3	-10.4	-14.4	-20.8	-10.1

Source: M.A.F. (1), 1965 and 1972.

It is evident from Table 5.5 that the hired farm labour has declined more rapidly than the family labour hours in both peak and idle seasons. This decrease in hired labour hours appeared with the range of 56.5 per cent to 63.2 per cent during the labour idle seasons of December, January and February, and in July at the labour peak season, indicating a much greater decrease than that of family labour. It is mainly because the rural wage rate is lower than that of non-farm sector. On the other hand, the family labour decreased without any big differentiation between labour peak seasons and idle seasons, compared with the seasonal differentiation for the decrease in hired labour. It is closely related to the expansion of employment capacity in the non-farm sector as mentioned earlier. It is also due to the increase in use of farm machinery in order to substitute for the decreasing draught animal power and to improved efficient labour use since 1964 (Chapter 6).

Another noticeable source behind the decrease in total labour hours is that family members belonging to the small farm are turned into non-farm workers within the rural areas as the economy develops (Table 5.6). The rate of employment in non-farm work in small farms increased at the higher rate of 10.0 per cent compared with the decreasing rate in large farms of 5.35 per cent.

TABLE 5.6

PROPORTION OF RESIDENT FAMILY MEMBERS EMPLOYED IN NON-FARM JOBS, SELECTED YEARS, SINCE 1963

Period	Small farm[a]		Large farm[b]	
	No. in family[c] (persons)	Proportion of non-farm jobs (per cent)	No. in family[c] (persons)	Proportion of non-farm jobs (per cent)
1963	5.33	1.69	8.23	1.22
1964[d]	5.41	1.90	8.83	1.13
1968	5.09	2.75	7.68	1.04
1971	4.87	3.70	7.21	.83
1964-71[e]		10.00		-5.35

Source: M.A.F., (1), 1963 and 1972.

Notes: a. Less than 0.5 ha.
b. More than 2.0 ha.
c. Family members on individual farm units.
d. Benchmark year 1964.
e. Annual compounded increase rate.

The continuing decrease in farm labour hours, especially in hired labour hours, is inducing change in the characteristics of the farm labour structure. The relative composition of family labour increased since 1964 (Table 5.4), and family labour intensive farming has also increased. In particular, the continuing decrease in hired labour has increased the rate of participation of younger generation labour and female labour (Table 5.7).

TABLE 5.7

RELATIVE CONTRIBUTIONS OF YOUNG LABOUR TO TOTAL LABOUR HOURS WORKED, SELECTED YEARS, 1956-1971

Year	Female labour hour to Family labour hour	Young labour hour[a] to Total labour hour	Young male labour to Total young labour hour
		(per cent)	
1958	30.3	12.3	50.6
1964[b]	31.1	10.5	51.7
1968	31.6	12.8	52.6
1971	34.2	14.3	52.8
		Annual increase rate (%)	
1964-1971	1.37	4.52	0.30

Source: M.A.F. (1), 1960 and 1971.

Notes: a. 16 to 20 years old.

b. Base benchmark year.

Young labour forces, especially, increased at an annual compounded rate of 4.52 per cent since 1964, and this increase is mainly based on the young male labour forces comprising from 50.6 per cent in 1958 to 52.8 per cent in 1971 of the total young labour forces (Table 5.7).

In Korean rural society, the young labour forces attend the rural youth associations and the 4-H Club, and learn new farming knowledge and skill through them. In particular, the 4-H Club is an organization for rural youth, for the purpose of improving traditional farming methods and adopting new knowledge and skills acquired from experimental plots and the extension service. The membership of the 4-H Club has increased about 3.62 times from 1958 to 1971 (M.A.F. (2), 1965 and 1972). Through it, these young labour forces not only participate in farm production, but also contribute to improving farming methods and adopting new farming knowledge based on the recent work dealing with decision making in Korean farming. According to the work of Professor Wang (1971, pp. 53-59), farms including members of the 4-H Club show a higher rate of adopting new farming skills and technology than the farms that do not include members of the Club; farms with young generations active in the 4-H Club adopted new technology at the level of 63 per cent, and other farms at the level of only 44 per cent. In addition, Wang reported that young generation groups (over 19 years old) influenced the farm operation in improving farm production at a rate of 37 per cent.

Consequently, these structural changes in farm labour indicate that the relative increase in fresh young labour input is continuous, resulting in improvement of quality of farm labour. In addition, the relative increase in family labour hours employed in farming may bring an improvement in labour efficiency. That is to say, the Korean farms are moving from less efficient to more efficient farm management with the use of more and new farm supplies and equipment (Chapter 6).

There is some evidence from Figure 5.1 that the labour requirements of the labour peak season in July and the busy farm season in August are considerably less than before. This is mainly due to the fact that the rice transplanting time is beginning earlier, in order to avoid a conflict of labour use between the winter crop (barley) and the summer crop (rice). This reflects the improved farming skill and methods through new farming knowledge among the family labour forces (Chapter 5.2). However, an efficient use of labour input may reduce the number of working hours already required for farm production.

5.2 Improvement in quality of labour input

As mentioned in Chapter 2, in literature on measuring labour quality, the most commonly used measure of labour quality has been years of schooling. This study attempts to use schooling years of labour forces for the measurement of labour quality, assuming that educational quality of the labour forces is a main factor affecting total labour hours worked in farming. The relative earnings of the educational levels of the labour forces are then measured by the marginal productivity of the schooling levels, assuming that differential relative earnings of labour forces are mainly determined by the educational levels. These relative earnings are used as weights in constructing the aggregate labour input. This adjusted labour input is defined as an efficiency of labour input, while labour quality itself is defined in terms of educational variables in Chapter 7.

Role of education of labour forces in farm production

In Korean farming, it is often argued that the abilities of farmers and their decisions in their farming about how to use new farm supplies and equipment are derived from their experience without formal education, or often from neighbouring successful farmers, and thus farm production can increase even in the absence of formal education of farmers. Even if this is a true statement, it does not indicate that this is a necessary and adequate condition for the improvement of farm operations and for further increasing farm production.

It is argued here that a continuing increase in farm production and progressive farm operations will only result if the knowledge and skill of farm operators and family members keeps increasing and changing. If we accept this, we shall see that the source of this knowledge and skill is based on formal education.

In small family farming, the research results of O.R.D. (Office of Rural Development, a government agency) and other agricultural institutions cannot usually be applied directly by the farmer, because of the wide differences between the farm situation and that of the research institutions or experimental plots, even in the same region. In order to make the institutional research results effective, farmers themselves need to do research on their farms under their different situations. This requires scientific thought and action on the part of farm operators.

In Korean farming, the farm operator's attitude and preferences in farming are strongly influenced by the activities of the family members (Kim and Kuwan, 1967, pp. 67-69) "decision making in Korean farming is determined by farm operator himself (36.1 per cent); farm operator + family members (35.7 per cent); and farm operator + family members + neighbours and kin (23.7 per cent)."

Thus, formal education of family members provides an advantage for the farm operator in using new farm input and more farm input as recommended by the institutions.

The work of Lee, J.H. (1968, pp. 106-109) has shown proof of the contribution of farmer's education to the farm production. He found that a highly educated family's farm obtained a higher marginal value product for the farm resources than a less educated family's farm, and indicated that increasing resource productivity would be achieved through the improvement of the farmer's education. He concluded that "farmers with more education, on the average, earned higher incomes than farmers with little education" in terms of schooling years (Lee, J.H., 1968, pp.106-109).

Consequently, family farms with more highly educated labour forces are better adjusted to adopt new farming operations than those with less education. Thus, formal education for the family members is an innovatory factor because it is an important source of scientific transformation in farming.

Education cost and living expenditures of farm household

TABLE 5.8

RELATIVE COMPOSITION OF EDUCATION COSTS TO LIVING EXPENDITURES, 1962-1971

Year	Living cost (A)	Education cost (B)	Relative cost (B/A)
	(Won)		(per cent)
1962	55,739	2,034	3.4
1964	101,118	3,753	3.7
1968	143,104	9,732	6.8
1971	244,463	18,363	7.5
	Annual Increase Rate[a]		
1962-1971	18.4	28.0	10.4

Source: M.A.F. (1), 1970 and 1972.

Note: a. During the same period: food 16.8%, housing 21.4%, fuel and light 15.3%, clothing 17.8%, others 21.8%.

The relative share of total living expenditures devoted to the costs of education in the Korean farm household is increasing at an annual rate of 10.4 per cent (Table 5.8). As shown in the footnote to Table 5.8, the cost of education per farm household is increasing at the highest rate, 28.0 per cent, among the items of farm family living costs. This high increase in education cost may be due to the fact that formal education for family members will contribute to improving farm operations and that it is a profitable investment for the human development of family members. In any case, it is concluded that formal education for the family members is an important source of improving labour quality.

Education system

Before introducing the statistics on levels of schooling for farm labour input, we need to select appropriate lines of division in levels of education for the measurement of labour quality.

The Korean education system during the period of this study, has adopted the 6-3-3-4 system: 6 years primary school, 3 years middle school, 3 years high school, 4 years college and university. Before the so-called 'New School System', we had the 'Old School System' which was composed as follows: 6 years primary school, 4 or 5 years middle schoole, 3 years expert technical school, and 4 years university. This old school system has been reformed into the new school system, from the period to 1945 to 1948.[18]

The educational reforms were carried out not only in the school system but also in the principles and contents of education. In general, the old system focussed mainly on non-practical schooling based on the conventional Confucian thought, while the new system is a practical and scientifically based education. The characteristics of the quality of schooling are quite different, especially in the higher levels of schooling.

The Korean statistical yearbook on education compiled the statistics on education of the labour force without distinguishing which educational system they came from, so the quality of schooling among them is mixed. However, in the case of agricultural labour forces in this study, it is meaningless to distinguish between levels of schooling above high school, because so few agricultural workers reach this level, and their relative composition in the labour force has not changed significantly.

18 The United States military government planted the American education system in Korea to provide the Korean people with democratic education (H.N.A., 1973, p. 217).

Measurement of quality in labour input

For the purposes of this study, levels of schooling of farm labour forces in formal education are classified into three kinds of education as follows:

1. Non-schooling (N_0) - no schooling (including barely literate labour with no schooling).
2. Primary schooling (N_1) - up to and including 6 years schooling.
3. High schooling (N_2) - over 7 years schooling.

Thus, the breakdown of the total quantity of labour (N) in terms of schooling background is as follows:

$$N = N_0 + N_1 + N_2, \quad N = \sum_{i=0}^{n} N_i$$

where N_i = labour forces with i schooling level.

This breakdown means that the marginal value of products for the different levels of schooling of the labour input will differ.

In order to aggregate quality of labour by schooling levels, their wage differentials are introduced as a weighted base, assuming that labour is paid for its marginal product from the standpoint of the production function by the levels of schooling; the index of labour quality (E) is measured as weighted wages of different categories of schooling based on the relative composition of these categories in total labour quantity.

Hence, $E = \sum_{i=0}^{n} N_i W_i$

where N_i = relative composition with i schooling in total quantity of labour

W_i = wage for labour with i years schooling

i.e., $W_i = \partial f / \partial N_i$ which stands for marginal value of products for different educational categories of labour input.

In this study, for computational purposes, it is convenient that the wage rate of the non-schooling labour input is introduced as a standard unit

(Table 5.9), so the wage ratio of those with i schooling over non-schooling is formulated as follows:

$$A_i = W_i/W_0$$

where W_0 = wage rate of labour input with no schooling

W_i = wage rate of labour input with i schooling

Hence, the index of quality of labour (E) is rewritten in the following form:

$$E = \sum_{i=0}^{n} N_i A_i$$

As mentioned earlier, the efficiency of labour input (L) or adjusted labour input is estimated from the quality of labour (E) measured above:

$$L = E \cdot N$$

$$L = N \sum_{i=0}^{n} N_i A_i$$

where $N = N_0 + N_1 + N_i$

$$N_i = \sum_{i=0}^{n} N_i/N$$

Thus, the efficiency of labour input is an adjusted labour input based on the index of the quality of the labour input measured by schooling levels.

The Table 5.9 provides the average wage rates by schooling level, and Table 5.10 presents the basic data on the percentage distribution of labour quantity (Appendix A10) by schooling level for the period 1956 to 1971.

Table 5.10 shows that the labour quality of farm workers employed in farming has steadily improved to a higher schooling level. The most noticable facts are the decrease in the relative share of non-schooling in the labour force, which dropped from 65.2 per cent in 1956 to 32.9 per cent in 1971; and the sharp rise in the relative share of primary schooling from 27.2 per cent in 1956 to 51.0 per cent in 1971.

TABLE 5.9

AVERAGE WAGE RATE PER DAY BY SCHOOLING LEVEL, BASED ON THE MARGINAL VALUE PRODUCTS,[a] 1965

	Average wage rate	Numeral Index	
		Index	W_i / W_0
	(Won)	(per cent)	
Non-schooling (N_0)	76	100.0	1.000
Primary schooling (N_1)	95	125.0	1.250
High schooling (N_2)	175	230.3	2.303

Sources: Lee, J.H.(1968), p. 100. J.A.R.E.

Note: a. F.E.S. records data of M.A.F. (1) surveyed from 1200 farms. A.E.R.I. of M.A.F. was computed.

TABLE 5.10

PERCENTAGE DISTRIBUTION OF MAN EQUIVALENT FARM LABOUR HOURS BY SCHOOLING LEVEL, SELECTED YEARS, 1956-1971

Year	Non-schooling	Primary schooling	High schooling
		(per cent)	
1956	65.2	27.2	7.6
1964	35.7	52.0	12.3
1971	32.9	51.0	16.1
		Annual compounded growth rate (%)	
1956-1964	-7.25	8.44	6.20
1964-1971	-1.16	- .28	3.92
1956-1971	-4.46	4.28	5.13

Source: Appendix A10.

In particular, from a turning point in 1964, the relative composition of primary schooling comprised a large share, within the range of 51 per cent to 52 per cent until 1971. On the other hand, the relative composition of high schooling which comprised the smallest share of 7.6 per cent in 1956 has improved rapidly to 16.1 per cent in 1971.

This structural change in upgrading of labour quality was mainly due to the increase in relative share of primary schooling in the labour forces at annual rate of 8.44 per cent before 1964, while since 1964, due to the increase in relative composition of high schooling at annual rate of 3.92 per cent. This improvement in labour quality indicates that younger generations with schooling in farming are being employed for the farm production, and they substitute for the less educated hired labour forces and family members that migrated out from the farm sector, together with the substitution for the less educated labour of older generations. In addition, relatively increasing the family labour intensive farming improved labour quality due to the decrease in less educated hired labour input.

According to the work of Professor Park (1966, p. 8), 'most of the younger generation in Korea are attending the formal education which is within the village district. Hence, within the next ten years, most of the farm operators will have a primary school education or above', and he mentioned that younger farm operators who had a middle or high school education would substitute for older generations. In his work, school education of farm operators on 84 sample farms was as follows:

- without school education: 57.1 per cent
- primary school: 37.0 per cent
- middle and over high school: 5.9 per cent.

Whatever the causes may be, the quality of labour input employed in farming has increased. From 1956 to 1964 the quality of labour input improved at an annual rate of 1.26 per cent, and from 1964 to 1971 at an annual rate of 0.52 per cent. Over the period 1956 to 1971 the quality of labour improved at an annual rate of 0.91 per cent (Table 5.11). As a result, adjusted labour input in terms of efficiency in labour input improved much more than the quantity of labour input (Table 5.11).

TABLE 5.11

INDICES FOR QUANTITY AND QUALITY OF LABOUR INPUT, AND EFFICIENCY OF LABOUR INPUT, SELECTED YEARS, 1956-1971 (1956 = 100)

Year	Quantity of labour (N)	Quality of labour (E)	Efficiency of labour input (L)[a.]
		(per cent)	
1959	97.0	102.8	99.7
1964	89.3	110.5	98.7
1968	79.5	111.2	88.4
1971	77.3	114.6	88.6
	Annual compounded growth rate (%)		
1956-1964	-1.40	1.26	- .16 (11%)
1964-1971	-2.04	.52	-1.53 (75%)
1956-1971	-1.70	.91	- .80 (47%)

Source: Tables 5.3 and 5.10. Appendices A9 and A11.

Note: a. $L = E \cdot N$ where $E = \sum_{i=0}^{n} N_i A_i$

Figures in parentheses in (L/N) . 100.

It is evident from Table 5.11 that efficiency of labour input decreased at a much smaller rate (0.8 per cent) than the rate of decrease (1.7 per cent) in quantity of labour input during the whole period, mainly because improvement of quality in labour substituted at a level of abour 47 per cent for the reduction of labour quantity. In particular, since 1964 efficiency of labour input is estimated to have increased abour 75 per cent relative to the reduction of labour quantity during the period 1964-1971.

In conclusion, the continuing decrease in labour quantity in farming is due to the reduction of the hired labour forces and surplus family labour forces. This continuing decrease in farm labour input caused a change in the structure of farm labour input, resulting in the substitution of younger labour forces for hired and outmigrated family labour forces, and in an increase in family labour intensive farming.

Consequently, the quality of farm labour input has improved. This upgrading of labour quality based on the structural changes in farm labour input contributes to increasing labour efficiency, substituting for the reduction in quantity of labour input. Finally, this quantity of labour input, quality of labour input and efficiency of labour input (or adjusted labour input) enters into the aggregate production function model in Chapter 7. This improvement of quality in labour input through the schooling variable will be further discussed as a source of technical change and as a source of increase in total farm output, in Chapter 7.

CHAPTER 6

OTHER INPUT IN KOREAN AGRICULTURE

A generally agreed characteristic of the Korean farms is that land is a scarce resource and labour is a less scarce resource. This being the case it is often argued that in order to increase farm production, chemical or biological technology in farming should be developed so that more can be grown on the limited area of land.

In this concept, a method of increasing farm production is to require a new farm input, and more inputs of intermediate products such as fertilizers pesticides, seed and other sorts used in farming. These improvements depend on the development of the farmer's knowledge and skill so that he will use new and more farm input. Moreover, by using farm machinery and implements or draught animals, factor inputs are employed more intensively in farming and are used more efficiently (Kim and Whang, 1970, p. 49).

On the other hand, the use of chemical inputs and mechanical equipment requires other physical inputs such as farm service buildings, fuel, feeds, and other materials. Thus, increase in farm production occurs as a result of the combination of a great variety of farm supplies, equipment and implements, along with the development of new knowledge and skill on the part of the farmers. Among these various factors affecting farm production, our concern in this chapter is devoted to measuring physical farm inputs, described as 'Other Input'.

Measurement of other input

The concept of 'other input' means current capital expenditure on inputs used in farming excluding labour and land input. That is, the term 'other input' is defined as the current expenditure for farm input, together with annual capital service flow of the fixed capital used for farm production.

For the measurement of the 'other input' it is assumed that the quality of farm supplies and equipment has been improved over time, but that their quality is the result of mixed technical effect. Therefore, the quality of each input is ignored. In addition, seed input is included in the unspecific seeding item, and so, biological technology is excluded in discussion the other input.

For aggregate discussion later, the other input is grouped into six major items:

1. Chemical inputs such as fertilizers and pesticides;
2. Mechanical input such as farm machinery and implements;
3. Draught animal power;
4. Charges for water and other items;
5. Farm service buildings; and
6. Miscellaneous inputs.

For the measurement of the other input series used in farming, each type of fixed capital and current expenditure of each farm input category is converted into real value terms or physical inputs, in order to avoid the distorting effect of price change over time. The fixed capital consists of land, farm service buildings, large plants, large animals, large implements (M.A.F. (1), pp. 26-28 and p. 94). Here, land is excluded. The current expenditure on farm input include fertilizers, pesticides, agricultural implements, seed and seeding, fuel and light, charges for water and other charges, and other items (M.A.F. (1), pp. 72-73).

The real value terms of physical inputs in each category of farm inputs are measured by dividing the current values by an index of prices paid by farmers based on the 1964-1966 average price according to the form of Laseyres quantity index:

$$C_t = \sum_{j=1}^{n} C_{jt} P_{jo} / \sum_{j=1}^{n} C_{jo} P_{jo}$$

where C_{jo} and C_{jt} are identified with the item of other inputs in the base period and compared periods, respectively.

(j = 1.2.3. --- n)

and P_{jo} if their price in the base period with the 1964-1966 average price.

In this study, the fixed capital stock is converted into annual service flow by using depreciation and interest charges. The depreciation on the fixed capital investment is obtained from the official data published by M.A.F. (1) and compiled by N.A.C.H. (1). The depreciation method of the fixed capital is officially estimated to an adjusted straight line method developed by B.R.S. of M.A.F.((1), 1972, p. 26).

The interest charge on the fixed capital investment is calculated by multiplying each type of real fixed capital by a 'short term' interest rate of 12 per cent applied by the bank association during the price weight period 1964-1966 (E.P.B., 1973, p. 38). These interest charges of the real fixed capital investment are added to depreciation charges on each type of the real fixed capital category.

As a result of these estimates on different categories of farm inputs, the real value of 'other input' category is associated with the volume of physical farm input. These estimated categories of real input groups were simply aggregated in constructing 'other input', and then this other input, along with each category of the other input, was computed to an index with 1956 = 100. Indices of the input series estimated by sub-groups and input are presented in Table 6.1.

TABLE 6.1

INDICES AND RATE OF INCREASE OF MAJOR INPUT SUB-GROUPS, SELECTED YEARS, (1956 = 100 BASED ON 1964-1966 PRICE WEIGHTS)

Year	Fertilizers Pesticides %	Machinery implements %	Charges %	Building of farm services %	Animal expenditures %	Miscellaneous inputs %	Total other inputs %
1958	106.2	126.4	121.5	164.2	94.2	165.4	131.1
1962	193.2	211.4	287.3	171.1	68.3	141.2	164.7
1964	177.2	221.2	230.5	204.0	66.9	166.0	165.1
1968	232.2	249.1	456.3	163.6	64.8	180.5	190.1
1971	287.4	276.4	460.8	224.0	100.3	251.7	244.3
			Annual compounded growth rate (%)				
1956-1971	7.30	7.00	10.70	5.52	0.48	3.28	6.14

Source: Appendix A12.

Components of increase in other input

It is evident from Table 6.1 that the 'other input' in Korean farming grew steadily at an annual rate of 6.14 per cent during the period of this study. The remarkable characteristics of this high rate of growth resulted, on the one hand, from a steady increase in chemical input such as fertilizers and pesticides, and farm mechanical input including farm implements (Table 6.1)

In particular, the main reason for the increase in 'other input' was the fact that chemical input, a major share of the 'other input', increased steadily from 36.6 per cent in 1956 to 43.1 per cent in 1971 (Table 6.2). Because even though public charges and farm machinery and implements increased at a high growth rate, their relative proportions of 'other input' comprise the smallest share within abour 6.2 per cent and 3.0 per cent, respectively. Moreover, the relative shares in the other items show a decreasing trend and a stagnation in miscellaneous inputs (Table 6.2). Thus, it can be said that chemical fertilizers and pesticides are key supplies for farm production, as well as being a main source of the increase in 'other input'.

Improvements in chemical input

In Korean agriculture, fertilizer supply was predominantly dependent on imported fertilizers until 1960, and so, sufficient amounts of the fertilizers that farmers wanted to use for farm profuction were not supplied at the optimum period of crop production, mainly because the fertilizer marketing system was not operated efficiently as a result of the complex administrative waste between Korea and the exporting countries (N.A.C.F., Monthly Farm Survey, 1968, pp. 10-12).

Moreover, until 1969 supply of domestic chemical fertilizers was not sufficient for farm production. This resulted in the low input level for application of fertilizer used in farming until 1969 (Table 6.3).

TABLE 6.2

RELATIVE COMPOSITION OF SUB-GROUPS IN OTHER INPUT, SELECTED YEARS, (BASED ON 1964-1966 PRICE WEIGHTS)

Year	Fertilizer Pesticides %	Machinery implements %	Charges %	Building of farm services %	Animal expenditures %	Miscellaneous inputs %	Total other inputs (Won)
1956	36.6	2.7	3.3	26.1	13.8	17.5	12125 (100)
1962	42.9	3.5	5.8	27.1	5.7	15.0	19970 (100)
1968	44.7	3.5	7.8	22.5	4.7	16.7	23045 (100)
1971	43.1	3.0	6.2	23.9	5.6	18.2	28620 (100)
				Average annual increase rate (%)			
1956-1971	1.10	0.71	4.29	-0.58	-6.18	0.26	6.14

Source: Appendix A12

TABLE 6.3

INDICES OF USE OF FERTILIZERS AND PESTICIDES AT THE FARM LEVEL, SELECTED YEARS, (1956 = 100 INPUT BASED ON 1964-1966 PRICE WEIGHTS)

Year	Fertilizer %	Pesticides %
1959	106.2	128.7
1961	177.5	204.6
1964	194.7	403.7
1967	205.6	858.3
1968	214.3	950.8
1971	225.0	2,792.6

Source: Appendix A12

In order to overcome this shortcoming, since 1960 the affairs and marketing channels for imported fertilizers have been operated by the N.A.C.F. under the administrative support of M.A.F., so as to supply fertilizers at the optimum production period. Moreover, the domestic Chung Ju fertilizer company was set up in 1960, and the HONAM fertilizer company in 1963. Particularly since 1967 a rapid increase in domestic fertilizer production supplied by about ten newly built fertilizer manufacturing plants meets fertilizer demand for farm production. Moreover, from a turning point of 1967, fertilizer supply has changed from reliance on imported fertilizers (excluding potash fertilizers) to self-sufficiency and surplus fertilizer has been exported since 1967 (Table 6.4).

This expansion in the supply of domestic manufactured fertilizers and the improved marketing system for it caused the farmers to apply more fertilizers, especially since 1964. This fact is presented in Table 6.3, which shows that since 1961 application of fertilizers for farm production has continued to increase.

TABLE 6.4
DOMESTIC PRODUCTION OF CHEMICAL FERTILIZERS BY ELEMENTS OF FERTILIZER,[a]
SELECTED YEARS

Year	N	P_2O_5 (M/T)	K_2O	Total[b]	Exports of fertilizer[c] (M/T)
1960	6145	-	-	6145 (13359)[d]	
1962	37382	-	-	37382 (81265)	
1964	64916	-	-	64916 (141121)	
1967	155694	21231	9513	186438 (420581)	20,000 (urea)
1968	321557	121205	42138	484900 (1056862)	25,000 (urea)
1971	408001	144686	46785	599472 (1291354)	96,600 (urea), 68,972 (C-F)

Notes: a. means plant nutrients of N, P_2O_5 and K_2O.

b. M.A.F. (2), 1972, pp. 84-85.

c. N.A.C.F. (3), 1972, pp. 34-35.

d. Parentheses indicate quantity of chemical fertilizers: Urea, Cal Cyon, Pot Chloride, Compound Fertilizer, Triple Superphosphate, Post Chlo, Supershosphate and Fused Phosphate.

On the other hand, expansion of domestic pesticide production has coincided with the period of domestic fertilizer supply; since 1961 pesticide input used for farm production has continued to increase (Table 6.3) along with the increase in domestic pesticide supply (Table 6.5).

TABLE 6.5

PESTICIDES PRODUCTION INDEX, SELECTED YEARS, 1960-1971

Year	Quantity (1000 kg)	Index (1965 = 100) (per cent)
1960	2,139	20.9
1962	7,293	71.3
1964	25,726	251.3
1971	25,832	252.4

Source: M.A.F. (2), 1972, pp. 88-89

Especially, the rapid increase in pesticide used for farm production since 1967 as shown in Table 6.5, has been mainly due to the mass use of pesticides in the paddy field, by aeroplane and community anti-insect programmes.

On the other hand, since abour 1962 the rapid increase in chemical fertilizers and pesticides in farming has coincided with the increase in upland agriculture, due to the land reclaimation project (Chapter 4) and the continually decreasing labour input due to the outmigration of farm labour (Chapter 5). That is, in order to improve infertile upland newly developed since 1962, more application of fertilizers per unit of land is required to improve land productivity.

There is evidence that application of fertilizers on newly developed upland is much higher than on already cultivated upland. "According to the field survey of cocoon production on 312 sample farms, fertilizers are used much more on reclaimed upland (N, 8 kg/10 a; P, 6.53 kg/10 a) than on already cultivated upland (N, 407 kg/10 a; P, 3.13 kg/10 a)" (Whang, 1970, p. 54). In particular, the continually decreasing labour input caused more use of pesticides to control weeds and pests efficiently with less labour input. It also caused more application of chemical fertilizers instead of farm manure, which had required greater labour input for its production.

There is some statistical evidence that during the period of this study, production of farm supplied manures and grass manure continues to decrease, compared with the increase in application of chemical fertilizers, along with the decrease in labour input (Table 6.6).

TABLE 6.6

APPLICATION OF CHEMICAL FERTILIZERS AND PRODUCTION OF FARM MANURES, SELECTED YEARS

Year	Nitrogen	Farmyard manure	Green manure
	(1965 = 100)		
1956	49.5	79.4	282.8
1961	96.8	76.6	248.2
1968	131.2	-	138.0
1971	159.4	-	50.7

Source: M.A.F. (2), 1972, pp. 427-428.

However, these improvements in chemical input for the farm production are the main source of the increase in 'Other Input'.

Changes in mechanical input and draught animal power

As shown in Table 6.1 a noticeable change in farm input items of the other input category is in farm machinery and draught animal power. These inputs are often described as tools or energy sources to substitute for farm labour input and to improve the efficiency of labour input. Especially, farm machinery and implements are regarded as a new technical farm input to substitute for traditional draught animal power.

In Korean farming, especially before 1963, the draught animal power has been a dominant source of energy, along with human labour, especially in the paddy field, even up to the present. This is mainly due to the fact that the draught animal is more technically effective than the power ploughing machine in deep ploughing work, and that the draught animal is also essential for the production of farm manure compost (Kim and Whang, 1970). In spite of these advantages for the farm production, draught animal power has shown a decreasing tendency since 1963 , and the relative importance of draught animal power has also declined from 13.8 per cent in 1956 to 5.6 per cent in 1971 (Table 6.2). On the other hand, farm machinery and implements have increased steadily at an annual rate of 7 per cent, and also their relative composition of other input has increased slightly from 2.7 per cent in 1956 to 3.0 per cent in 1971 (Table 6.2).

The main reason for this decrease in draught animal power and for the increase in farm machinery has been a result of growth in the non-farm sector, and the economic problems of draught animal management within the farm sector itself. As mentioned in Chapter 5, the industrialization caused an absolute reduction in farm labour input which even though it was not great, its impact on total farm production will be severe in the family labour farming system, because in small scale farming, farm labour forces are a principal source of power. Moreover, a small decrease in labour supply due to the outflow of rural labour forces will have a great effect on farm wage rates and farm productivity because farm technology has been inelastically formed toward the conventional farming methods.

Indeed, the farm labour shortage during labour peak seasons has caused an increase in farm wage rates - from 199 Won in 1964 to 695 Won in 1971 (N.A.C.F. (1), 1972, p. 82).[19]

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19 At the time of writing the value of the South Korean Won was approximately 540 = $Aust 1.00.

This increasing wage rate strongly influenced the decrease in draught animals, mainly because about 60 per cent of the management cost items for draught animals is comprised by the wage cost (Chung, 1971).

Moreover, as the Korean economy developed, the rapid increase in demand for meat, especially since 1965, has made the economic profitability of beef cattle greater than that of draught animals. Combining with the increasing wage rates this has caused a shift from draught animals to beef cattle (Chung, 1971).

So, farm machinery and implements should be introduced to lessen the burden of farm wage rises and to substitute for the required labour input at the labour peak seasons and busy farming seasons, and for the decrease in draught animal power.

In this situation, the development of domestic manufacturing plants in the 1960s has supplied farm machinery and equipment to the farm sector. Especially since 1964, the expanding domestic supply of farm machinery and implements has caused more use of farm mechanical inputs in farming (Tables 6.1 and 6.7).

TABLE 6.7

NUMBER OF AGRICULTURAL IMPLEMENTS AND MACHINES SUPPLIED TO FARM HOUSEHOLDS, SELECTED YEARS, (1965 = 100)

Year	Power plough machine	Anti power equipment	Power pump	Power winding machine	Power threshing machine
		(per cent)			
1956	-	6.4	-	35.6	7.2
1962	13.3	9.4	56.7	67.5	42.4
1964	58.8	67.7	59.0	84.1	77.3
1967	346.8	168.5	121.5	107.9	134.7
1971	1515.9	915.8	222.4	132.2	335.0

Source: M.A.F. (2), 1972, pp. 428-429.

Thus, farm machinery and implements increased steadily to substitute for the decrease in labour input and draught animal power, expecially since 1964. But mechanization of Korean farms will not comppletely replace draught animals, mainly because of the small farm size and because draught animals produced farm manure and were specially suited to paddy farming. In this regard, farm mechanization of Korean farms will appear to substitute for the absolute decrease in labour input rather than for the decrease in draught animals.

Changes in charges and other farm input

The continuing increase in charges for water and other inputs has been caused by the improvement in land input, through the augmenting of current capital expenditures by public and private institutions. This means that under the constrained land supply for farm production, farm production can increase through the improvement of the land's capacity for farm production. But the relative share of charges in total other input comprises a minority share of from 3.3 per cent in 1956 to 6.2 per cent in 1971, even though its share continues to increase over time (Table 6.2).

On the other hand, it is hard to prove that increase in charges is a favourable economic incentive to increase farm production, mainly because its effect appears to add to the production costs instead of having a direct effect on increasing farm production. Moreover, its effect is attributable to the other input. In Korean agriculture, farm service buildings are the most important components of fixed capital except land; farm service buildings are estimated at about 61.5 per cent in 1956 and at about 69.6 per cent in 1971, of the fixed capital except land (M.A.F. (1), 1958 and 1972). But farm service buildings are not only used for farm dwellings, but are also included in farm production. Therefore it is impossible to separate the purposes for which farm buildings are used and also it is hard to prove that farm service buildings are improved for the purpose of farm production over time. In this respect, even though the farm service building input has been rising at an annual rate of 5.5 per cent during the period of this study, this does not necessarily directly affect the increase in farm production.

Thus farm service buildings as a factor in farm production is a rather weak and ambiguous concept. But the relative composition of farm service buildings changed without any significant trend (Table 6.1 and Table 6.2). Therefore it is assumed that farm service buildings do not affect growth in the other input.

Finally, miscellaneous inputs include feed, seed, and seedlings, fuel and light, unspecific input of livestock and sericulture, and the other intermediate products. This farm input shows an increasing trend, but its relative share of other input has not changed much, while showing fluctuation trends over time (Table 6.1 and Table 6.2).

In particular, until 1962 the decrease in the relative share of miscellaneous input to other inputs was mainly due to the fact that modern farm supplies are assumed to have substituted for unspecific traditional farm supplies as the economy has developed. The large increase in the relative share of miscellaneous input from 16.8 per cent in 1967 to 18.2 per cent in 1972 has been mainly due to the increase in feed for the raising of beef cattle and dairy cattle (Table 6.8).

In conclusion, growth in the other input occurred as a result of the increase in the chemical inputs such as fertilizers and pesticides, along with the increase in charges, farm machinery and implements. But the main source of the rapid increase in 'Other Input' is caused by the more application of chemical fertilizers and pesticides. On the other hand, mechanical input has not much increased, but its increase is to substitute for the decrease in labour input.

TABLE 6.8

INDEX OF BEEF CATTLE AND DAIRY CATTLE RAISING, SELECTED YEARS, 1956 to 1971

Year	Beef Cattle (%)	Dairy Cattle (%)
1956	-	0.6
1961	142.7	17.4
1967	264.8	156.1
1971	355.9	453.9

Source: M.A.F. (2), 1972, pp. 429-430.

This conclusion suggests that in Korean farming, more fertilizer input is being used to improve infertile land and land saving technology, and new pesticide input is being employed for the control of pests and disease, together with the elimination of weeds. On the other hand, farm machinery and implements have increased slightly in order to substitute for the decreasing labour input since 1964 and to improve the efficiency of labour input. This other input is introduced in aggregate production function models in Chapter 7.

CHAPTER 7

MEASUREMENT OF TECHNICAL CHANGE IN KOREAN AGRICULTURE

7.1 Empirical results of the production function models

Regression models and empirical results

In this chapter the rate of technical change is measured and its nature determined. The five models derived in Chapter 2 are briefly summarized in Table 7.1.

TABLE 7.1

CHARACTERISTICS OF REGRESSION MODELS

Models[a]	Dependant variable	Characteristics of factor inputs			Technical change	Description
		Land[b]	Labour[c]	Other inputs[d]		
I	Q_t	R_t	N_t	C_t	T1	Natural units of factor inputs
II	Q_t	S_t	N_t	C_t	T2	S_t: land input adjusted by the change in land use
III	Q_t	K_t	N_t	C_t	T3	K_t: land input adjusted by irrigated land and land use
IV	Q_t	S_t	L_t	C_t	T4	L_t: labour input adjusted by educational quality of labour forces
V	Q_t	K_t	L_t	C_t	T5	

Notes: a. These models are described in Chapter 2. All are log linear in form.

b. See Chapter 4.

c. See Chapter 5.

d. See Chapter 6.

The observations estimated by ordinary least squares, using the five assumed models, are presented in Table 7.2.

TABLE 7.2
REGRESSION RESULTS FOR PRODUCTION FUNCTION MODELS I - V

Regression models	Dependant variable	Constant	Coefficients of regression variables: Land	Labour	Other input	Technical change	Coeffic. of peter. R^2	S.E.R.	F	Durbin-Watson stats
I	Q_t	1.6999	.4389	.3393	.2218	.0173	.891	.0336	32.53	1.91
		(1.6085)	(2.4100)[a]	(1.2639)	(1.5563)	(1.3765)				
II	Q_t	2.9688	.4166	.3813	.2022	.0204	.920	.0126	46.76	2.02
		(10.3007)[a]	(2.6777)[a]	(1.6383)	(1.5091)	(1.8584)[a]				
III	Q_t	2.9829	.4161	.3887	.1952	.0198	.904	.0318	37.83	2.09
		(10.7757)[a]	(2,7964)[a]	(1.7473)[a]	(1.4922)	(1.8271)[a]				
IV	Q_t	2.8643	.4703	.3220	.2077	.0159	.921	.0324	46.80	2.06
		(12.6311)[a]	(3.6366)[a]	(1.6419)	(1.5824)	(1.8791)[a]				
V	Q_t	2.8861	.4676	.3364	.1960	.0154	.906	.0317	38.35	2.14
		(13.2427)[a]	(3.7928)[a]	(1.8000)[a]	(1.5320)	(1.83538)[a]				

Source: Data from Appendix A13 and Appendix A14, and alternative variables of factor inputs in each model.

Note: The figures in parentheses are the 't' value of the estimated coefficients: a = indicates significance at the 5 per cent level.

The estimated values of the parameters of the models are based on the variables and their definitions as described in Table 7.1, and derived from the equations of the production function models in Chapter 2. There model I is expressed by equation (2.7), model II by equation (2.11), model III by equation (2.13), and model IV and model V are, respectively, represented by equations (2.15) and (2.17).

Guideline for significance tests in regression models

Significance tests for the empirical results of the models are made to determine whether or not the models represent definite economic propositions.

Since the regression models are a simple algebraic representation of economic theory, statistical tests of significance for the results may not represent their worth in describing farm production from the practical and logical point of view. However, the significance tests of the results are important as to the correctness of the models.

The first test made on these production function models is for the existence of constant returns to scale. It will be recalled that this was assumed in Chapter 2 in describing the estimated equations. Therefore it is important to establish this at an early stage of the analysis. The test of hypothesis of constant return to scale function is made for models I, IV and V.

If the models pass this test, then we can proceed to consider the following tests and properties. These are, first, whether the signs and orders of magnitude of the parameters of the production function models are closely identified with the characteristics of the Korean agriculture economy. Secondly it is considered whether the models are supported by statistics, such as R^2, the statistics of the regression coefficients and the Durbin-Watson statistic, testing for autocorrelation of the residuals. In addition, it is asked whether there are significant variations in the coefficients of time between production function models, that is whether the rate of technical change differs significantly between models.

The statistical tests are applied to each model individually, to see how well each model explains the data and to examine the significance of the coefficients of the various factor inputs. This is because each model is considered to be a valid representation of the characteristics of the factor inputs employed in farming, and each provides some information as to the factors affecting the rate of technical change and to the measurement of the rate of technical change.

Statistical test of the hypothesis of constant returns to scale

Constant returns to scale of the production function models are tested using the same sources of data as in Table 7.2. The results are presented in Table 7.3 and indicate that these production function models obey the hypothesis of constant returns to scale. This because the constraint of constant returns to scale is imposed by expressing output and factor input as ratios to whatever type of land input is appropriate.for the model in question. Thus when the land input is added to the equation its estimated coefficient (δ), should not be significantly different from zero, in order to be consistent with the constant return to scale production function model. Mathematically, the constant returns to scale production function takes the following form:

$$Q_t = A(t)\ R_t^{\alpha}\ L_t^{\beta}\ C_t^{\gamma} \qquad \text{(i)}$$

where $\alpha = 1 - \beta - \gamma$ or $\alpha + \beta + \gamma = 1$

Then, the equation for testing constant returns to scale function takes the form:

$$Q/R = A(t)\ (^{L}/_{R})^{\beta}\ (^{C}/_{R})^{\gamma}\ R^{\alpha} \qquad \text{(ii)}$$

and $\delta = 0$ is a necessary condition for $\alpha + \beta + \gamma + \delta = 1$, that is, in order to get constant returns to scale function of equation (i).

Tests of significance of the coefficient (δ) of land in models I, IV and V indicate significant levels in the 't' test, as in Table 7.3. Hence constraint $\alpha + \beta + \gamma = 1$ is upheld in models I, IV and V.

TABLE 7.3

RESULTS OF THE TESTS OF CONSTANT RETURNS TO SCALE, SELECTED MODELS I, IV AND V

Selected models	Dependent variables	Coefficient of regression equations			T	R^2	Durbin-Watson
		Labour/ land	Other/ land	Land			
I	Q_t/R_t	.3510 (1.5738)	.2345 (1.4563)	.0510[a] (.1089)	.01667 (1.2369)	.889	1.91
IV	Q_t/S_t	.2991 (1.5678)	.1930 (1.5378)	.0712[a] (.1958)	.0165 (1.7523)	.901	2.04
V	Q_t/K_t	.3224 (1.5952)	.1881 (1.4535)	.0405[a] (.0138)	.01576 (1.6941)	.901	2.13

Source: Based on the data of Appendix A13 and Appendix A14.

Notes: a. Indicates coefficients not significantly different from zero.

Model I: $\text{Log }(Q/R) = \text{constant} + \beta \log (N/R) + \gamma \log (C/R) + \delta \log R + a\,T$

Model IV: $\text{Log }(Q/S) = \text{constant} + \beta \log (L/S) + \gamma \log (C/S) + \delta \log S + a\,T$

Model V: $\text{Log }(Q/K) = \text{constant} + \beta \log (L/K) + \gamma \log (C/K) + \delta \log K + a\,T$

Figures in parenthesis indicate 't' value of the estimated coefficients.

Since these production function models exhibit constant returns to scale, and therefore are compatible with the theory advanced in Chapter 2, we can proceed to test how well the estimated regression models explain the data.

Agreement with a priori belief

These production function models all have coefficients of the expected sign and of a reasonable order of magnitude. Although there is no readily available information for factor shares in Korean agriculture based on time series analysis, several recent works[20] using cross-sectional data suggest that factors of determining farm output are, in order of importance, land input, labour input and capital services or other input.

In particular, most of the economic input/output analysis of farm management has been carried out assuming constrained land input or given land inputs. This means that the land input used for farm production has been defined as a pre-determined factor, and so its coefficient should show a higher elasticity than for any other factor input.

In Korean agriculture, apparently, farm land is the scarcest factor, and labour input the lease scarce factor. Under this farm production condition, other inputs such as chemical fertilizers, farm machinery, and implements, and the other farm supplies have been employed to improve infertile land input and land saving technology, together with the improvement in efficiency of labour use.

It can be said that the other inputs are employed to substitute for land and labour input in order to increase agricultural production. In the past work of this writer (1972), it has been proved that the factors, in order of output elasticity, are the expansion of cropland, the increase in efficiency of labour input and current capital use. The models, estimated in this study, suggest acceptable economic implications for the Korean agricultural economy, which any agricultural economist will recognize from the order of coefficients in the regression models.

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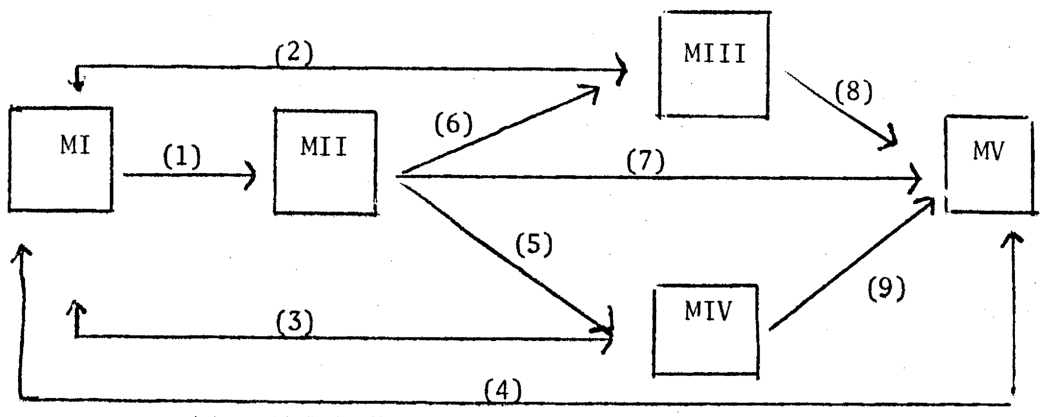
20 Lee, Jae Han (1964, pp. 20-53).
Han, Kyoo Soo (1971, p. 64).
Park Jin Han (1966, p. 175-197).
Lee Gi Uk (1972, pp. 81-94).

Statistical tests of significance in models

Next, it is to be determined whether or not these models are sufficiently supported by the statistical tests. In order to determine the preferred regression model, we proceed according to the following chart:

FIGURE 7.1

CHOICE OF A REGRESSION MODEL



The figures in parentheses indicate the order in which the models are compared.

First, a test is made to examine whether or not the models explain the data, and if they do, we proceed to determine which regression model is preferred through the indicators of R^2, the 't' tests of the coefficients in the regression equations, and the Durbin-Watson statistics (Table 7.4).

TABLE 7.4

RESULTS OF TESTS FOR THE FIVE DIFFERENT MODELS

Models	R^2	Significance level in coefficient			Technical change	Durbin-Watson test
		Land	Labour	Other Input		
I	.891	5%	10%	10%	10%	1%
II	.920	1	5	10	5	5
III	.904	1	5	10	5	5
IV	.921	1	5	10	5	5
V	.906	1	5	10	5	5

Source: From Table 7.2

From the results of R^2 and 't' test, as summarized in Table 7.6, it is clear that all the models explain the data satisfactorily at the significance level of 90 per cent.

For more detailed discussion of the 't' test, in the case of model I, if we employ a one-tailed significance test with null hypothesis that coefficients of factor inputs are, respectively, equal to zero, then, for 13 degrees of freedom, we may reject the null hypothesis with 95 per cent confidence in land input. Other input and time variables have coefficients significantly different from zero at the 90 per cent level. In addition, the Durbin-Watson test indicates that the residuals are not positively auto-correlated, that is, the null hypothesis is not rejected, on the ground that $d = 1.911 > 1.66 = d_u$ at the significance points of d_L and d_u 1%, while at the 5 per cent level the test is inconclusive, on the ground that d_L $(.74) < d_u$ (1.93).

The results of these statistical tests indicate that model I can be introduced in support of economic arguments, together with the use of the estimated rate of technical change, even though the statistical specifications at 't' test are shown to be of low significance level. This is mainly due to the fact that this model explains data at 90 per cent significance level and represents the characteristics of the Korean agricultural economy. In the same statistical procedure as for model I it is tested in the case of model II, model III, model IV and model V as summarized in Table 7.4.

Following the chart in Figure 7.1 and comparing model I to model V indicates that the statistical specifications are significantly improved except for the order of R^2. In the case of R^2, model IV shows the highest significance level, and the others follow in the order model II, V, III and I. If we consider the 't' values associated with each regression coefficients in each model, model V is found to be highly stable, on the ground that the coefficient of land and labour, together with the exponential time trend in terms of technical change, are significantly different from zero at the 5 per cent level.

On the other hand, the Durbin-Watson d-statistics imply that for these models the null hypothesis cannot be rejected in favour of negative first-order auto-correlation at the 5 per cent level of significance, mainly because d values of the four models show greater than the value of d_u $(1.93 = d_u)$.[21]

In some statistical senses the d-statistics in the four models may be indicated to be less significant than model I. In particular the model V is less significant than model IV. However, the most important result obtained from the four different models is that the coefficients of the exponential time variable (T) show a higher level of significance.

Interestingly, the rate of technical change is decreased from model II to model V. In this context, five different regression models are necessary in order to examine the nature of technical change and to determine the rate of technical change as a source of increased total farm output.

In conclusion, from the results of economic implications and statistical specifications for the five models, model IV and model V are determined to be more appropriate regression models.

But from the statistical standpoint of analysis for the nature of technical change and sources of the increased total farm output, this study should employ model I and model V. This is mainly due to the fact that model I is described by the natural unit of factor inputs, while model V is expressed in efficiency units of land and labour input and in natural

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21 "In the case of sample values of d in excess of 2.0, a test is made against the alternative hypothesis of negative first-order auto-correlation, compute (4 -d) and refer this value to d_L and d_u." (Johnston, 1972, p. 252).

units of other input, especially, model V showed a greatly decreased rate of technical change. In addition, the model I and model V may show the problem facing the Korean agriculture economy, in particular, comparing model I with model V, we can get much information to better understand the sources of the past growth in total farm output.

But for the case analysis on the process of technical change which attempts to find out factors determining the rate of technical change, all five models are employed in this study.

Finally it should be noted that this study is mainly focussed on the two models, regression model I and model IV, for labour productivity.

7.2 Measurement of technical change

Technical change in regression model I

In this section, the amount of technical change in Korean farming is calculated. The time span considered is 1956-1971. In this period, total farm output increased at an annual average growth rate of 3.18 per cent. Land and other inputs increased by 0.69 per cent and 6.32 per cent per annum respectively, but the labour input, declined by 1.62 per cent per annum (Table 7.5).

TABLE 7.5
INDEX MEASURES OF TOTAL FARM OUTPUT AND FACTOR INPUTS, SELECTED YEARS, 1956-1971

Year	Total farm output	Factor inputs		Other input
		Land	Labour	
		(per cent)		
1956	100.0	100.0	100.0	100.0
1959	104.8	94.2	97.0	131.1
1964	127.4	100.3	89.3	165.1
1971	157.3	109.8	77.3	244.3
	Average annual growth rate (%)			
	3.18	.69	- 1.62	6.32

Source: Date from Chapters 3, 4, 5 and 6.

By applying model I based on equations (2.6) and 2.7) to the data of Table 7.5, we can measure the rate of technical change as a source of growth in total farm output. Equations (2.8) and 2.9) in Chapter 2 can be written thus:

$$\dot{Q}/Q = \dot{A}/A + \propto \dot{R}/R + \beta \dot{N}/N + \gamma \dot{C}/C \quad \text{or}$$

$$\dot{A}/A = \dot{Q}/Q - [\propto \dot{R}/R + \beta \dot{N}/N + \gamma \dot{C}/C] \qquad (2.18)$$

$$(\propto = 1 - \beta - \gamma)$$

Factor shares estimated for model I are introduced into equation (2.18):

during the period 1956-1971

$$\dot{A}/A = \dot{Q}/Q - [.4389 \dot{R}/R = .3393 \dot{N}/N + .2218 \dot{C}/C] \qquad (2.19)$$

Substituting the observed average annual growth rates for each of the factors R, N, and C and for Q into equation (2.19), an average annual growth rate of technical change is obtained:

$$\dot{A}/A = 3.18 - [.4389 (.690) + .3393 (-1.620) + .2218 (6.32)]$$

$$= 3.18 - [.3028 - .5497 + 1.4018]$$

$$\therefore A/A = 2.02$$

The estimate of $\dot{A}/A$ derived by this method differs slightly from the rate of technical change (a) estimated in model I. This is because the average rate of growth are used and the error term is ignored. Strictly speaking, in any year (t), the rate of technical change $\dot{A}(t)/A(t)$ is given by

$$\dot{A}(t)/A(t) = a + \dot{U}t/Ut$$

$$= 1.73 + \dot{U}t/Ut \qquad (2.20)$$

where $\dot{U}t/Ut$ = error factor

ρ Ut = .029

Solow (1957) suggested that "in the neutral case it is apparent that error factor will be absorbed into the estimate A(t)". This indicates clearly that the rate of technical change is a result of the difference $(\dot{A}/A)$ between the observed annual rate of growth in total farm output in terms of total factor inputs $(\dot{I}/I)$ in the absence of technical change. That is, the magnitude of technical change is mainly dependent on the changes in total farm output ($\dot{Q}/Q$) and total factor inputs ($\dot{I}/I$).

However, from the results of equation (2.20), during the period 1956-1971, with an average annual growth rate of 3.18 per cent in total farm output, the other input ($\dot{C}/C$) increased at an average annual rate of 1.4 per cent, and thus 44.1 per cent (1.4018 of 3.18 per cent) is attributable to the increased use of the other input. Land input ($\propto \dot{R}/R$) increased at an average annual rate of .3028 per cent, contributing 9.5 per cent (.3028 of 3.18 per cent) to the growth of total farm output, while labour input decreased at an annual rate of .5497 per cent, resulting in an adverse effect of 17.3 per cent on the growth in total farm output.

As a result, of the annual increase in total farm output (3.18 per cent) 45.6 per cent (1.45 of 3.18 per cent) was caused by the effect of the increased total factor inputs, and the remaining 54.4 per cent (1.73 of 3.18 per cent) was caused by the effect of the rate of technical change (Table 7.6). From the empirical result, the increased total farm output is attributable more to the effect of technical change than to the total factor inputs (Table 7.6).

Apart from technical change, the increased total farm output is caused by the increased intensity of other input, along with the expansion of land input (Table 7.5).

The decrease in labour input employed in farming has an adverse effect on increasing total farm output. The observed technical change ($\dot{A}/A$) is what is left over after allowing for the effects of the decrease in labour input to some extent, and the improvement in other input and land input, and the substitution of other input for labour input or land input (the next section will deal with this in more detail).

TABLE 7.6

SOURCES OF GROWTH IN TOTAL FARM OUTPUT AND AVERAGE ANNUAL RATES OF CHANGE IN INPUT AND OUTPUT, 1956 to 1971

Average annual rate of change in			Total factor input[a]	Technical change	Total farm output
Land	Labour	Other input			
$(\alpha \dot{R}/R)$	$(\beta \dot{N}/N)$	$(\gamma \dot{C}/C)$	$(\dot{I}/I)$	$(\dot{A}/A)$	$(\dot{Q}/Q)$
	(per cent)			(per cent)	
.3028	-.5497	1.4018	1.450	1.73	3.18
(9.5)	(-17.3)	(44.1)	(45.6)	(54.4)	(100.0)

Source: Data from model I.

Note: a. $\dot{I}/I = \alpha \dot{R}/R + \beta \dot{N}/N + \gamma \dot{C}/C + U_t$ in model I.

The parentheses are percentages of the contribution the factor inputs and the technical change to the increased total farm output. Based on the indexes with price weights of 1964-1966 = 100, 1956 = 100.

In order to observe the trends in the rate of technical change, the rate of technical change, A(t) can be calculated by integration based on the equation (2.20):

$$\int \frac{\dot{A}(t)}{A(t)} = \int \frac{1}{A}\frac{dA}{dt} = \int a + \frac{1}{u}\frac{du}{dt}$$

$$\therefore \int \frac{1}{A} dA = \int a\, dt + \int \frac{1}{u} du$$

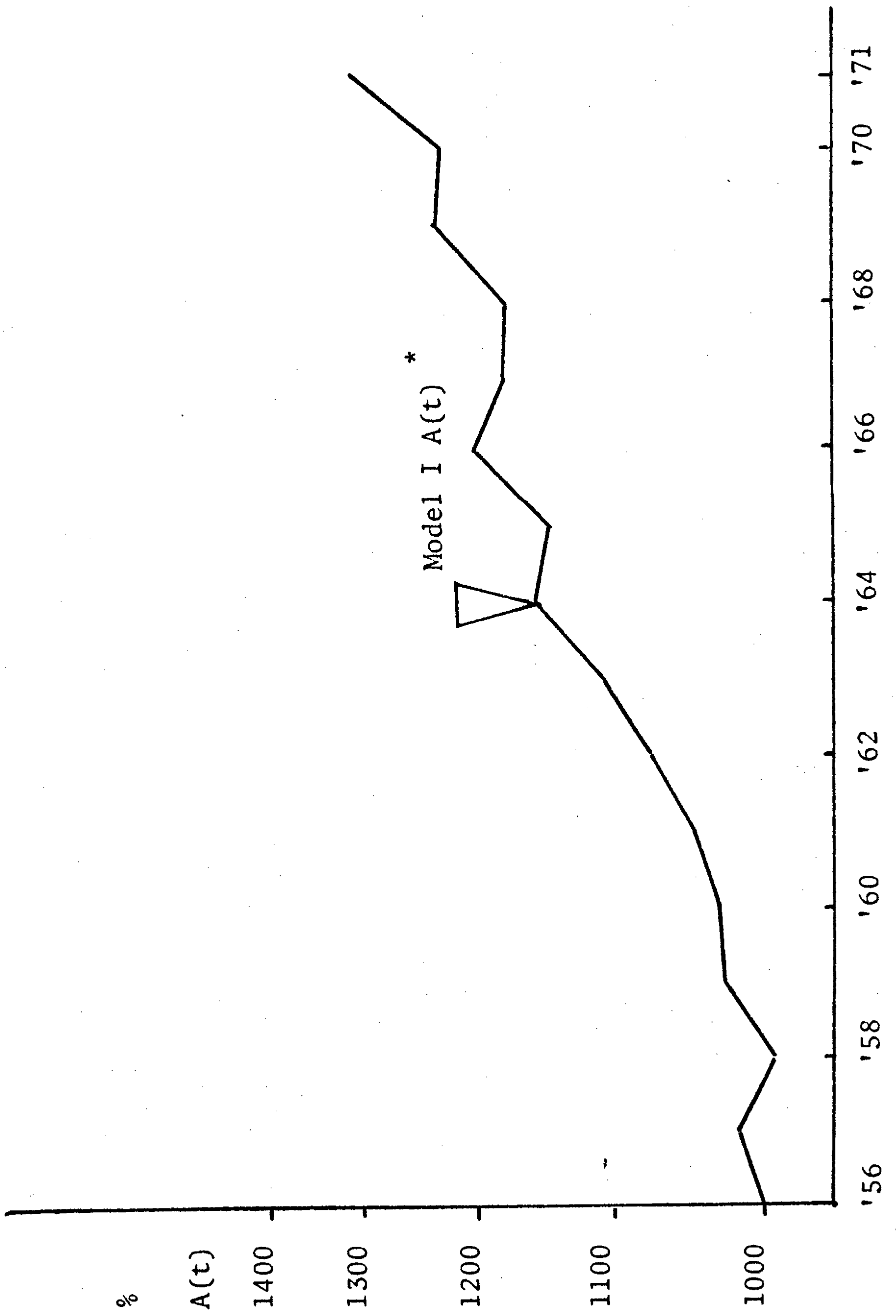
where $\ell n A = at + \ell n u + \text{constant}$

$$A(t) = KoUt\,\ell^{at} \qquad (2.21)$$

where ℓn,Ut is the observed residual in the estimate of model I and Ko is a scaling factor. The resultant growth in technical change in model I is presented in Figure 7.2.

FIGURE 7.2

INDEX OF TECHNICAL CHANGE (1)



* Based on the equation (2.21)

Sources: Data from model I and Appendix A15

Although the underlying trend shows an upward shift, it can be seen that the index of technical change over time is also characterized by short-term fluctuation of total farm output due to variable weather conditions as mentioned in Chapter 3. The general trend, however, is one source of the annual rate of growth in total farm output. Namely that which occurs as a result of improvement in efficiency of resource use in farming.

As mentioned in Chapter 2, the rate of technical change is measured as a residual term. Thus, the magnitude of the technical change reflects the influence of all factors other than changes in explicitly included inputs. In particular, no account is taken of changes in the quality of factors such as farmer's skill and knowledge and the proportion of irrigated land.

In other words, the rate of technical change as measured in model I is a biased estimate. In an attempt to reduce the biased rate of technical change, models involving quality adjustment of factor inputs are introduced in the following section.

Technical change in model IV

As described in part I of Chapter 7, model IV includes land input adjusted for changes in land use, labour input adjusted for changes in educational quality of the labour force, and other input as in model 1. As shown in the statistical specifications in part I of Chapter 7, this model explained the data of all the regression models. These adjusted land and labour inputs are described in detail in Chapters 4 and 5, but are summarised briefly in this section.

During the period of this study, the land use pattern has been reorganized by rapid urbanization and the increase in number of farm households (Chapter 4). Moreover, some of the farm land used for farm production has been abosrbed into the non-farm sector as the economy has developed since 1962. The upland reclamation project has therefore been instituted to replace land absorbed into the non-farm sector. Therefore the increased land input is based on the expansion of the infertile newly developed upland. The quality of land input is relatively less than the increase in land input, because the quality of the new upland is poorer than that of the paddy fields and the upland already cultivated. Thus relative earnings of the newly developed upland are lower than those of paddy field and upland already cultivated. In addition, relative earnings of the old upland is also lower than that of paddy fields. These structural changes in the pattern of land use have caused the quality of land input to decrease relatively, despite the increase in absolute land input (Chapter 4, and Table 7.7).

TABLE 7.7

INDICES OF ADJUSTED FACTOR INPUTS, AND TOTAL FARM OUTPUT, SELECTED YEARS, 1956 to 1971, BASED ON 1956 = 100

Year	Total farm output	Land			Labour			Other input		
		MI	MIV	MV	MI	MIV	MV	MI	MIV	MV
					(per cent)					
1959	104.8	94.2	91.6	92.1	97.9	98.7	99.7		131.1	
1964	127.4	100.3	97.4	98.9	89.4	98.7	98.7		165.1	
1968	127.9	110.2	105.4	107.7	79.5	88.4	88.4		190.1	
1971	157.3	109.8	104.4	108.9	77.3	88.6	88.6		244.3	
1956/ 1971	3.18	.69	.51	.59	-1.62	-.71	-.71		6.32	

Source: Data from models I , IV and V. (Appendix A13 and Appendix A14).

On the other hand, the continuing decrease in hired labour input due to outmigration from the farm sector has caused idle family labour forces to be employed, especially since 1964. It has resulted in the participation of educated younger family labour and other family labour which was not actively employed in farming, particularly in large scale farms. This family labour force is believed to be better educated than the hired labour (Chapter 5). Moreover, the structural changes in labour input in farming have resulted in an improvement in qualtiy of the labour input, even though the absolute labour hours employed in farming have continued to decrease (Chapter 5, and labour input in model IV in Table 7.7).

The labour input adjusted for educational quality in model IV has decreased much less rapidly than the natural labour units of model I. As a comparison, where the adjusted land input increased at an annual rate 0.51 per cent less than that of the physical land input in model I, the adjusted labour input declined at 0.71 per cent, a much smaller rate of decrease than the decrease in absolute labour input given by model I.

TABLE 7.8

SOURCES OF GROWTH IN TOTAL FARM OUTPUT AND AVERAGE ANNUAL RATE OF CHANGE IN FACTOR INPUTS AND OUTPUT

Models	Average annual rate of change in			Total[c] factor inputs	Technical change	Total farm output
	Land	Labour	Other input			
	(per cent)			(per cent)		
I [a]	.3028 (9.5)	-.5497 (.17.3)	1.4018 (44.1)	1.45 (45.6)	1.73 (54.4)	3.18 (100.0)
IV [b]	.2399 (7.5)	-.2286 (.7.2)	1.3127 (41.3)	1.59 (50.0)	1.59 (50.0)	3.18 (100.0)
V[b]	.2759 (8.7)	-.2388 (-7.5)	1.2387 (39.0)	1.64 (51.6)	1.54 (48.4)	3.18 (100.0)

<u>Notes</u>: a. See Table 7.6.

b. Following the same method derived from equation (2.18) to (2.19) and (2.20) in model I,

Model IV,

$$\dot{A}/A = \dot{Q}/Q = [.4703\ \dot{S}/S + .3220\ \dot{L}/L + .2077\ \dot{C}/C]$$

Substituting the observed average annual growth rate of each factor of Table 7.8 into this equation,

$$\dot{A}/A = 3.18 - [.4703\ (.51) + .3220\ (-.71) + .2077\ (6.32]$$
$$= 3.18 - [.2399 - .2286 + 1.3127]$$
$$\therefore \dot{A}/A = 1.86$$

$= a + \rho U_t$

Thus, $\dot{A}/A = 1.59 + .27\ U_t$ where a is the estimated coefficient of time in model IV. i.e., a = 1.59

ρ is coefficient of error factor from equation (2.20).

Model V,

$$\dot{A}/A = \dot{Q}/Q - [.4676\ \dot{K}/K + .3364\ \dot{L}/L + .1960\ \dot{C}/C]$$

$$= 3.18 - [.4676\ (.59) + .3364\ (-.71) + .1960\ (6.32)]$$

$$= 3.18 - [.2759 - .2388 + 1.2387]$$

$$\dot{A}/A = 1.90$$

In the same way as the equation (2.20),

$\dot{A}/A = 1.54 + .36\ U_t$ where a = 1.54 is the estimated coefficient of time in model V. U_t is error factor.

c. In order to get percentage shares of total farm output:

$$\dot{I}/I = \alpha_4 \dot{S}/S + \beta_4\ \dot{L}/L + \gamma_4\ \dot{C}/C + U_{4_t} \qquad \text{(Model IV)}$$

$$\dot{I}/I = \alpha_5\ \dot{K}/K + \beta_5\ \dot{L}/L + \gamma_5\ \dot{C}/C + U_{5_t} \qquad \text{Model V)}$$

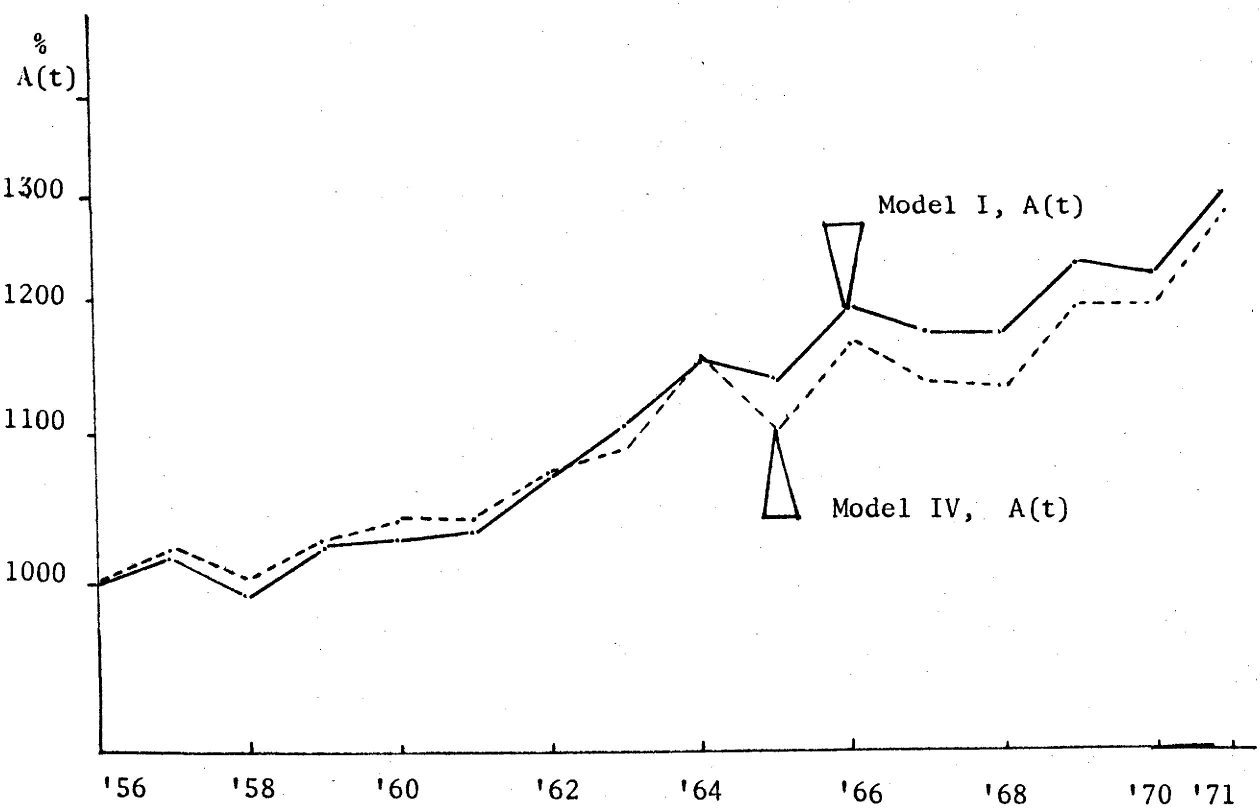
Figures in parentheses are percentages of the contribution of the factor inputs and the technical change to the increased total farm output.

Applying these adjusted factor inputs to model IV the results derived indicate that the sources of the increased total farm output (3.18 per cent) are based on the effect of the increased other input (41.3 per cent) and the increased land input (7.5 per cent). But their contribution to the growth in total farm output is much less in model IV than in model I. On the other hand, the adjusted labour input in model IV makes greater contribution to the increased total farm output than that of model 1. That is to say, the adjusted labour input shows an adverse effect of 7.2 per cent on growth in total farm output, but its effect is much less adverse than the 17.3 per cent given by model 1 (Table 7.8).

This improvement in the adjusted labour input causes an increase in the effect of total factor inputs on growth in total farm output, despite the relative decrease in factor shares of land and other input, and a decrease in magnitude of technical change from 1.73 per cent to 1.59 per cent, compared with model 1. As a result, in model IV, about 50 per cent of the growth in total farm output is attributable both to the total factor input and to technical change. However, this quality adjustment of land and labour input in model IV reduced the magnitude of technical change in model I. These effects are shown in Table 7.8 and Figure 7.3

FIGURE 7.3

INDEX OF TECHNICAL CHANGE (2)



Source: Appendix A15

Nature of technical change and its sources

In this section, an attempt is made to determine the sources of technical change.

As shown in Table 7.2 of Chapter 7, the rate of technical change in model V is much lower than in any other model, even though model V explains the data at a lower level of significance than model IV.

Therefore, after analyzing the rate of technical change in model V we examine some facts about technical change.

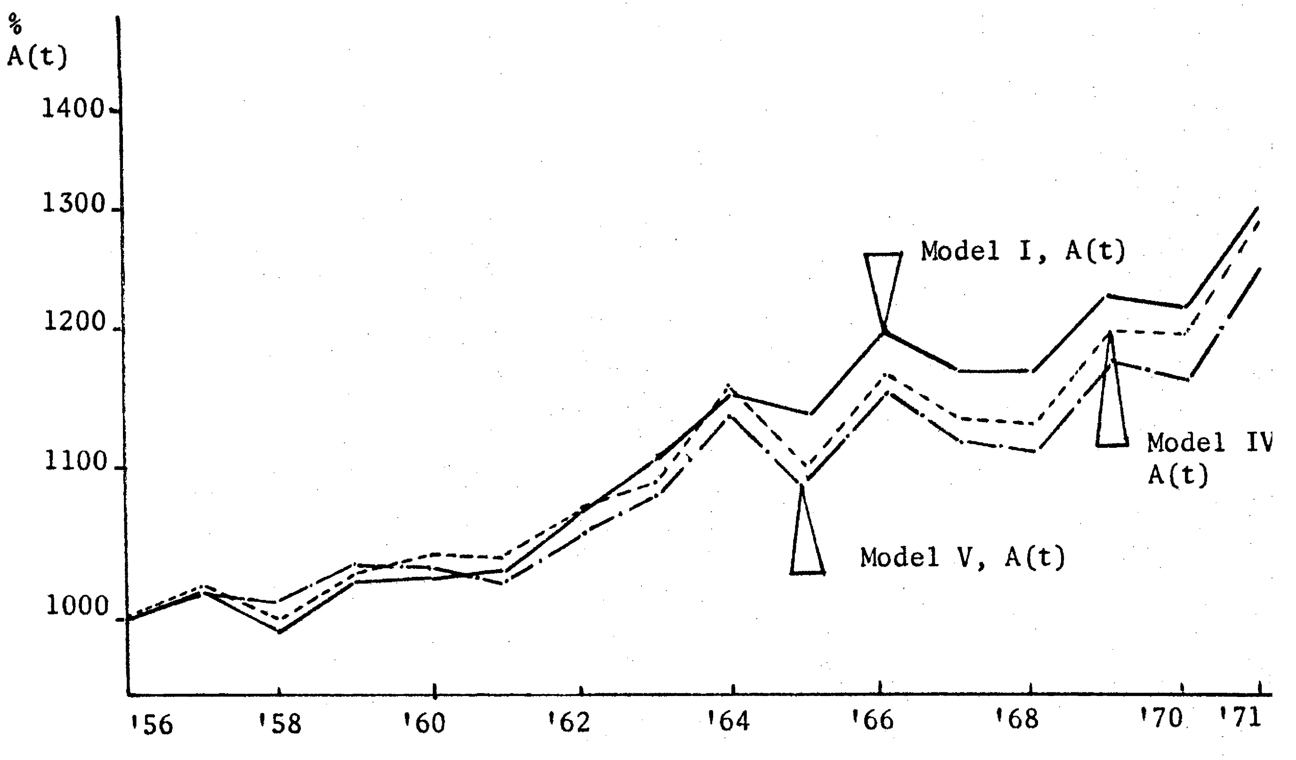
The factors included in model V are a land input adjusted for irrigated land input, an adjusted labour input and other input as in model V (Table 7.1). The average annual growth rates of factor inputs of model V are shown in Table 7.8. It is evident from model V that the improvement in irrigated paddy field produces a small increase in the adjusted land input, resulting in an increase in the relative share of land input in the increased total farm output. Moreover, its improvement also marginally increases the relative factor share of other input in total farm output, while the effect of the adjusted labour input on the increased total farm output decreased slightly (Table 7.8). Thus, apart from the technical change, the contribution of adjusted land input and other input to the growth in total farm output is increased, compared with model IV.

As a result of the average annual growth rate of total farm output (3.18 per cent), about 51.6 per cent (1.64 of 3.18) is attributable to the effect of the total factor inputs and the remaining 48.4 per cent (1.54 of 3.18) is due to the effect of technical change (Table 7.8). This suggests that expansion of irrigated paddy field is primarily an output augmenting technical change, whereas changes in pattern of land use are more properly a quality correction.

The magnitude of technical change in model V is lower than in model IV. This trend in technical change in model V is presented in Figure 7.4, along with models I and IV.

FIGURE 7.4

INDEX OF TECHNICAL CHANGE (3)



Source: Appendix A15.

From these empirical results it is evident that some of the reduction in technical change is based on the adjustment for quality of irrigated land input and quality of labour input.

Thus the amount of the reduction in technical change between model I and IV and V can be explained as an effect of factor input quality, and the remainder in model IV or V as an unexplained effect, i.e., as the magnitude of technical change.

In order to understand the sources of the reduction of technical change and to determine the contributions of factor quality changes to the reduction in technical change, the rates of technical change derived from the five models, in Table 7.2 of this chapter are examined.

The changes in the rates between models are shown in Figure 7.5 based on the Table 7.9.

TABLE 7.9

COMPARISON OF RATES OF TECHNICAL CHANGE

Models	Change in rate of technical change				
	I	II	III	IV	V
I ↓ →	0	.0031	.0025	-.0014	-.0019[a]
II		0	-.0006	-.0045	-.0050 (.0019)
III			0	-.0039	-.0044 (.0013)
IV				0	-.0005[a]
V					0

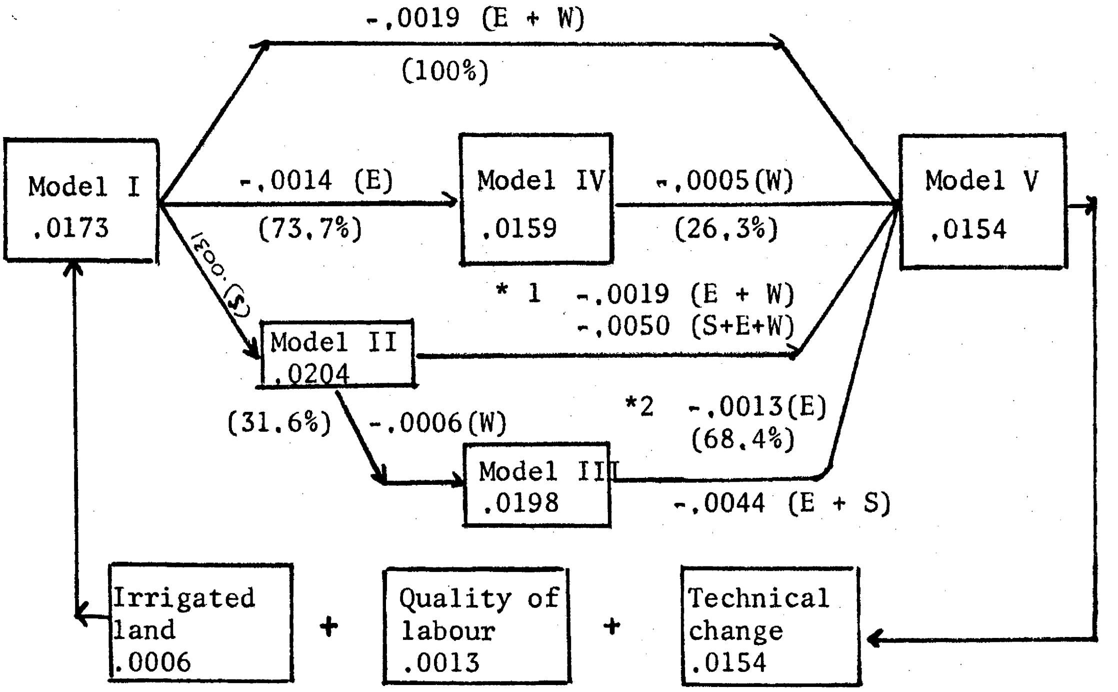
Source: Table 7.2.

Note: a. Main rates embodied in technical change.

The figures in parentheses indicate effect embodied in technical changes after quality correction of land input.

FIGURE 7.5

FLOW CHART OF PROCESSES IN TECHNICAL CHANGE



Notes: a. * Figures indicate of inclusion in technical change after making a correction for quality in land input,
i.e. 1. (S+E+W) - S = .0019
2. (E+S) - S = .0013

b. Percentages in parentheses are the effect of embodiment in factor inputs.

c. E = quality of labour input
W = irrigated land input
S = structural changes in pattern of land use.

Figures in squares indicate the rate of technical change in model I, model IV and Model V.

Source: From Table 7.2 in Chapter 7.

Figures 7.5 and Table 7.9 show that the reduction in technical change from model I to model V is about 11 per cent (.0019 of .0173). Of the reduction in technical change, about 68.4 per cent is attributable to the effect of improvement in qualtiy of labour input, and the remaining 31.6 per cent to the effect of improved irrigated land. It should be noted that there are slight differences in rates of factors augmenting technical change along the different paths in Figures 7.5 between model 1 and model V. These differences are the result of estimated error.

However, the unexplained residual rate of technical change amounts to 1.54 per cent per annum as a source of growth in total farm output. Thus the apparent technical change in model I is composed of 3.5 per cent of the expansion in irrigated land input (.0006 of .0173) and 7.5 per cent of the improvement in quality of labour input (.0013 of .0173). The remaining 89 per cent (.0154 of .0173) is a truly unexplained residual rate of technical change.

Technical change and partial productivity

The rate of technical change in model I and IV is measured as changes in total farm output per unit of total factor input of land, labour and other input, when total factor input is a weighted combination.

Partial productivity is measured as average land productivity (Q/R), average labour productivity (Q/N), and average productivity of other input (Q/C).

Labour productivity in Korean farming is a criterion in allocating farm resources in the selection of crops and the pattern of the cropping system, taking into consideration the existence of peak and idle seasons for labour. Moreover, growth in labour productivity can be described as a contribution to overall economic growth, because labour input saved in the growth of total farm output can be employed in the non-farm sector and other farming such as the processing of by-products (Bu-up).

From this point of view, an index of labour productivity can be used as an indicator of agricultural progress and as an index of efficient farm resource use.

In this section, an attempt is made to analyze the relationship between partial productivity of factor inputs and technical change.

The main emphasis is focussed on the analysis of factors determining labour productivity. First of all, in order to understand the relation between partial productivity of factor inputs, the time paths of partial productivity of the various factor inputs are examined.

Figure 7.6 shows that when the rate of technical change in model I increased with a time trend, labour productivity increased faster than any other productivity, especially since around 1963. On the other hand, land productivity increased slowly, while the productivity of other input continued to decrease.

The continuing decrease in productivity of other input is mainly due to the intensity of use of other input to improve infertile land and to substitute for the decreased labour input, resulting in a much faster increase in other input than in total farm output (Table 7.10).

TABLE 7.10

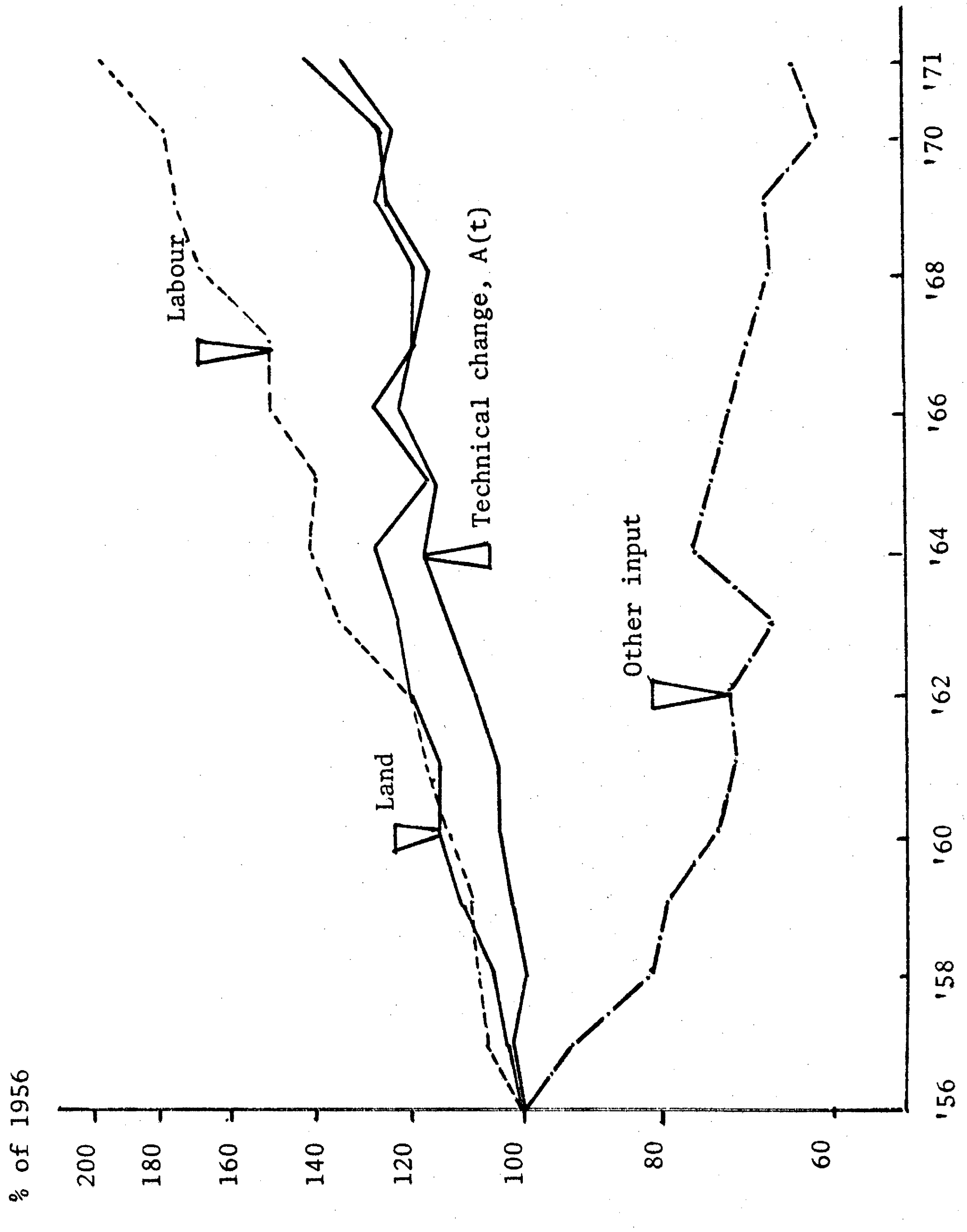
INTENSITY OF OTHER INPUT PER UNIT OF LAND AND LABOUR, SELECTED YEARS, 1956 TO 1971, PER CENT

Year	Total farm output	Intensity of other input per			Other input
		Land	Labour	Other input	
	(Q)	(C/R)	(C/N)	(C/Q)	(C)
1958	107.1	129.1	114.8	122.4	131.1
1962	118.9	167.5	167.0	138.5	164.7
1964	127.4	164.5	184.6	129.6	165.1
1966	132.2	173.3	208.2	137.2	181.4
1969	138.3	184.8	260.9	146.9	203.2
1971	157.3	222.4	315.6	155.3	244.3

Sources: Data from model and based on the Appendix A13.

FIGURE 7.6

INDICES OF PARTIAL PRODUCTIVITY AND TECHNICAL CHANGE, A(t)
1956 to 1971



Source: Appendix A16 and model I.

In particular, since around 1963, 'Other Input', involving chemical fertilizers, pesticides and farm machinery, has increasingly been employed in farming, for the improvement of infertile newly developed upland and to substitute for the absolute decrease in labour input due to outmigration from the farm sector (Table 4.7, Table 5.3, Table 6.3 and Table 6.6). Thus, the intensive use of 'Other Input' has been substituted for primary inputs such as land and labour inputs. Hence an increase in labour productivity has occurred, together with an improvement in land productivity, while the productivity of 'Other Input' continues to decrease as mentioned above.

Factors affecting labour productivity

From the analysis of factor productivity in model I it is evident that the rapid growth in labour productivity has been based on the intensive use of 'Other Input' to substitute for the absolute decrease in labour input. This fact might suggest that the continuing decrease in labour input caused a reallocation of farm resource use, mainly because the total farm output increased. However, for more detailed analysis of the increased labour productivity, a model VI is derived from model IV.

From the model IV, $Q/S = A(L/S)^{\alpha} (C/S)^{\beta} e^{at} U_t$, or

$$Q = AS^{1-\alpha-\beta} L^{\alpha} C^{\beta} e^{at} U_t,$$

the following form is obtained, $Q/N = A(S/N)^{1-\alpha} (C/S)^{\beta} E^{\alpha} e^{at} U_t$

or in logarithmic form, $\log (Q/N) = \log A + (1-\alpha) \log (S/N) + \beta \log (C/S)$

$$+ \alpha \log E + e^{at} + U_t \qquad \text{(Model VI)}$$

where L = E * N = labour in efficiency units

S/N = ratio of land to labour input

C/S = ratio of other input per land input

E = quality of labour input

a = rate of technical change over time

t = time

U_t = error term

The factor shares of various inputs are dervied from the model IV.

It should be noted that the coefficient of quality (E) in labour input is not significantly different from the coefficient of the natural unit of labour input (N), when the regression model IV is estimated using N and E as separate variables. Therefore both coefficients have been constrained to equality. This approach is based on the work of Griliches, Z. (1970, pp. 81-82).

Applying the data of Table 7.11 to model VI, the effects of contribution of the various components to the growth in labour productivity are measured in Table 7.11. The trends in components are presented in Figure 7.7

It is evident from Table 7.11 that for the period 1956-1971, the growth in labour productivity is attributable to the increase in the ratio of land to labour input (46.4 per cent), intensity of Other Input to land input (23.9 per cent) and an error term (.8 per cent). This suggests that over 52.8 per cent of the growth in labour productivity is based on the relative increase in other input being substituted for land and labour, and on factors augmenting technical change. On the other hand, 46.4 per cent of it occurred as a result of the continuing decrease in labour input relative to land input.

TABLE 7.11

COMPONENTS OF LABOUR PRODUCTIVITY CHANGE, 1956 to 1971, SELECTED YEARS, 1956 = 100

Year	Labour productivity (Q/N)	Ratio of land to labour (S/N)	Intensity of other input per land (C/S)	Quality of labour (E)	Technical change[a] (A(t))	
		(per cent)				
1958	106.7	100.0	130.7	102.0	103.2	
1962	120.6	97.7	171.3	109.3	109.6	
1964	142.6	108.8	169.8	110.5	112.8	
1971	203.3	139.3	234.7	114.6	123.9	
		Growth rate of components (%)				
1956/1971	2.033	1.393	2.347	1.146	1.239	
		Relative shares of growth in labour productivity[b]				
1956/1971	(100) 2.033	(46.4) .944	(23.9) .486	(18.2) .369	(10.7) .218	(.8) .016 U_t

<u>Source</u>: Data of model IV and Appendix A17.

<u>Notes</u>: a. $A(t) = (1 + a)^t$

b. Based on Model VI:

$$Q/N = A(S/N)^{.6780} (C/S)^{.2077} (E)^{.3220} e^{.0159t} U_t$$

then, $2.033 = .6780 (1.393) + .2077 (2.347) + 3220 (1.146) + .218 + .016 U_t$

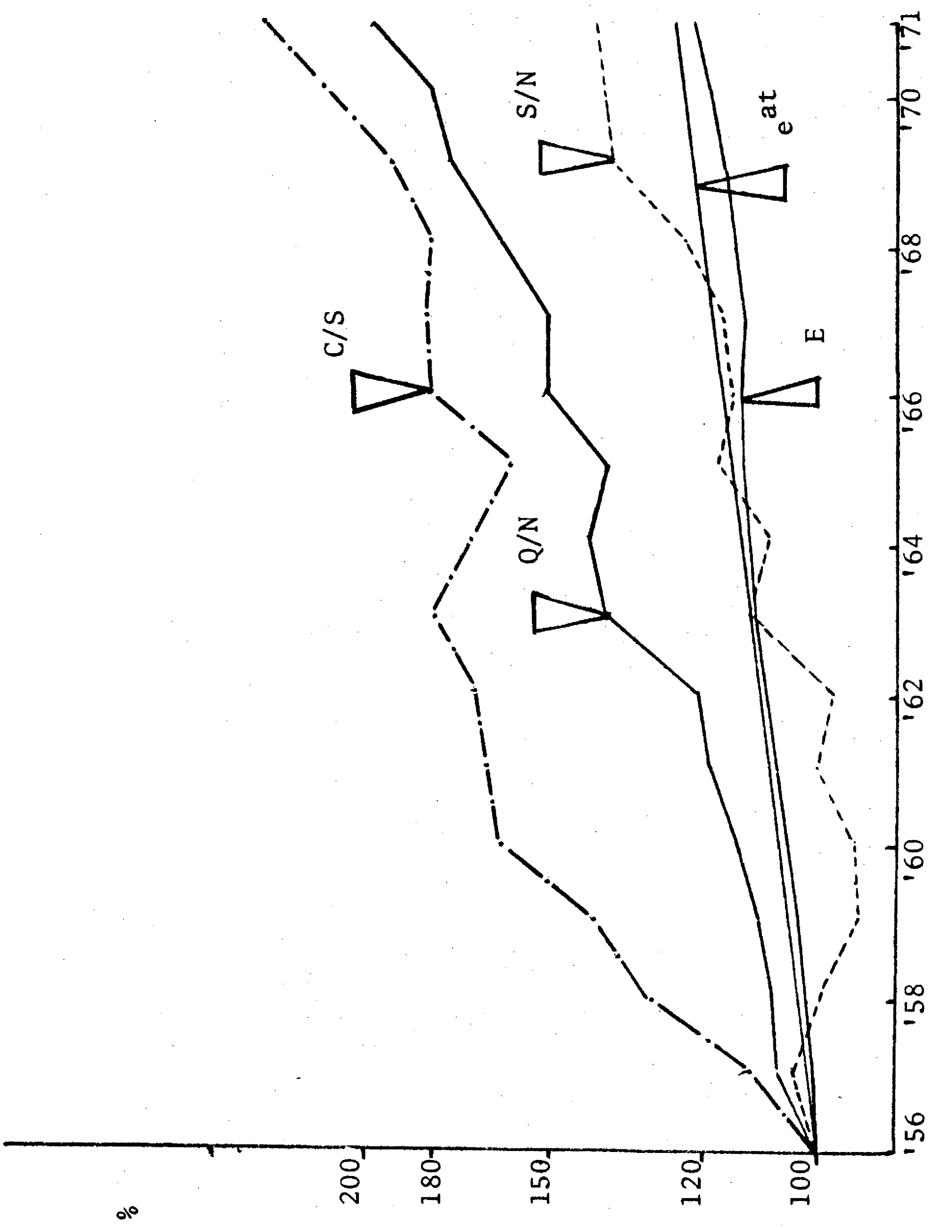
Hence: $2.033 = .944 + .486 + .369 + .218 + .016 U_t$

2.033	.944	.486	.369	.218	.016 U_t
↓	↓	↓	↓	↓	↓
(100)	(46.4)	(23.9)	(18.1)	(10.7)	(.8)

Model VI is derived from model IV.

FIGURE 7.7

COMPONENTS OF LABOUR PRODUCTIVITY *



* Based on the model IV.

Q/N = labour productivity: C/S = intensity of other input per land: S/N = ratio of land to labour: e^{at} = rate of technical change.

Thus, the continuing decrease in labour input, without decreasing total farm output, causes the growth in labour productivity to accelerate. This is because the decreased labour input is substituted by the other input and by improvement in quality of labour input, along with the contribution of technical change. Thus the main sources of increasing labour productivity are based on the improvement in efficiency of labour input through the intensive use of other input and quality improvement in labour input, along with technical change.

CHAPTER 8

SUMMARY AND CONCLUSIONS

During the whole period of this study (1956-1971) total farm output has increased at an average annual rate of 3.18 per cent. This increased total farm output is based on food crops production, but the relative share of food crops in total farm output decreased slightly from 84.3 per cent in 1956 to 78.0 per cent in 1971 (Table 3.5). This decrease in relative share of food crops is due to the fact that as the Korean economy develops, non-food crops with their relatively high income elasticities, and the special crops and sericulture suitable to the newly developed upland increase much faster than the food crops (Table 3.5). But not much change has occurred overall in the composition of total farm output. On the other hand, the increased total farm output showed irregular short-term fluctuations influenced by climatic conditions (Figure 3.1).

The most significant changes in factor inputs used for this increased total farm output are as follows:

a. The expansion of irrigated paddy field and the relative downgrading of the quality of total land input due to the relative increase in share of upland in total land input (Chapter 4).

b. The large decrease in absolute farm labour hours employed in farming and the improvement in quality of labour input through schooling (Chapter 5).

c. Intensive applications of chemical fertilizers and pesticides and more use of farm machinery and implements (Chapter 6).

These significant changes in farm resource use are caused by various socio-economic factors, but from the macro point of view of the Korean economy, it is clear that they have been brought about by the growth in the non-farm sector.

First of all, farm land supplied for farm production has been increasingly used for the objectives of the non-farm sector with urbanization and industrialization, especially since 1962. This change in the land use pattern caused a decrease in farm land input, and in particular, a decrease in fertile land input. This resulted in the land development projects such as upland reclamation and expansion, improvement of irrigation and water resource development. Although farm land increased slightly through the substitution of infertile upland for fertile land absorbed by urbanization, the relative quality of total land input was slightly downgraded, despite the continuing upgrading in paddy fields through the expansion of irrigated land input (Chapter 4).

Another important event influenced by the non-farm sector is that the large increase in farm supplies and equipment through the expansion of domestic manufacturing has resulted in the intensive use of chemical fertilizers and pesticides, farm machinery and implements in farming, especially since around 1962 (Chapter 6).

This intensive use of farm supplies and equipment has closely coincided with the absolute decrease in farm labour input through outmigration from the farm sector, due to the increase in employment in the non-farm sector (Chapter 5). Increased chemical input has also been closely related to the upland reclamation.

From the observed changes in farm resource use, it is evident that intensive use of other inputs has been substituted for primary land input to improve infertile land, and for the decreasing labour input so as to improve the efficiency of labour use. On the other hand, a continuous absolute decrease in farm labour input has caused the structure of farm labour inputs to change, i.e. to more intensive family labour farming, especially with the greater participation of new and better educated younger labour. This has resulted in the improvement in quality of the labour input (Chapter 5).

From the point of view of the growth in total farm output at an average annual rate of 3.18 per cent, the observed changes in farm resource use support the hypotheses of Chapter 2. That is, hitherto idle farm resources such as newly developed upland and the greater participation of surplus family labour can be utilized to increase total farm output, and new and increased use of farm supplies and equipment can increase total farm output. MOreover, the improved land input through the expansion of irrigated paddy field and the improvement in the quality of labour input through the participation of younger and better educated family labour can contribute to increasing total farm output.

However, these improvements in factor inputs and reallocation of farm resource use for farm production contributed not only to the increase in total farm output, but also to its resulting in the creation of technical change to accelerate growth in total farm output (Chapter 7).

The contributions of these various factor inputs to the increased total farm output are calculated using the relative shares of factor inputs estimated from aggregate production function models I to V, and the unexplained residual from models I to V is described as the rate of technical change (Tables 7.6, 7.8, and Figure 7.5).

Model I is characterized by three physical factor inputs; land, labour and other input, with a time trend, while model IV and model V also include quality adjustments to land and labour input based on model I (Table 7.1). That is, models IV and V allow for factor augmenting effects, such as irrigated land input and quality of labour input through the education of labour force.

From the observed results of model I, of the average annual rate of 3.18 per cent in growth of total farm output, 45.6 per cent (1.45 of 3.18) was caused by the effect of the increased total factor input, and the remaining 54.4 per cent (1.73 of 3.18) by the effect of technical change (Table 7.6).

The nature of this technical change as an important source of growth in total farm output is observed by looking at the factor augmenting effects, based on the rate of technical change derived from models I and V. The rate of technical change between model I and V is reduced by about 11 per cent (.19 of 1.73 per cent). This proportion can be accounted for by changes in factor quality. The remaining 89 per cent (1.54 of 1.73 per cent) is an unexplained technical change. Of this reduction in technical change between model I and V about 7.5 per cent is caused by the improvement in quality of labour input and 3.5 per cent is caused by the increase in irrigated land input (Figure 7.5).

Consequently, from the observed results of model V, it is concluded that about 51.6 per cent of the growth in total farm output is caused by the increased total factor input and the remaining 48.4 per cent of growth in total farm output by the apparent technical change. Apart from technical change, sources behind the growth in total farm output are based on the intensive use of 'Other Input' (39 per cent) and the increase in land input (8.7 per cent), along with the factor augmenting effects (11.4 per cent). On the other hand the decreased labour input resulted in the adverse effect of 7.5 per cent on the growth in total farm output (Table 7.8 and Figure 7.5). In addition, the unexplained technical change is supposed to be attributable to the climatic conditions and a disembodied technical change as an output augmenting effect.

The most significant growth in farm resource productivity has been in labour productivity, compared with the slight increase in land productivity and the continuing decrease in productivity of other input (Figure 7.6). This rapid growth in labour productivity is evident from the continuing decrease in labour input and the continuing increase in total farm output.

The sources of this growth in labour productivity are related to the improvement in efficiency of labour use through the relative increase in land input to the absolute decrease in labour input (46.4 per cent); through the land saving technological change due to the intensive use of other input (23.9 per cent); and through the improvement in quality of labour input due to the increase in educated younger labour input (18.2 per cent); and by the technical change (10.7 per cent) as a source of growth in total farm output (Table 7.11). In addition there has been considerable substitution of other input for labour input. This growth in labour productivity may provide an economic incentive for the farmer to maintain higher total farm output.

In conclusion, some policy implications can be drawn from the empirical results of this study. It is evident that under the existing small scale farming and continually decreasing farm labour input, further increase in total farm output can only be achieved through technical change and increased application of farm supplies such as chemical fertilizers and pesticides, together with more use of farm machinery and implements, so as to substitute these non-farm inputs for primary land and labour input.

The technical change as an important source of growth in total farm output will be accelerated by the improvement in irrigated paddy field, and by the development of farmers' knowledge and skill through education, especially extension education for the younger labour forces and education in research techniques for old farmers.

On the other hand, further increase in total farm output can be achieved by the improvement of the relatively slow increase in land productivity because ultimately total farm output is based on the farm land. This improvement in land productivity can be achieved by the more intensive use of technical non-farm inputs so as to improve infertile land, and by increasing land capacity through more irrigation.

It is thus indicated that the more intensive use of technical non-farm inputs in farming should be achieved through expanding supply, by further developing the domestic manufacturing plants.

Further development of farmers' knowledge and skill can be achieved through a productive and practical system of farmer education. Further expansion of irrigated land can be achieved by means of the water resource development projects, and long-run private and public capital investment.

No attempt is made in this study to formulate a precise policy, but its implications are principally governmental policy rather than for policy at individual farm level.

However, given the sources of past growth in total farm output indicated by this study it would be expected that a logical policy for the further expansion of farm output should consider the following:

1. Ensure the ready supply of improved fertilizers and farm machinery at competitive prices to allow the continued improvement of infertile land and land productivity, and the inprovement in the efficiency of labour use.
2. Formulation of an appropriate policy for development of farmer's knowledge and skill through an unified system of agricultural school, farm research and extension organization.
3. Encouragement of research in the uplands to improve the relatively slow increase in land productivity and in the possible economic expansion of water resource development so as to accelerate the

continuing increase in the irrigated area and improve the timeliness of irrigation.

4. Encouragement of further research into the suitability of developing new arable land in hilly forest areas in order to further increase total farm output and allow the further diversification of farming systems in these upland areas.

5. Formulation of a unified economic policy for the farm and non-farm sectors. The growth rate of total farm output could probably be accelerated if the farm sector and non-farm sector were to be brought under a unified policy to regulate the allocation of labour input and non-farm inputs between sectors so that the opportunity costs of each factor of production in both sectors are equal.

Finally, some implications for further economic research to get more rigorous empirical conclusions can be drawn from the empirical results of this study.

The implication of our finding, that a large part of the rate of technical change as the main source of past growth in total farm output remains an unexplained residual, is that further work must be done. This residual was described as an output augmenting effect or a disembodied technical change.

In early studies of the western economy, economists formed a large residual factor, which they identified with technical change.

In the recent work of Jorgenson and Griliches (1967), they introduced quality changes in factor inputs to explain the nature of technical change and reduced the residual factor practically to zero as measured in the United States economy. Therefore they concluded that the technical change was mainly due to the improvement in quality of factor inputs.

There have been various attempts in this study to reduce the residual to zero for the Korean agricultural sector. Quality adjustments of factor inputs such as land and labour are applied in this study to explain apparent technical change, but we find that the residual factor is not reduced to any great extent. It resulted in the similar conclusion of the early studies of the western economy. Thus, the results in this study are quite different from those in the conclusion of Jorgenson and Griliches for the United States economy.

This implication indicates that the specific Cobb-Douglas production function form used in this study may not adequately describe the production process in Korean agriculture, and may not fully take account of the characteristics of the Korean agriculture. It suggests that the empirical models of the western economy are not adequately applied to the Korean agriculture.

However, there are a number of possibilities which need to be investigated in such future research. These include:

a. Different weights could be used in adjusting factor inputs for quality change.

b. Additional factors may have to be incorporated, e.g. extension work, type of seed.

c. Adjustment of factor inputs ought to be made for effect of weather. That is, a part of inputs such as harvest labour and farm inputs depends on output rather than output depending on these inputs.

d. Errors of aggregation may be causing biases in the estimated coefficients. That is, disaggregation by crops and disaggregation of output and inputs by regions and farm size may provide more acceptable results.

Finally, from the results of the empirical research about the econometric studies of production function in Korean agriculture, it is obvious that further research ought to be studied for a suitable model and method that fully takes account of the characteristics of the Korean agricultural setting.

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APPENDIX A

SUPPLEMENTARY TABLES

Appendix A1 - A4 and A18	:	Data of Total Farm Output.
Appendix A5 - A12	:	Data of Factor Inputs (Land, Labour, Other Inputs).
Appendix A13 - A17	:	Data of Regression Models and Partial Productivity.

APPENDIX A1

INDICES OF TOTAL FARM OUTPUT FOR THE BASE YEAR

	1956 = 100 as the base of			
Year	1964 - 1966 = 100		1959 - 1961 = 100	
	Won	%	Won	%
1956	98,114	100.0	40,065	100.0
1957	104,037	106.0	42,509	106.1
1958	105,066	107.1	44,015	109.9
1959	102,796	104.8	42,849	107.0
1960	102,345	104.3	42,546	106.2
1961	110,112	112.2	45,854	114.4
1962	116,623	118.9	47,922	119.6
1963	119,030	121.3	48,832	121.9
1964	124,945	127.4	50,188	125.3
1965	120,834	123.2	49,310	123.1
1966	129,745	132.2	52,286	130.5
1967	126,040	128.5	49,546	123.7
1968	125,493	127.9	50,064	125.0
1969	135,727	138.3	55,165	137.7
1970	134,858	137.5	54,234	135.4
1971	154,297	157.3	60,138	150.1

Sources: Report on the Results of Farm Household Economic Survey and Production Cost of Agricultural Products, Bureau of Agricultural Research and Statistics, Ministry of Agriculture and Fisheries, Republic of Korea.

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APPENDIX A2

TRENDS IN TOTAL FARM OUTPUT AND FOODCROPS, 1956 = 100, BASED ON 1964-1966 PRICE WEIGHTS

Year	Total farm output		Food crops		Non-food crops	
	Value	Index	Value	Index	Value	Index
	Won	%	Won	%	Won	%
1956	98,114	100.0	82,683	100.0	15,431	100.0
1957	104,037	106.0	88,487	107.0	15,550	100.8
1958	105,066	107.1	88,979	107.6	16,087	104.3
1959	102,796	104.8	85,907	103.9	16,889	109.5
1960	102,345	104.3	85,042	102.9	17,303	112.1
1961	110,112	112.2	91,984	111.3	18,128	117.5
1962	116,623	118.9	97,189	117.5	19,434	125.9
1963	119,030	121.3	100,054	121.0	18,976	123.0
1964	124,945	127.4	105,894	128.1	19,051	123.5
1965	102,834	123.2	102,864	124.4	17,970	116.5
1966	129,745	132.2	110,501	133.6	19,244	124.7
1967	126,040	128.5	103,983	125.8	22.057	142.9
1968	125,493	127.9	101,170	122.4	24.323	157.6
1969	135,727	138.3	110,605	133.8	25.122	162.8
1970	134,585	137.5	109,081	131.9	25,777	167.1
1971	154,297	157.3	120,351	145.6	33,946	220.0

Sources: See Appendix A1

APPENDIX A3

TRENDS IN INDICES OF FOOD CROPS AND NON-FOOD CROPS, 1956 = 100, BASED ON THE 1964-1966 = 100 PRICE WEIGHTS

Year	Total food crops	Vege-tables & fruits	Live-stock, meat & poultry	Special crops	Seri-culture	Others	Total farm output
1957	107.02	91.48	86.73	99.93	104.26	126.59	106.0
1958	107.62	114.45	95.72	116.34	128.19	85.15	107.1
1959	103.90	111.49	119.71	214.33	109.58	60.09	104.8
1960	102.85	94.68	119.71	187.68	84.58	112.47	104.3
1961	111.25	124.41	163.31	160.82	77.66	62.17	112.2
1962	117.54	105.91	171.21	139.25	111.17	130.48	118.9
1963	121.01	97.03	168.08	170.06	144.68	128.40	121.3
1964	128.07	106.02	155.46	146.62	205.32	123.18	127.4
1965	124.41	82.54	117.96	279.24	206.92	112.47	123.2
1966	133.64	84.80	154.93	197.86	246.28	171.22	132.2
1967	125.76	133.98	135.22	193.91	268.08	139.14	128.5
1968	122.36	134.89	150.12	334.29	301.06	130.98	127.9
1969	133.77	156.88	161.12	261.62	605.85	116.78	138.3
1970	131.93	142.76	143.49	356.93	697.87	129.93	137.5
1971	145.56	164.67	201.34	490.49	1251.06	182.94	157.3

Sources: See Appendix A1

APPENDIX A4

RELATIVE IMPORTANCE OF CROPS AND NON-CROPS IN TOTAL FARM OUTPUT, 1956-1971, (Unit:Per cent)

Year	Total food crops	Vege-tables & fruits	Live-stock, meat & poultry	Special crops	Seri-culture	Others
1956	84.27	7.45	2.50	1.52	.19	4.07
1957	85.05	6.43	2.05	1.43	.19	4.85
1958	84.69	7.96	2.24	1.65	.23	3.23
1959	83.57	7.93	2.86	3.11	.20	2.33
1960	83.09	6.76	2.87	2.74	.16	4.38
1961	83.54	8.26	3.64	2.18	.13	2.25
1962	83.34	6.64	3.61	1.78	.18	4.45
1963	84.06	5.96	3.32	2.13	.23	4.30
1964	84.75	6.20	3.06	1.75	.31	3.93
1965	85.13	4.99	2.40	3.45	.32	3.71
1966	85.17	4.78	2.16	2.28	.36	5.25
1967	82.50	7.77	2.64	2.30	.40	4.39
1968	80.62	7.86	2.94	3.98	.45	4.15
1969	81.49	8.45	2.92	2.88	.84	3.42
1970	80.89	7.74	2.61	3.95	.97	3.84
1971	78.00	7.80	3.20	4.75	1.52	4.73

<u>Sources</u>: See Appendix A1.

APPENDIX A5

LAND IMPROVEMENT IN IRRIGATED LAND

Year	Irrigated land to total farm land		Irrigated land to paddy field		Irrigated land to paddy land	
			(per cent)			
1956	27.0	(100.0)[a]	45.3	(100.0)[a]	32.9	(100.0)[a]
1957	28.3	(104.8)	47.4	(104.6)	32.3	(98.2)
1958	28.6	(105.9)	48.0	(106.0)	33.3	(101.2)
1959	28.9	(107.6)	48.4	(106.8)	33.0	(100.3)
1960	29.5	(109.3)	49.5	(109.3)	33.1	(100.6)
1961	30.2	(111.9)	50.7	(111.9)	36.6	(111.2)
1962	31.1	(115.2)	52.4	(115.7)	38.1	(115.8)
1963	31.4	(116.3)	53.2	(117.4)	39.4	(119.8)
1964	31.8	(117.8)	54.7	(120.8)	42.6	(129.5)
1965	31.1	(115.2)	54.6	(120.5)	46.1	(140.1)
1966	31.9	(118.2)	56.8	(125.4)	45.9	(139.5)
1967	32.4	(120.0)	58.0	(128.0)	47.4	(144.1)
1968	31.5	(116.7)	56.7	(125.2)	49.3	(149.8)
1969	35.1	(130.0)	63.2	(139.5)	50.0	(152.0)
1970	40.1	(148.5)	70.9	(156.5)	50.0	(152.0)
1971	38.2	(141.5)	68.6	(151.4)	49.7	(151.1)
	Annual compounded growth rate (%)					
1956-1971	2.34		2.81		2.79	

Source: M.A.F. (2), 1957 to 1972.

Note: a. Indices of 1956 = 100.

APPENDIX A6

RELATIVE COMPOSITION OF PADDY FIELD AND UPLAND TO THE TOTAL FARM LAND AND INDEX OF QUALITY IN LAND

Year	Relative composition in		Quality	
	Paddy	Upland		
	(per cent)			
1956	66.4	33.6	220.36	(1.000)
1957	65.7	34.3	219.09	(.994)
1958	65.0	35.0	217.82	(.988)
1959	63.1	36.9	214.38	(.973)
1960	61.3	38.7	211.11	(.958)
1961	63.9	36.1	215.83	(.979)
1962	63.9	36.1	215.83	(.979)
1963	66.1	33.9	219.81	(.998)
1964	62.7	37.3	213.65	(.970)
1965	63.4	36.6	214.92	(.975)
1966	61.7	38.3	211.84	(.961)
1967	59.2	40.8	207.31	(.941)
1968	61.2	38.8	210.93	(.957)
1969	62.8	37.2	213.83	(.970)
1970	60.5	39.5	209.66	(.951)
1971	60.4	39.6	209.48	(.951)

Sources: M.A.F. (1), 1958 to 1973. N.A.C.F. (1), 1958 to 1972.

Note: a. Indices of 1956 = 100.

APPENDIX A7

RELATIVE COMPOSITIONS OF IRRIGATED LAND AND NON-IRRIGATED LAND TO PADDY FIELD AND ADJUSTED QUALITY IN PADDY FIELD TO TOTAL LAND INPUT

Year	Relative composition in: Irrigated land	Relative composition in: Non-irrigated land	Quality in paddy[a]	Adjusted quality[b] in paddy field to total land
	(per cent)			
1956	45.3	54.7	1.000	66.4
1957	47.4	52.6	1.005	66.0
1958	48.0	52.0	1.006	65.4
1959	48.4	51.6	1.007	63.5
1960	49.5	50.5	1.009	61.9
1961	50.7	49.3	1.012	64.7
1962	52.4	47.6	1.016	64.9
1963	53.2	46.8	1.018	67.3
1964	54.7	45.3	1.021	64.0
1965	54.6	45.4	1.021	64.7
1966	56.8	43.2	1.026	63.3
1967	58.0	42.0	1.029	60.9
1968	56.7	43.3	1.026	62.8
1969	63.2	36.8	1.041	65.4
1970	70.9	29.1	1.058	64.0
1971	68.6	31.4	1.053	63.6

<u>Sources</u>: M.A.F. (1), and (2), 1958 to 1973.

<u>Notes</u>: a. $q_t = a.\frac{D_{1t}}{P_t} + b.\frac{D_{2t}}{P_t}$ or $q_t = \frac{H_i D_{1t}}{P_t} + \frac{D_{2t}}{P_t}$

(Equation 4.6, then indices of 1956 = 1).

b. $q_t = \frac{P_t}{R_t}$ (Equation 4.8 of Chapter 4).

[$\frac{P_t}{R_t}$ in paddy column in Appendix A6]

APPENDIX A8

ADJUSTED LAND INPUT AND QUALITY OF LAND

Year	Land input	Adjusted land		Quality of land	
	(R_t)	(S_t)[a]	(K_t)[b]	(r_t)[c]	(Z_t)[d]
		(per cent)			
1956	100.0	100.0	100.0	1.000	1.000
1957	103.5	102.9	103.3	.994	.998
1958	101.5	100.3	100.8	.998	.993
1959	94.2	91.6	92.1	.973	.978
1960	90.6	86.8	87.5	.958	.966
1961	97.7	95.6	96.6	.979	.989
1962	98.4	96.3	97.6	.979	.992
1963	98.9	98.7	100.2	.998	1.013
1964	100.3	97.2	98.9	.970	.986
1965	105.8	103.2	105.0	.975	.992
1966	104.6	100.5	102.7	.961	.982
1967	107.5	101.1	103.5	.941	.963
1968	110.2	105.5	107.7	.957	.977
1969	109.9	106.6	110.3	.970	1.004
1970	109.0	105.4	108.6	.951	.996
1971	109.8	104.4	108.9	.951	.992

Source: See Appendix A6.

Notes: a. $S_t = R_t \cdot r_t$

b. $K_t = R_t \cdot Z_t$

c. See Appendix A6.

d. See Equation 4.8 in Chapter 4.

APPENDIX A9

TOTAL FARM LABOUR HOURS AND EFFICIENT LABOUR INPUT

Year	Labour input (N)	Quality of labour [a] (E)	Efficient labour input b (L)
		(per cent)	
1956	100.0	100.0	100.0
1957	99.4	101.0	100.4
1958	100.3	102.0	102.3
1959	97.0	102.8	99.7
1960	91.9	104.5	96.0
1961	95.2	106.8	101.7
1962	98.6	109.3	107.8
1963	87.6	109.7	96.1
1964	89.3	110.5	98.7
1965	88.1	111.2	98.0
1966	87.1	111.7	97.3
1967	85.1	112.1	95.4
1968	79.5	111.2	88.4
1969	77.8	111.8	87.0
1970	76.4	112.4	85.9
1971	77.3	114.6	88.6

Sources: M.A.F. (1) and (2), 1958 to 1972.
N.A.C.F. (1), 1958 to 1972.
B.O.K., 1957.
E.P.B., 1960.

Notes: a. and b. See Appendix A10 and A11.

L = N . E : N . b. column of Appendix A11.

APPENDIX A10

COMPOSITION OF THE FARM LABOUR FORCES BY SCHOOLING LEVELS, 1956-1971

Year	Labour force	Non-educated labour	Primary school	Higher education
		(per cent)		
1956	100.0	65.2	27.2	7.6
1957	100.0	63.0	28.8	8.2
1958	100.0	60.8	30.4	8.8
1959	100.0	59.0	31.8	9.2
1960	100.0	57.1	32.2	10.7
1961	100.0	48.0	40.9	11.1
1962	100.0	38.9	49.5	11.6
1963	100.0	38.3	49.7	12.0
1964	100.0	35.7	52.0	12.3
1965	100.0	35.0	52.1	12.9
1966	100.0	34.2	52.6	13.2
1967	100.0	34.5	52.3	13.2
1968	100.0	35.3	51.7	13.0
1969	100.0	35.0	51.2	13.8
1970	100.0	34.9	50.9	14.2
1971	100.0	32.9	51.0	16.1

<u>Sources</u>: M.A.F. (1), 1962 to 1973.
N.A.C.F. (1), 1958 to 1972.
B.O.K., 1957.
E.P.B., 1960.

APPENDIX A11

INDICES OF LABOUR QUALITY BY SCHOOLING LEVEL[a]

Year	Non-educated labour (N_0)	Primary school N_1)	Higher school (N_2)	Quality of labour [b]
		(Index : %)		
1956	.652	.340	.175	1.000
1957	.630	.360	.189	1.010
1958	.608	.380	.202	1.020
1959	.590	.398	.212	1.028
1960	.571	.403	.246	1.045
1961	.480	.511	.255	1.068
1962	.389	.619	.267	1.093
1963	.383	.621	.276	1.097
1964	.357	.650	.283	1.105
1965	.350	.651	.297	1.112
1966	.342	.658	.304	1.117
1967	.345	.679	.304	1.121
1968	.353	.646	.299	1.112
1969	.350	.630	.317	1.118
1970	.349	.636	.327	1.124
1971	.329	.638	.370	1.146

Notes: a. Based on the wage rate of Table 5.9.

b. Index of 1956 = 100: $E = \sum_{i=0}^{n} Ni\ Ai$ (Chapter 5.2)

where E = quality of labour

$N = N_0 + N_1 + N_2$

Ai = Wi/Wo

Wi = wage rate by schooling level

APPENDIX A12

MAJOR INPUT SUB-GROUPS OF "OTHER INPUT", 1956 TO 1971
INPUTS BASED ON 1964-1966 PRICE WEIGHTS

Year	Fert-ilizer	Pest-icides	Machinery & imple-ments	Animal power	Farm building	Public changes	Misc.	Total other input
				(Won/Unit)				
1956	4,333	108	326	1,668	3,165	400	2,125	12,125
1957	4,379	87	357	1,969	3,411	569	3,037	13,849
1958	4,429	286	412	1,571	5,197	486	3,514	15,895
1959	4,603	139	523	1,401	6,018	646	2,560	15,890
1960	5,773	166	509	1,467	5,932	697	2,876	17,420
1961	7,692	221	718	1,193	5,925	868	2,703	19,320
1962	8,336	242	689	1,139	5,415	1,149	3,000	19,970
1963	9,037	448	890	1,179	6,367	876	3,193	21,990
1964	7,434	436	721	1,116	5,858	922	3,528	20,015
1965	8,088	514	634	1,172	5,503	979	3,243	20,133
1966	8,734	699	639	1,066	5,287	1,412	4,156	21,993
1967	8,907	928	662	993	5,175	2,008	3,776	22,449
1968	9,285	1,027	812	1,081	5,179	1,825	3,836	23,045
1969	9,491	1,474	732	1.090	6,048	1,837	3,962	24,634
1970	10,520	2,136	748	1,235	6,393	1,812	4,200	27,044
1971	9,747	3,016	901	1,673	7,091	1,843	5,349	29,620

<u>Sources</u>: M.A.F. (1) and (2), 1958 to 1972.
N.A.C.F. (1) and (2), 1958 to 1972.
B.O.K., (1972).

APPENDIX A13

DATA OF REGRESSION MODEL I, 1956-1971

Year	Total farm output [a]		Farm land [b]		Farm labour [c]		Other input [d]	
	Quantity	Index	Quantity	Index	Quantity	Index	Quantity	Index
	(Won)		(Pyong)		(Hours)		(Won)	
1956	98,114	100.0	2,720	100.0	2,370	100.0	12,125	100.0
1957	104,037	106.0	2,816	103.5	2,355	99.4	13,849	114.2
1958	105,066	107.1	2,760	101.5	2,378	100.3	15,895	131.1
1959	102,796	104.8	2,561	98.2	2,298	97.0	15,890	131.1
1960	102,345	104.3	2,464	90.6	2,177	91.9	17,420	143.7
1961	110,112	112.2	2,656	97.7	2,255	95.2	19,320	159.3
1962	116,623	118.9	2,675	98.4	2,336	98.6	19,970	164.7
1963	119,030	121.3	2,691	98.9	2,077	87.6	21,990	181.4
1964	124,945	127.4	2,728	100.3	2,177	89.3	20,015	165.1
1965	120,834	123.2	2,878	105.8	2,087	88.1	20,133	166.1
1966	129,745	132.2	2,844	104.6	2,064	87.1	21,993	181.4
1967	126,040	128.5	2,924	107.5	2,016	85.1	22,449	185.2
1968	125,493	127.9	2,996	110.2	1,883	79.5	23,045	190.1
1969	135,727	138.3	2,988	109.9	1,844	77.8	24,634	203.2
1970	134,858	137.5	2,965	109.0	1,810	76.4	27,044	223.0
1971	154,297	157.3	2,986	109.8	1,833	77.3	29,620	244.3

Source: See Appendix A1, Appendix A8, Appendix A9, and Appendix A12.

Notes: a. Based on Appendix A1, and concept of Chapter 3. b. Based on Appendix A8, and concept of Chapter 4.
c. Based on Appendix A9, and concept of Chapter 5. d. Based on Appendix A12, and concept of Chapter 6.

APPENDIX A14

DATA OF REGRESSION MODELS IV AND V, 1956 TO 1971

Year	Total farm output [a]	Farm land IV [b]	Farm land V [c]	Farm labour IV [d]	Farm labour V [e]	Other input [f]
		(per cent)				
1956	100.0	100.0	100.0	100.0		100.0
1957	106.0	102.9	103.3	100.4		114.2
1958	107.1	100.3	100.8	102.3		131.1
1959	104.8	91.6	92.1	99.7		131.1
1960	104.3	86.8	87.5	96.0		143.7
1961	112.2	95.6	96.6	101.7		159.3
1962	118.9	96.3	97.6	107.8		164.7
1963	121.3	98.7	100.2	96.1		181.4
1964	127.4	97.2	98.9	98.7		165.1
1965	123.2	103.2	105.0	98.0		166.1
1966	132.2	100.5	102.7	97.3		181.4
1967	128.5	101.1	103.5	95.4		185.2
1968	127.9	105.5	107.7	88.4		190.1
1969	138.3	106.6	110.3	87.0		203.2
1970	137.5	105.4	108.6	85.9		223.0
1971	157.3	104.4	108.9	88.6		244.3

Notes:
a. See Appendix A1.
b. See Appendix A8.
c. See Appendix A8.
d. and e. See Appendix A9.
f. See Appendix A12.

APPENDIX A15

ESTIMATES OF TECHNICAL CHANGE, A(t), 1956 TO 1971

	$\dot{A}/A$			$A(t)^*$		
Year	Model I	Model IV	Model V	Model I	Model IV	Model V
1956	-	-	-	1.00000	1.00000	1.00000
1957	.01546	.01574	.01556	1.01546	1.01574	1.01556
1958	-.01747	-.01493	-.01413	.99799	1.00081	1.00143
1959	.02151	.02743	.02755	1.01950	1.02824	1.02898
1960	.00874	.01800	.01251	1.02824	1.04624	1.04149
1961	.00534	-.00685	-.01395	1.03358	1.03939	1.02754
1962	.03634	.03155	.02788	1.06992	1.07094	1.05542
1963	.03320	.02863	.02422	1.10312	1.09957	1.07964
1964	.05704	.06113	.06421	1.16016	1.16070	1.14385
1965	-.01226	-.06010	-.06004	1.14790	1.10060	1.08381
1966	.06218	.07446	.06811	1.21008	1.17506	1.15192
1967	-.03762	-.02792	-.02949	1.17246	1.14714	1.12243
1968	.00134	-.00470	-.00468	1.17380	1.14244	1.11775
1969	.07446	.07117	.06219	1.24826	1.21361	1.17994
1970	-.02522	-.01134	-.01419	1.22304	1.20227	1.16575
1971	.11559	.10945	.11358	1.33863	1.31172	1.27933

Sources: Data from Regression Models I, IV and V.

Note: * A(t) is measured based on the equation (2.21) in Chapter 7, and then A(t) is set by 1956 = 100.

APPENDIX A16

TRENDS IN PARTIAL PRODUCTIVITY, 1956 TO 1971

Year	Land productivity	Labour productivity	Other input productivity
		(per cent)	
1956	100.0	100.0	100.0
1957	102.4	106.7	92.8
1958	105.5	106.7	81.7
1959	111.3	108.1	80.0
1960	115.2	113.6	72.7
1961	114.9	118.0	70.5
1962	120.9	120.6	72.2
1963	122.6	138.4	66.9
1964	127.0	142.6	77.1
1965	116.4	139.9	74.2
1966	126.5	151.9	72.9
1967	119.5	151.0	69.5
1968	116.1	161.0	67.4
1969	125.9	177.8	68.1
1970	126.1	180.0	61.7
1971	143.3	203.3	64.4

Source: Based on Appendix A13.

APPENDIX A17

COMPONENTS OF LABOUR PRODUCTIVITY CHANGE

Year	Labour productivity [a]	Ratio of land to labour [b]	Other input per land [c]	Quality of labour [d]	Technical change [e]
		(per cent)			
1956	100.0	100.0	100.0	100.0	100.0
1957	106.7	103.5	111.4	101.0	101.6
1958	106.7	100.0	130.7	102.0	103.2
1959	108.1	94.4	143.1	102.8	104.8
1960	113.6	94.5	165.8	104.5	106.4
1961	118.0	100.4	166.8	106.8	108.0
1962	120.6	97.7	171.3	109.3	109.6
1963	138.4	112.7	184.2	109.7	111.2
1964	142.6	108.8	169.8	110.5	112.8
1965	139.9	117.1	161.4	111.2	114.3
1966	151.9	114.1	180.7	111.7	115.9
1967	151.0	116.1	183.2	112.1	117.5
1968	161.0	123.9	180.7	111.2	119.1
1969	177.8	137.0	191.1	111.8	120.7
1970	180.0	138.0	215.4	112.4	122.3
1971	203.3	139.3	234.7	114.6	123.9

<u>Sources:</u> a. Data from Appendix A16.

b. and c. Data from Model IV.

d. Data from Appendix A9.

e. $A(t) = (1 + a)^t$ in Model IV.

APPENDIX A18

ESTIMATES OF TOTAL FARM OUTPUT, 1956 TO 1971
(UNIT : WON/UNIT)

Year	Food crops	Special crops	Vege-tables & fruits	Live-stock, meat & poultry	Seri-culture	Others
1956	82,683	1,493	7,308	2,456	188	3,986
1957	88,487	1,492	6,686	2,130	196	5,046
1958	88,979	1,737	8,364	2,351	241	3,394
1959	85,907	3,200	8,148	2,940	206	2,395
1960	85,042	2,802	6,919	2,940	159	4,483
1961	91,984	2,401	9,092	4,011	146	2,478
1962	97,189	2,079	7,740	4,205	209	5,201
1963	100,054	2,539	7,091	3,956	272	5,118
1964	105,894	2,189	7,748	3,818	386	4,910
1965	102,864	2,169	6,032	2,897	389	4,483
1966	110,501	2,954	6,197	3,805	463	5,825
1967	103,983	2,895	9,791	3,321	504	5,546
1968	101,170	4,991	9,858	3,687	566	5,221
1969	110,605	3,906	11,465	3,957	1,139	4,655
1970	109,081	5,329	10,433	3,524	1,312	5,179
1971	120,351	7,323	12,034	4,945	2,352	7,292

Source: See Appendix A1.