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ECONOMIC GROWTH AND STRUCTURAL CHANGE IN TAIWAN---
1952-1972, A PRODUCTION FUNCTION APPROACH

by

THOMAS PEI-FAN CHEN

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

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ABSTRACT

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THOMAS PEI-FAN CHEN

Adviser: Professor Elliot Zupnick

This study attempts to provide an analytical review of the post-war Taiwanese economy from the production point of view. The production functions of the agricultural sector and the manufacturing sector are estimated. Within the framework of the neo-classical theory of production, this study measures the technological changes in the agricultural and manufacturing sectors and their impact on growth and structural change. It also analyzes the problems of unemployment and income distribution of the economy during the process of its development.

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CHAPTER ONE

INTRODUCTION

Taiwan, standing in the west of the Pacific Ocean, is separated from mainland China by the Taiwan Strait. The island has been ruled by the Dutch (1624-1661), the Spanish (1626-1630), General Cheng, better known as Koxigo, (1661-1683), the Manchurian Empire (1683-1894), the Japanese (1895-1945), and the Nationalist Chinese (1946-). However, in historical literature there is no sure evidence to indicate when Taiwan was first discovered and by whom.

The island, with an area of 35,961 square kilometers, is about one third the size of the State of Virginia in the United States.[1] However, sixteen million hard-working and peace-loving people inhabit this island. Because of the small size of its territory, one may have difficulty locating the island on a map. But in terms of population size, Taiwan is larger than two thirds of the member nations of the United Nations. With these things in mind, how can one ignore the existence of Taiwan and the future of its people?

Although people may fail to realize Taiwan's existence or its geographic location, Taiwan is very often mentioned by economists in discussions of economic development. Usually Taiwan is singled out as an example of a successful developing country in the post-war period. During the period 1952-1972, with a population growth rate as high as 3.15 percent per year, the gross domestic product in real terms grew 8.41 percent per year, giving a growth rate of 5.25 percent annually in real per capita gross domestic product (see Table I). This is one of the highest and best sustained growth rates in the world.

What are the factors contributing to such a rapid economic growth rate in Taiwan and how are they operating? The answers to such questions are indeed not easy. Numerous and varied forces interact to influence growth and structural change in a society, such as the level of savings and changes in the structure of final demand, the effects of specific resource endowments, and the role and impact of national economic policy.[2] The purpose of this study is to present an analytical review of Taiwan's economic growth during the past two decades. It is restricted, however, to the measurement of technological change and its impact on growth, employment, and income distribution. The entire analysis is carried out within the framework of the neo-classical theory of production with two broad homogeneous classes of inputs; labor capital. It is neoclassical especially in the sense that the production function used in this study are assumed to be smooth and continuous and are at least twice differentiable, with the marginal products of inputs both positive and continuously diminishing.

Since the agricultural sector is traditionally important in a developing economy, and the manufacturing sector usually plays a central role in the process of industrialization and growth, the analysis of these two sectors may provide us with some insights into the development process of the economy. Thus, we first estimate the production functions of the two sectors, and from there we examine the extent and bias of technological change. The empirical findings of the production characteristics of the two sectors provide us with the foundations with which we tackle the problems of unemployment and income distribution arising during the development stage of the economy.

Chapter two is devoted to a discussion of the theoretical aspects of this study. Chapters three and four are devoted to the empirical analysis of the agricultural sector and the manufacturing sector respectively. In Chapter five we analyze the employment and income distribution problems during the process of Taiwan's development.

In this study the period chosen for analysis is 1952-1972 for the following main reasons; 1) The Nationalist Chinese began to govern Taiwan in 1945 and launched a series of four year economic plans in 1953. This study covers the post-war period and may serve as a partial review of the Nationalist Chinese economic achievement in Taiwan. 2) Although Taiwan has been under the Nationalist Chinese rule since 1945, most statistics published by the governments during the war and the immediate post-war period, 1940-1950, were manipulated for reasons of national security. The severe inflation in the early years of the post-war period also placed the economic activities in a state of turmoil during that period. We thus start with the year in which the data is more reliable and economic activities returned to normal.

FOOTNOTES

1
The entity of Taiwan includes 76 small islands with a total area of 201 square kilometers. Sixty-three of them are located about 64 kilometers to the west of Taiwan proper and are collectively called Penghu. Others are scattered on all sides of the principal island.

2
There are quite a few studies regarding Taiwan's development. A list of selected English publications in this area is given in the appendix.

CHAPTER TWO

THEORETICAL ASPECTS

2.1. Brief Review of the Methodology

There are three methods of sources-of-growth analysis, which attempt to distribute the contribution of various current factor inputs to current output growth. In this section the productivity index method, Solow's measure, and the method of direct estimation of a production function will be briefly discussed in turn.

2.1.1. Productivity Index Method

Two types of productivity indexes can be presented.

1) A partial productivity index: the ratio of real output to one of the inputs. For example, in a two-factor production model, we can have the indexes of X/N and X/C, where X is output, N and C are inputs of labor and capital respectively.

2) A total factor productivity index: the ratio of real output to a weighted average of the labor and capital inputs. The weights are labor's share and capital's share of income. One such index may take the form $M=X/(N^{\alpha}.C^{\beta})$, where M is the total factor productivity and α and β are labor's share and capital's share of income respectively.

These two indexes are interpreted as a measure of the output per unit of resource foregone in production. As Kendrick puts it, "The inputs are estimated without allowance for changes in their quality, so that changes in the ratio of output to inputs (i.e., the total factor productivity index) may be interpreted as reflecting all the diverse forces that affect the quality, or 'productive efficiency,' of the factors.... Movements of these 'partial productivity' ratio reflect substitutions between factors as well as changes in productive efficiency."[1] By such features, the productivity index method is used to quantify the impact of productivity changes on economic aggregates and structures.

The main merit of such a method is its simplicity. But it is too weighty. What are the sources of changes in these productivity indexes? It can be easily shown[2] that changes in the partial productivity index may be due to changes in (a) economies of scale, (b) neutral and/or non-neutral technical change, and (c) the quantity of the other inputs. Therefore, the change of the partial productivity index should not be identified as a change in efficiency of that factor input.

The total productivity index is the same as the Abramowitz Residual,[3] which is the divergence in the growth of output relative to the growth of the combined factor inputs. Given the percentage change in output over a period of time, dX/X, the percentage change in labor input dN/N, and the percentage change in capital input dC/C, the residual determines how much of dX/X is attributable to something other than dN/N and dC/C. Symbolically,

$$\frac{dX}{X} - \alpha \frac{dN}{N} - \beta \frac{dC}{C} = \text{residual} \qquad (2.1.1)$$

where α and β represent the shares of labor and capital of income. Integrating both sides:[4]

$$\int\left(\frac{dX}{X} - \alpha\frac{dN}{N} - \beta\frac{dC}{C}\right) dt = \int (\text{residual})\ dt$$

or

$$\ln\frac{X}{N^{\alpha}.C^{\beta}} = \int (\text{Residual})\ dt, \qquad (2.1.2)$$

where t is time. The time derivative of equation (2.1.2) is

$$\frac{\Delta\left(\frac{X}{N^{\alpha}\cdot C^{\beta}}\right)}{\frac{X}{N^{\alpha}\cdot C^{\beta}}} = \text{residual.} \qquad (2.1.2A)$$

Thus the total productivity index is similar to the Abramowitz residual.

In a static sense the total factor productivity (also called multifactor productivity) may represent the source of growth other than the quantity changes in inputs. That is, changes in the total factor productivity between any two periods are taken as a comparison of the actual real output of period I, to the output which would have been in period II, had the productivity efficiency of period I prevailed.

Again, the total factor productivity index is too weighty. If we take the total differential of the total factor productivity, for example, using a CES production function of the form $X=r\cdot[kN^{-\rho}+(1-k)C^{-\rho}]^{-\frac{V}{\rho}}$, where X is output, N is labor input, C is capital input, r is production efficiency parameter, k is capital intensity, V is economics of scale, and ρ defines elasticity of factor substitution

$\sigma = \frac{1}{1+\rho}$, we see from equation (2.1.4) that the change in the total factor productivity may be due to technological changes (neutral and/or non-neutral), and/or changes in quantities of inputs.

$$M = \frac{X}{N^{k}\cdot C^{1-k}} = \frac{r[kN^{-\rho} + (1-k)\ C^{-\rho}]^{-V/\rho}}{N^{k}\cdot C^{1-k}} \qquad (2.1.3)$$

and

$$dM = \frac{\partial M}{\partial r}dr + \frac{\partial M}{\partial V}dV + \frac{\partial M}{\partial \rho}d\rho + \frac{\partial M}{\partial k}dk + \frac{\partial M}{\partial N}dN + \frac{\partial M}{\partial C}dC \qquad (2.1.4)$$

In equation (2.1.4), the first four terms refer to the change of output attributable to changes in technology, while the last two terms refer to the change attributable to changes in inputs. If the last two terms are non-zero, the total factor productivity index is a biased estimate of the contribution of technological change to output growth.

As we shall see later, it will be more fruitful in the analysis if we are able to separate the forces which make up the residual[5].

2.1.2 Solow's measure

In the literature of measuring technological change, one can not overlook Solow's method.[6] Without using a specific production function, Solow's technological change refers to any kind of shift in the production function of the form:

$$X=F(C, N; t) \qquad (2.1.5)$$

where X is output, C is capital, N is labor, and t is time.

Solow's measure is a catch-all concept, for it combines all factors influencing output other than changes in the quantity of labor and capital.

Assuming the technical change is neutral, i.e. shifts in the production function leave the marginal rate of factor substitution unchanged and simply increases or decreases the output, the production function can be re-written as

$$X=A(t)f(C, N) \qquad (2.1.6)$$

where A(t) measures the cumulative effect of shifts over time.

If we differentiate equation (2.1.6) totally with respect to time t and divide by X, we get

$$\frac{\dot{X}}{X}=\frac{\dot{A}}{A}+A\frac{\partial f}{\partial C}\cdot\frac{\dot{C}}{X}+A\frac{\partial f}{\partial N}\cdot\frac{\dot{N}}{X} \qquad (2.1.7)$$

And from the marginal productivity conditions, $\frac{\partial X}{\partial C}=\frac{q}{P}$ and $\frac{\partial X}{\partial N}=\frac{W}{P}$, where p is the output price, and q and w are capital rental and labor wage respectively, we get the capital and labor shares as

$W_c = \frac{\partial X}{\partial C} \cdot \frac{C}{X}$, and $W_N = \frac{\partial X}{\partial N} \cdot \frac{N}{X}$. And Equation (2.1.7) becomes

$$\frac{\dot{X}}{X} = \frac{\dot{A}}{A} + W_C \cdot \frac{\dot{C}}{C} + W_N \cdot \frac{\dot{N}}{N} \qquad (2.1.8),$$

or

$$\frac{\dot{A}}{A} = \frac{\dot{X}}{X} - W_C \frac{\dot{C}}{C} - W_N \frac{\dot{N}}{N} \qquad (2.1.9).$$

Notice equation (2.1.9) is the same as the Abramowitz residual.

Further assume the sector is operating in the range of CRS (constant returns to scale), and let $\frac{X}{N} = m$, $\frac{\tilde{c}}{n} = k$, and $W_n = 1 - W_c$.

Equation (2.1.8) then becomes

$$\frac{\dot{M}}{m} = \frac{\dot{A}}{A} + W_C \frac{\dot{k}}{k} \qquad (2.1.10).$$

In equation (2.1.10), given the time series of k, m, and W_c, we can get the A(t) series which is a rough profile of technical change. And $\frac{X(t)/N(t)}{A(t)}$ gives the output per labor unit if there had been no shift in production function. We may call it "corrected" output per labor unit, or output per labor unit net of technical change.

Solow also tested whether a non-neutral technical change is present by examining whether $\dot{A}/A$ is correlated with C/N.[7]

From the above discussion we may see that both the Abramowitz residual and the Solow measure are basically the same. However, Solow's method was used presumably to measure only the neutral technological change under the assumption that the sector is operating in the range of CRS, while the Abramowitz residual holds for any type of production function and the residual includes more than the pure elements for technical change. Nevertheless, both the Abramowitz residual and the

Solow measure are not able to decompose the residual into more detailed components which may create neutral or non-neutral types of technological change. As it will be shown in section 2.2.3., an a priori specification of only neutral technical change in a production function may cause a biased estimation of the contribution of technological change to growth. Therefore, we turn to the method of direct estimation of a production function which yields more fruitful results.

2.1.3. Direct Estimation of a Production Function

A production function expresses the relationship between the maximum quantity of output and the inputs required to produce it, and the relationship between the inputs themselves. With the application of statistical techniques to the data on output and factor inputs, we can estimate the parameters of a particular form of a production function. These parameters reveal the characteristics of the production function, such as (a) the degree of returns to scale, (b) the technology of efficiency, (c) the degree to which the technology is capital or labor intensive and (d) the ease with which capital is a substitute for labor. Changes in the characteristics of a production function may cause the change of output growth. And it is relatively easy to define a technological change in terms of changes in the characteristics of a production function. For example, changes in (a) and (b) may cause neutral change while changes in (c) and (d) may cause non-neutral technical change.

In this study two commonly used production functions, Cobb-Douglas function and the Constant Elasticity of Substitution (CES) function, will be estimated for the agricultural sector and the manufacturing sector. The estimates and the changes of the production parameters in these two sectors provide the basic foundation for the analysis of the sources of growth and of potential problems in the developing process.

2.2 Technological Change and Growth

2.2.1 Neutral and Non-Neutral Technological Change

The components of technological changes can be classified in a variety of ways. But for our purposes we focus on the set that technological change is specified as neutral technical change and non-neutral technical change. Following the Hickson neutrality concept which is concerned with the effects of technological progress during a period in which input supplies are relatively fixed, a neutral technical change in production does not affect the marginal rate of factor substitution. Non-neutral change does. Non-neutrality can be defined by the sign of the proportionate rate of change in the marginal rate of factor substitution for a given factor ratio. In other words, in a two-factor production model using labor and capital, if the production function is altered between the two periods such that the marginal product of capital increases relative to the marginal product of labor for a given capital-labor ratio, there is a capital-using (labor-saving) technological change. If the marginal product of capital decreases relative to the marginal product of labor, there is a capital saving (labor-using) technological change. Neutral change results from the same rate of change in the marginal products of both labor and capital. Symbolically, the marginal rate of substitution of labor for capital $MRS_{CN} = \frac{\partial X/\partial C}{\partial X/\partial N}$, and the bias of technology $B(t) = \frac{d \ln MRS_{CN}}{dt}$. In the Hicksian sense, technical change is capital-using if $B(t) > 0$, is capital-saving if $B(t) < 0$, and is Hicksian neutral if $B(t)=0$.

2.2.2 Determinants of Biased Technological Change

In terms of the characteristics of the production function specified in section 2.1.3., a neutral technical change may be due to a change in the efficiency of a technology and/or a change in the economics of scale. Variations in the capital intensity and/or the elasticity of factor substitution can produce non-neutral technical change, either capital-using or capital-saving depending on the relative size of change.

In a Cobb-Douglas production function of the form:

$$X=A_o e^{rt} N^{\alpha}.C^{\beta} \qquad (2.2.1),$$

the marginal rate of factor substitution is

$$MRS_{CN} = F_C/F_N = \frac{\beta}{\alpha}.\frac{N}{C} \qquad (2.2.2).$$

It is clear that the ratio of the output elasticity of capital to the output elasticity of labor (β/α) is the only determinant of Hicksian neutrality.[8]

If we specify the production function in a CES form as

$$X = A_o e^{rt}[kC^{-\rho}+(1-k)N^{-\rho}]^{-V/\rho} \qquad (2.2.3),$$

where k is the capital intensity, v is the degree of homogeneity, and ρ defines the elasticity of factor substitution σ as $\sigma = \frac{1}{1+\rho}$ or $\rho = \frac{1}{\sigma} - 1$, the marginal rate of factor substitution is

$$MRS_{CN} = \frac{k}{1-k} \left(\frac{N}{C} \right)^{1/\sigma} \qquad (2.2.4).$$

From equation (2.2.4) we see capital intensity and elasticity of factor substitution are the determinants of Hicksian neutrality. If $dMRS_{CN} > 0$ there is a capital-using technical change. $dMRS_{CN} < 0$ implies labor-using. And $d\, MRS_{CN}=0$ means the technical change is neutral.

We may conclude that in both Cobb-Douglas and CES functions, shifts in the efficient parameter r and/or the degree of homogeneity, $\alpha+\beta$ or v, will not produce non-neutral technical change, since they do not appear in the expression of the marginal rate of factor substitution. On the other hand, variations in capital intensity k and elasticity of factor substitution σ will result in biased technical change.

Under the CES production function of the form $X=A_0 e^{rt}[kC^{-\rho}+(1-k)N^{-\rho}]^{-\frac{\nu}{\rho}}$ where all the variables X, N, and C are in index number form, some properties of non-neutral technical change can be derived:

(1) Taking the partial derivative of equation (2.2.4) with respect to k, we get

$$\partial MRS_{CN}/\partial k = (N/C)^{1/\sigma}.1/(1-k)^2 > 0 \qquad (2.2.5),$$

since $\frac{N}{C} > 0$, and $k < 1$. Therefore an increase in capital intensity always results a capital-using technical change.

(2) Also taking the partial derivative on equation (2.2.4) with respect to σ, we get

$$MRS_{CN} / \partial\sigma = -(MRS_{CN}.\ln\ (N/C)\ ).1/\sigma^2 \qquad (2.2.6).$$

Since $MRS_{CN} > 0$, $MRS_{CN}/\partial\sigma$ will be greater than zero if $(N/C) < 1$ and $MRS_{CN}/\partial\sigma$ will be smaller than zero if $(N/C) > 1$. That is, the effect of an increase in σ on neutrality depends on the relative growth rate of the two input factors in the production process (since all the variables, X, N, and C, in equation (2.2.3) are in index number form, $\frac{N}{C} > 1$ implies labor is growing factor than capital).

(3) The total differential of equation (2.2.4) is

$$dMRS_{CN} = [(N/C)^{1/\sigma}.1/(1-k)][(1/(1-k))dk-(k.\ln(N/C).1/\sigma^2)d\sigma] \quad (2.2.7).$$

From equation (2.2.7), we find: A) Under the condition $(N/C) < 1$, i.e. capital is growing faster than labor, increases in both k and σ ($dk > 0$, $d\sigma > 0$) will result in capital-using technical change, i.e. $d\,MRS_{CN} > 0$. If among k and σ, one increases and the other decreases, then the sign of $dMRS_{CN}$ will depend on the relative forces of $(1/(1-k))dk$ and $(k.\ln(N/C).1/\sigma^2)d\sigma$. B) Under the condition $(N/C) > 1$ i.e labor is growing faster than capital, three outcomes are possible. (1) If $dk > 0$, and $d\sigma < 0$, then $dMRS_{CN} > 0$, i.e. the result is capital-using. (2) If $dk < 0$, and $d\sigma > 0$, then $dMRS_{CN} < 0$, i.e. the result is capital-saving. (3) If both k and σ increase or decrease in the same direction, the sign of $dMRS_{CN}$ depends on the relative forces of $(1/(1-k))dk$ and $(k.\ln(N/C).1/\sigma^2)d\sigma$.

2.2.3. The Effect of Technological Change on Economic Growth

The contribution of a neutral technical change to growth is unambiguous. An upward-shift neutral change contributes positively to growth. A downward-shift neutral change contributes negatively to the growth.

The contribution of non-neutral technical change to the growth is more ambiguous. An increase in capital intensity implies there is an increase in the marginal product of capital relative to that of labor, therefore giving a capital-using technical change. But an increase in capital intensity will raise the rate of growth only if capital input is growing faster than labor input in the production process, because if capital is relatively cheap, a new technology calling for greater capital intensity generates a higher rate of growth.[9] An increase in the elasticity of factor substitution, σ, may result in labor-using technical change only if labor is growing faster than capital as shown in equation (2.2.6). However, an increase in the elasticity of factor substitution always raises the growth rate.[10] This is true because the same rate of growth can always be maintained at a lower unit cost, if technological progress permits the substitution of the relatively cheap factor for the relatively expensive one with greater ease. Therefore, with a fixed budget outlay a higher rate of growth can be obtained. Putting these factors together there is no guarantee that non-neutral technical change will contribute positively to growth. Hence, the a priori assumption of only neutral technical change in the production process may either under or over estimate the contribution of technical change to the growth.

2.2.4. Determinants of Technical Bias and the Effect of Technical Change on Economic Growth under a Purely Factor Augmenting Model

A purely factor augmenting CES production function with constant returns to scale can be written as

$$X = [a(e^{\delta t}C)^{-\rho}+b(e^{\lambda t}N)^{-\rho}]^{-1/\rho} \qquad (2.2.8),$$

where X is the output, C and N are the natural units of capital and labor inputs, $e^{\delta t}C$ and $e^{\lambda t}N$ are the capital and labor inputs in efficiency units which are growing at the rates δ and λ respectively, and ρ defines the elasticity of factor substitution $\sigma = 1/(1+\rho)$.[11]

From equation (2.2.8) we can get:

$$F_{Ct}/F_C = -\rho.\delta \qquad (2.2.9)$$

$$F_{Nt}/F_N = -\rho.\lambda \qquad (2.2.10),$$

where $F_i = \frac{\partial F}{\partial i}$, i=C, N, and $F_{it} = \frac{\partial F_i}{\partial t}$. And the Hicksian neutrality can be expressed as $B(t)=\partial \ln MRS_{CN}/\partial t= \frac{\partial}{\partial t}\left(\frac{F_C}{F_N}\right) \Big/ \frac{F_C}{F_N}$

$$=F_{Ct}/F_C-F_{Nt}/F_N=(1-\frac{1}{\sigma})(\delta-\lambda) \qquad (2.2.11).$$

Equation (2.2.11) implies that technological bias depends on the rate of factor augmentation and the magnitude of the elasticity of factor substitution. For example, if the productivity of labor is growing faster relative to that of capital, $(\delta-\lambda) < 0$, and σ is less than one, labor-saving technical change will be the result $(B(t) > 0)$. It is generally believed that the industrial sector usually involves labor-saving technology, i.e. $B(t) > 0$. Thus, under the assumption that $0 < \sigma < 1$, the industrial sector must increase the efficiency of labor faster than that of capital.

Using equation (2.2.8), the output growth rate (R(t)) can be derived as:

$$R(t) = F_t/F=\partial \ln X/\partial t$$

$$=\delta.E^C+\lambda.E^N \qquad (2.2.12)$$

$$=\delta.E^C+\lambda.(1-E^C) \qquad (2.2.13),$$

where $E^C=(\partial X/\partial C)/(X/C)= \frac{(e^{\delta t}C)^{-\rho}}{(e^{\delta t}C)^{-\rho}+(e^{\lambda t}N)^{-\rho}}$,

$$E^N=(\partial X/\partial N)/(X/N)= \frac{(e^{\lambda t}N)^{-\rho}}{(e^{\delta t}C)^{-\rho}+(e^{\lambda t}N)^{-\rho}}$$

which are the output elasticity of capital and labor respectively. Notice that the output growth rate is a weighted average of the rates of factor augmentation which contribute positively to output growth (i.e. $\frac{\partial R(t)}{\partial \delta}, \frac{\partial R(t)}{\partial \lambda} > 0$). The weights are the output elasticities of the inputs.

Equation (2.2.11) and (2.2.12) have important implications in economic development processes. Let the subscripts A and M refer to the agricultural and manufacturing sectors. Assuming the rates of efficiency of labor and capital are the same in both the A and M sectors, the difference of the output growth rates in the two sectors is:

$$R_M(t)-R_A(t) = (E_M^c-E_A^c) \cdot (\delta-\lambda) \qquad (2.2.14)$$

Presumably, capital is more "important" or more sensible in the manufacturing sector, i.e. $E_M^c-E_A^c > 0$. To get $R_M-R_A > 0$, we have to guarantee $\delta-\lambda > 0$, i.e. capital's efficiency is growing faster than labor's. In other words, to fulfill the ambition of industrialization, a developing country has to have a higher efficiency rate in capital than that in labor.[12]

However, the condition $\delta-\lambda > 0$ for industrialization may create a conflicting condition for labor-saving (capital-using) technical progress in the manufacturing sector. Using the Hicksian concept, the bias $B = (1-\frac{1}{\sigma})(\delta-\lambda)$ will be less than zero (i.e. labor-using), if we restrict σ to a value less than one as generally believed in empirical findings and $(\delta-\lambda) > 0$.

Of course the assumption that the rates of efficiency of capital and labor are the same in both the A and M sectors is unnecessary. If $\delta_A \neq \delta_M$, $\lambda_A \neq \lambda_M$, then the industrialization rate is

$$R_M(t)-R_A(t)=E_M^C(\delta_M-\lambda_M)-E_A^C\ (\delta_A-\lambda_A)-(\lambda_A-\lambda_A) \qquad (2.2.15).$$

Assuming, again, that σ is less than one in both agricultural and manufacturing sector, the only case which guarantees successful industrialization is that labor using technological change prevails in the manufacturing sector, i.e. $(\delta_M - \lambda_M) > 0$, capital-using technological change prevails in the agricultural sector, i.e. $(\delta_A - \lambda_A) < 0$, and $\lambda_A < \lambda_M$. Otherwise, industrialization depends on the relative forces of δ_A, λ_A, δ_M, λ_M, E_M^C and E_A^C.

2.3. Technological Change and the Problems of Employment and Income Distribution

2.3.1. Technological Change and Employment

Employment is one of the major concerns in every economic system. As a member of the block of Asian countries, Taiwan experienced high rates of pupulation growth during 1952-1972 (3.15 percent per year), although its family planning program was regarded as successful during the past decade. While a high rate of population growth alone can provide potential unemployment problems and exert a negative impact on per capital output expansion, the introduction of labor-saving technological bias in production can cause the unemployment problem in developing countries to become more acute. The purpose of this section is to show how technological change affects employment. We first derive the demand for labor as follows:

Under the original CES function as defined above,

$$X=r[kC^{-\rho}+(1-k)N^{-\rho}]^{-V/\rho} \qquad (2.3.1),$$

assuming the producers are profit maximizers and all markets are competitive, the expansion path in equilibrium is

$$q/W = [k/(1-k)] \cdot (N/C)^{1/\sigma} \qquad (2.3.2),$$

where q is the rent on a unit of capital and w is the wage rate. From equation (2.3.2), we can get

$$C = N\left(\frac{q}{W} \Big/ \frac{k}{1-k}\right)^{-\sigma} \qquad (2.3.3).$$

Equation (2.3.3) combined with equation (2.3.1) and solved for N, yielding

$$N = r^{-\frac{1}{V}} . X^{\frac{1}{V}} \left[k\left(\frac{1-k}{k}\right)^{1-\sigma} . (q/W)^{1-\sigma} + (1-k)\right]^{\sigma/1-\sigma} \qquad (2.3.4),$$

which implies labor demand is a function of output, X, and the production parameters r, v, k, and σ. Notice also that labor demand is homogeneous of degree 1/V in output, and that the effect of the relative factor prices on labor demand depends on the size of k and σ The effects of the changes in the parameters on labor demand can be shown by the partial derivatives of equation (2.3.4) with respect to each parameter, e.g. $\frac{\partial N}{\partial \sigma}$, $\frac{\partial N}{\partial k}$, and $\frac{\partial N}{\partial r}$.

Under a factor augmenting CES function of the form:

$$X = [a(C\,e^{\delta t})^{-\rho} + b(N\,e^{\lambda t})^{-\rho}]^{-1/\rho} \qquad (2.3.5),$$

in equilibrium we have,

$$\frac{MP_C}{MP_N} = \frac{q}{W} = \frac{a}{b}\left(\frac{C}{N}\right)^{-\rho-1} . e^{-\rho\delta t+\lambda\rho t} \qquad (2.3.6).$$

From equations (2.3.6) and (2.3.5), we can get

$$\ln(N/C) = \sigma \ln(q/W) - \sigma \ln(a/b) + (1-\sigma)/\sigma^{2} [t.(\delta-\lambda)] \qquad (2.3.7)$$

and

$$\frac{\partial \ln(N/C)}{\partial t} = \left(\frac{1-\sigma}{\sigma^2}\right) \cdot (\delta-\lambda) \qquad (2.3.8),$$

which implies that technical change increases the demand for labor (in natural units) relative to capital only if (a) $\delta-\lambda > 0$ when $\sigma < 1$, or (b) $\delta-\lambda < 0$ when $\sigma > 1$.

If production function is of the Cobb-Douglas form, $X=A_o.e^{rt}.N^{\alpha}.C^{\beta}$, the labor demand can be derived as

$$N = \hat{A} \cdot X^{(1/\alpha+\beta)} . (q/W)^{(\beta/\alpha+\beta)} \qquad (2.3.9),$$

where $\hat{A} = (A_o \cdot e^{rt})^{-(1/\alpha+\beta)} . (\beta/\alpha)^{-(\beta/\alpha+\beta)}$. In chapter five, equations (2.3.7), (2.3.8), and (2.3.9) will be used to analyze the labor absorption problem in the agricultural and manufacturing sectors.

2.3.2. Technological Change and the Distribution of Income

Following Ferguson's derivation,[13] the production function with only neutral technological change can be written as:

$$X = e^{rt}.F(C,N) \qquad (2.3.10).$$

Under the assumption that (1) the production function is homogeneous of degree one, (2) both marginal products of labor and capital are positive (F_C, $F_N > 0$) and decreasing (F_{CC}, $F_{NN} < 0$), (3) the input and output markets are competitive, then the rate of change in labor's relative share can be expressed as

$$\dot{S}/S = -(1-S)\left(1-\frac{1}{\sigma}\right)(\dot{g}/g) \qquad (2.3.11),$$

where S is labor's share, g is the capital-labor ratio, and σ is the elasticity of factor substitution.

Notice that neutral change has no effect on the relative share of labor, since the overall or neutral technology parameter r does not enter equation (2.3.11). Notice also that in equation (2.3.11) since $(1-S) > 0$, if $\dot{g}/g > 0$ (i.e. the rate of capital accumulation exceeds the rate of increase in employed labor), then $\dot{S}/S \gtrless 0$ as $\sigma \lesseqgtr 1$. Or stated in another way, if technical change is neutral, the direction of change of relative input supplies and the magnitude of the elasticity of factor substitution are the only factors governing the behavior of relative shares. In particular, an increase in the capital-labor ratio will be accompanied by an increase or a decrease in labor's relative share as $\sigma \gtrless 1$. If $\dot{g}/g < 0$ (i.e. the rate of increase in the employed labor exceeds the rate of capital accumulation), $\dot{S}/S \gtrless 0$ as $\sigma \gtrless 1$. And if $\sigma = 1$ (as in Cobb-Douglas production function), then changes in the relative supplies of factors will have no effect on the relative share.

If technological change is biased, the rate of change in labor's relative share can be expressed as

$$\dot{S}/S = -(1-S)\left[B(t)+\left(1-\frac{1}{\sigma}\right)\frac{\dot{g}}{g}\right] \qquad (2.3.12),$$

where $B(t) = d\ \ln MRS_{CN}/dt = (F_{Ct}/F_C)-\frac{F_{Nt}}{F_N}$. Noting that when technical change is Hicks-neutral, $B(t)=0$, equation (2.3.12) reduces to equation (2.3.11).

Without considering the bias, if $\sigma < 1$ and $\dot{g}/g > 0$, labor's relative share tends to increase. With the bias, labor's relative share is increasing or decreasing as $B(t) \lesseqgtr 0$. More specific, $B(t) > 0$ is a necessary condition for decreasing labor's relative share. The sufficient condition for decreasing labor's share is that the size of

B(t) outweighs the size of $[(1-\frac{1}{\sigma})\frac{\dot{g}}{g}]$ such that the term $[B(t)+(1-\frac{1}{\sigma})\frac{\dot{g}}{g}]$ is negative. Such conclusions seem to offer a way of defining biased technical change; that is to say technical change is labor-using, neutral, or capital-using depending upon whether the relative share of labor increases, remains unchanged, or decreases, if $\sigma < 1$ and $(\dot{g}/g) > 0$.

In the specific case of a factor augmenting model in the CES form $X = [a(C\cdot e^{\delta t})^{-\rho}+b(N\cdot e^{\lambda t})^{-\rho}]^{-1/\rho}$, the relative factor share is

$$(q.C)/(W.N) = \frac{a}{b}.\left(\frac{C}{N}\right)^{-\frac{1}{\sigma}+1}.e^{(\delta t-\lambda t)(1-\frac{1}{\sigma})} \qquad (2.3.13),$$

and the effects of a shift, in the factor effiency rate can be expressed as

$$\frac{\partial\left(\frac{q\cdot C}{W\cdot N}\right)}{\partial\delta} = t\left(1-\frac{1}{\sigma}\right)\cdot\frac{q\cdot C}{W\cdot N} \gtreqless 0, \text{ as } \sigma \gtreqless 1 \qquad (2.3.14),$$

and

$$\frac{\partial\left(\frac{q\cdot C}{W\cdot N}\right)}{\partial\lambda} = -t\left(1-\frac{1}{\sigma}\right)\cdot\frac{q\cdot C}{W\cdot N} \gtreqless 0, \text{ as } \sigma \gtreqless 1 \qquad (2.3.15).$$

That is, whether improvements in factor efficiency will increase that factor's relative share or not depends on the magnitude of the elasticity of factor substitution.

The aggregate effects of changes in labor's and capital's efficiency rates on the factor share can be expressed as

$$d[(q.C)/(W.N)] = \frac{\partial\left(\frac{q\cdot C}{W\cdot N}\right)}{\partial\lambda}d\lambda + \frac{\partial\left(\frac{q\cdot C}{W\cdot N}\right)}{\partial\delta}d\delta$$

$$= t\cdot\frac{q\cdot C}{W\cdot N}.\left(1-\frac{1}{\sigma}\right)(d\delta-d\lambda) \qquad (2.3.16).$$

That is, the changes of the relative factor share depend on the magnitude of the elasticity of factor substitution and the relative sizes of the changes in the factor's efficiency rates.

One should be aware that the above relations we have derived are pure production phenomena and they may not be empirically confirmed. The discrepancies between the pure production estimates and the actual distribution of factor income share may be explained by market forces which are beyond the scope of this study. However, these relations may provide some theoretical guidance to the government in making policy concerning income distriburion.

2.4. Fitting the Production Functions

2.4.1. Fitting the Cobb-Douglas Production Function

In the estimation of the Cobb-Douglas production function in the agricultural sector and the manufacturing sector, we specify the function as

$$X = A_o \cdot e^{rt} . N^{\alpha} . C^{\beta} \qquad (2.4.1),$$

where X is output, N is man days employed, and C is utilized capital. Notice the function is "neutrally" shifting r percent per unit of time during the period under consideration.

Taking the first difference of each variable after applying a logarithm transformation on equation (2.4.1) to eliminate the correlation of t and C and the possible serial correlation in the regression, we get

$$\Delta \ln X = r+\alpha \Delta \ln N+\beta \Delta \ln C \qquad (2.4.2)$$

In available data, we have only capital stock based on the inventory method. Using the capital stock as the capital input in the regression (2.4.2) may result in a biased estimation of the production function because not all of the capital stock are actually employed. We therefore utilize the Wharton method[14] to find out the capacity utilization rates, S, and revise equation (2.4.2) as

$$\triangle \ln X = r + \alpha \triangle \ln N + \beta \triangle (\ln S + \ln K) \qquad (2.4.3)$$

where K is the capital stock. If the residual error of equation (2.4.3), U, is significantly correlated with capacity utilization, then the initial adjustment for capacity utilization is inadequate, and further adjustment is required. According to Brown,[15] the original adjustment for capacity utilization of the capital stock is inadequate by an amount that is equal to the contribution given by the capacity utilization variable S to the explanation of the residual U. We thus run a regression on $\triangle \ln U = U_o + U_1 \cdot \ln S$, and further adjust the regression (2.4.3) as

$$\triangle \ln X = r' + \alpha' \triangle \ln N + \beta' \triangle [(1+U_1) \ln S + \ln K] \qquad (2.4.4)$$

Notice the results of the regression on equation (2.4.3) or equation (2.4.4) will estimate only the rate of neutral technical change and the partial elasticity of the two factor inputs. To see if different technical epochs exist during the entire period 1952-1972, we follow the approach developed by Brown[16] to isolate these periods. We estimate the production functions of several sub-periods by using the regression (2.4.3) or (2.4.4), whichever is appropriate; and then applying the Chow[17] test to see whether the estimated parameters are statistically significantly different among the sub-periods. If they are, we conclude that the two sub-periods embrace different technologies. Finally, the dummy variable approach developed by D. Gujarati[18] is used to estimate the production function of the different technical epochs detected.

2.4.2 Fitting the CES Production Function

In sections (2.2.2) and 2.2.4) we show that σ, the elasticity of factor substitution, is also a determinant of biased technical change and will affect the growth rate of output. Since σ in a Cobb-Douglas production function always equals unity, serious limitations in the analysis may arise. To avoid limitations and for purposes of comparison, a CES production function is also estimated.

Since we are dealing with highly aggregate relationships in this study, the meaning of economies of scale may become very vague. In addition, in time series analysis, it is very difficult to distinguish between economies of scale and technical progress. Thus, in our empirical fitting of a CES production function, we use a constant returns to scale specification.

In order to avoid the unnecessary restriction that technical change affects the productivities of capital and labor in the same manner as presumed in the original CES function of the form $X=r[kN^{-\rho} + (1-k)C^{-\rho}]^{-1/\rho}$, we specify the CES production function as:

$$X=[a(C.e^{\delta t})^{-\rho} + b(N.e^{\lambda t})^{-\rho}]^{-1/\rho} \qquad (2.4.5),$$

where C and N are the capital and labor inputs in natural units respectively, $e^{\delta t}C$ and $e^{\lambda t}N$ are the capital and labor inputs in efficiency units, and ρ defines the elasticity of substitution $\sigma = 1/(1+\rho)$. The estimates of δ and λ, incorporated with the size of show the direction of technical biases. However, because of the non-linearity and complicity of equation (2.4.5), the parameters cannot be directly estimated.[19] To solve this problem, we assume (1) perfect competition in the factor and product markets, therefore making factor prices predetermined, and (2) the producers are motivated by profit maximization. The second assumption gives:

$$W^* = P.F_N = P.X^{1+\rho}.bN^{-(1+\rho)} e^{-\rho\lambda t} \qquad (2.4.6),$$

where W^* is marginal cost of labor, p is output price, and $F_N = \partial X/\partial N$. Since W^* is not observable, we let $W^* = W\cdot e^{rD}$, where W is the observed wage rate. And applying a logarithmic transformation to equation (2.4.6), we get

$$\ln (X/N) = -\sigma \ln b + \sigma \ln (W/P) + (1-\sigma)\lambda t + \sigma r D \qquad (2.4.7),$$

which is a non-linear form in the parameters and may give the estimates of σ (and therefore ρ), λ and r .

Equation (2.4.5) can be rewritten as

$$(C/X)^{\rho} - b[C/(N.e^{\lambda t})]^{\rho} = a.e^{-\delta\rho t} \qquad (2.4.8)$$

or as

$$\ln [(C/X)^{\hat{\rho}} - b(\frac{C}{N.e^{\hat{\lambda} t}})^{\hat{\rho}} = \ln a - \hat{\rho}\delta t \qquad (2.4.9),$$

where the parameters with the symbol ^ are the estimates from equation (2.4.7). The regression on equation (2.4.9) will give the estimate of the remaining parameter δ .

FOOTNOTES

1
John W. Kendrick, "Post-War Productivity Trends in the U. S., 1948-1969." NBER, 1973, p. 4.

2
In a CES production function, the partial productivity index of labor is $AP_N = \frac{X}{N} \quad \frac{\gamma[kc^{-\alpha}+(1-k)N^{-\alpha}]^{-\frac{v}{\rho}}}{N}$ where X: output, N: labor, C: capital, k: capital intensity, r: production shifting parameter, v: degree of homogeneity, ρ : defines the elasticity of substitution $\sigma = \frac{1}{\rho+1}$. Its total differential is

$$dAP_N = \frac{\partial AP_N}{\partial \gamma} dr + \frac{\partial AP_N}{\partial v} dv + \frac{\partial AP_N}{\partial k} dk + \frac{\partial AP_N}{\partial \alpha} d\alpha + \frac{\partial AP_N}{\partial c} dc + \frac{\partial AP_N}{\partial N} dN$$

The first two terms show the impacts of the neutral technical change and the economies of scale on the partial productivity. The third and the fourth terms represent the effects of non-neutral technical change on the partial productivity. The last two terms show the effects of changes in the quantities of inputs.

3
Moses Abramowitz, "Resource and Output Trends in the U. S. since 1870." AER, May 1956.

4
Two kinds of total factor productivity have been commonly used: $X/(N^{\alpha} . C^{\beta})$ and $X/(\alpha.N+ \beta.C)$. The former, weighted by the factor shares, was recommended by E. Domer, "On Total Productivity and All That", JPE, December 1962. The latter, used by Kendrick, utilizes a linear combination of labor and capital with factor prices as weights. The Domar form is based on a Cobb-Douglas production function, while Kendrick's formulation requires only that the underlying production function be homogeneous of degree one.

5
John Kendrick believes the measure of tangible factor inputs, unadjusted for quality change, and the associated total and partial productivity measure remain a useful point of departure for analysis of growth and change in economic aggregates and structure. However, the approach of Z. Griliches and D. W. Jorgenson in "The Explanation of productivity Change", R. E. Studies, July, 1967, not only adjusted labor input for the factors selected by E. Danison in "The Sources of Growth and Structural Change in U. S. and the Alternative Before Us", but also adjusted capital input for qualitative improvements and for changes in the ratio of capacity utilization, as well as being corrected for several other alleged "errors" in the measurement of output and inputs. Griliches and Jorgenson, therefore, found the residual vanished. Hence they even question the usefulness of the concept of technological advance on economic growth.

6
R. Solow, "Technical Change and the Aggregate Production Function", R. E. Statistics, August, 1957.

7
Such a test for the existence of non-neutral technical change is not adequate. In his reply to W. P. Hogan, "Technical Progress and Production Function", R. E. Statistics, November, 1958, Solow himself pointed out that the capital-labor ratio can change in such a way as to allow the proportional changes in the production function to be zero, while still allowing for non-neutral technical change.

8
The ratio β/α also denotes the capital intensity in the production process. Consider at equilibrium, $\frac{q}{W} = \frac{\partial x/\partial C}{\partial x/\partial N} = \frac{\beta}{\alpha} \cdot \frac{N}{C}$, where q and w are the prices of capital and labor respectively. For a given factor price ratio, the larger is β/α, the smaller will be N/C.

9
Mathematically, in the case of using a CES production $X = \gamma [kC^{-\rho} + (1-k) N^{-\rho}]^{-\frac{v}{\rho}}$, $\frac{\partial x}{\partial k} = (X/C^{\rho}[kC^{-\rho} + (1-k) N^{-\rho}])\left(\frac{V\sigma}{1-\sigma}\right)\left(1 - \frac{N}{C}\right)^{\frac{\sigma-1}{\sigma}}$

> 0, if $N/C < 1$
< 0, if $N/C > 1$, as long as $\sigma > 0$.

10
M. Brown, On the Theory and Measurement of Technological Change, Cambridge University Press, 1968, p. 57, has proved the following:

(a) $\frac{\partial X}{\partial \sigma} = 0$, if $C = N$

(b) $\lim_{C \to \infty} \frac{\partial X}{\partial \sigma} \Big|_{\sigma > 0 \text{ or } \sigma < 1} > 0$

(c) $\lim_{N \to \infty} \frac{\partial X}{\partial \sigma} \Big|_{\sigma > 0 \text{ or } \sigma < 1} > 0$

(d) $\lim_{k \to 1} \frac{\partial X}{\partial \sigma} > 0$

(e) $\lim_{k \to 0} \frac{\partial X}{\partial \sigma} > 0$

11
As the production factors became more productive, a given amount of factor inputs in natural unit may produce more output. Or a given output can be obtained from a reduced amount of factor inputs in natural unit. To show the technological change of this form one may specify the factor inputs in efficiency unit instead of natural unit in the production function. The forms $e^{\delta t}C$ and $e^{\lambda t}N$ mean that the

productivities of capital and labor are growing at a constant proportional rate δ and λ overtime respectively. We thus define δ and λ as the production efficiency rate of capital and labor.

12
Here we define industrialization as the manufacturing sector growing faster than the agricultural sector. Others may define industrialization simply as the non-agricultural sector growing but not necessarily faster than the agricultural sector.

13
C. Ferguson, "Neoclassical Theory of Technological Progress and Relative Factor Share", Southern Economic Journal, 1968.

14
"Index of Percentage Utilization of Industrial Capacity for the United States", Econometric Research Unit, University of Pennsylvania, 1960. The estimated utilization rates for the agricultural and the manufacturing sectors are presented in Table XII.

15
M. Brown, On the Theory and Measurement of Technological Change, the Cambridge University Press, 1968, pp. 144-147.

16
Ibid., pp. 113-118.

17
Gregory C. Chow, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions", Econometrica, July, 1960.

18
Damodar Gujarati, "Use of Dummy Variables in Testing for Equality Between Sets of Coefficients in Linear Regression", American Statistician, February and December 1970.

19
The independent variable of the logarithmic form of equation (2.4.5) still contains unknown parameters. A non-linear regression program can not be successfully applied directly to equation (2.4.5), because the production function is not very sensitive to mismeasurement of the elasticity of substitution, unless the observations include very different capital-labor ratio. The elasticity of substitution measures the curvature of the production isoquants and it is difficult to distinguish between different curves unless the observations span a wide range of capital-labor ratio.

CHAPTER THREE

AN ANALYSIS OF THE AGRICULTURAL SECTOR

The agricultural sector is initially a dominant sector in the developing countries, not only because the sector contains most of the economy's population but also because it constitutes the major part of the nation's income, labor force, and capital resources. Such facts combined with the belief that agricultural and rural production can be raised rapidly with little capital, and that rapid and large returns in the agricultural sector are possible with relatively minor changes in techniques, lead some economists to argue that having a developed agricultural sector is essential for overall economic development. These economists conclude that an agricultural revolution and a subsequent rise in agricultural productivity are prerequisites to generate the surplus to provide the needed capital and to release the labor force for the expansion of other sectors, presumably the manufacturing sector.[1] During the Japanese Occupation (1896-1945), Taiwan's agricultural sector was highly emphasized and was able to enjoy a high growth rate. According to Dr. T. H. Lee, during the period 1911-1940 Taiwan's agricultural sector, with relatively little capital investment, was growing at a rate of 3.1 percent per year, and, on the average, exporting 14.14 percent of its net domestic product to the non-agricultural sector.[2] However, the emphasis on the agricultural sector during the Japanese occupation was a Japanese colonial policy pursuing the so-called "an industrialized Japan and an agricultural Taiwan" policy, rather than a policy of paving the way for a purposeful industrialization.

After the Second World War, the struggle for industrialization became very fashionable among the developing countries. Taiwan was not an exception. The economy shifted its emphasis from agriculture to industry. This policy shift coincided with the shift of the ruling power from the Japanese to the Nationalist Chinese who launched a series of four-year economic plans in 1953. During the period 1952-1972, although the agricultural output in Taiwan was still growing at an average rate of 4.36 percent with the capital input increasing 5.26 percent per year and the labor input increasing 0.87 percent per year, the economy as a whole was growing even faster, at 8.41 percent per year (see Table 1). The manufacturing sector was growing at a rate of 12.77 percent per year during the same period. Consequently, the relative importance of the agricultural sector to the economy in terms of the value of output was declining. However, it was not until 1969 that the gross manufacturing domestic product surpassed the gross domestic product of the agricultural sector.

In this Chapter we use the theories discussed in Chapter Two to analyze the factors that contributed to the agricultural growth during the period of 1952-1972. The productivity index approach, Solow's measure, production under a Cobb-Douglas world, and the production under a CES world are presented in the subsequent sections. The discussion of the effects of technical change on employment and on income distribution in the agricultural sector will be presented in Chapter Five.

3.1. Productivity Indexes and Solow's Measure

Let us examine the productivity trends first. The real gross domestic product, which is the numerator of the productivity ratios, increased at an average rate of 4.36 percent per year between 1952-1972 (see Table II). Labor input, in terms of man days employed, rose at a rate of 0.87 percent per year. Capital input, in terms of real capital stock, increased 5.26 percent per year. Based on Domar's formulation $\frac{X}{N^{\alpha} \cdot C^{\beta}}$ it can be shown that the total factor productivity rose by 1.63 percent per year over the period 1952-1972. Since, in this sector the labor input was growing slowly relative to the capital accumulation during this period, this productivity increase may rest with a labor-saving technical change. Such a hypothesis can be further supported by the facts that the real output per man-day was rising at an average annual rate of 3.49 percent while the capital-labor ratio was growing at 4.39 percent per year, as indicated in Table II. The labor-saving bias of technical change during this period will be tested again by the method of production function estimation.

The results of the Solow's measure are also presented in Table II. According to Solow (equation (2.1.10) $\frac{\dot{q}}{q} = \frac{\dot{A}}{A} + W_{c}\frac{\dot{k}}{k}$ the A(t) series is a rough profile of technological change. Solow's measure shows that technical change has increased productivity by 22.25 percent between 1953 and 1972. Stated in a different way, the production function was shifting upward about 1.057 percent per year during that period. Since the coefficient of determination (R^2) of $\dot{A}/A$ and C/N is only 0.0288, we may feel comfortable to interpret the 1.057 percent annual upward shift in the production as the neutral shift which is presumed in the Solow formulation.[3] Following Solow's explanation, the "corrected GDP (gross domestic product) per man-day, or the GDP per man-day net of the shift in technology (symbolically $\frac{X(t)/N(t)}{A(t)}$) in the agricultural sector was growing at a rate of 1.94 percent per year (the last column of Table II). Examining this from a different angle, the NT $35.08 ($89.53 minus $54.45) of the NT $55.01 ($109.46 minus $54.45) increase in the real GDP per man-day can be inputed to increased capital (about 64%), and the remainder to increased productivity (about 36%).[4] In other words, capital formation rather than productivity increase is the major contributor to the output growth in the agricultural sector.[5]

As mentioned in Section 2.1 both the Solow measure and the total productivity index use the same concept as the Abramowitz residual. However, our findings indicate that shift in production efficiency based on the Solow measure is lower than the Doman formulation. This discrepancy can, however, be explained. Recalling the very characteristics of the two methods, Solow's method is used presumably to measure only the neutral technological change under the assumption that the sector is operating in the range of constant returns to scale, while the productivity index method is designed to reflect all the diverse forces that affect the quality of factor inputs, and hence includes more than the pure elements of technical change. In the agricultural sector capital was growing faster than labor. If the technological change is in the right direction - i.e. capital using - Solow's measure will surely under-estimate the contribution of technical change to the growth rate as discussed in Section 2.2.3.

3.2 Production under a Cobb-Douglas World in the Agricultural Sector

In this section, by estimating the Cobb-Douglas production function, we attempt to identify both the factors and the way these factors affect the growth of agricultural production. The procedure involves the estimation of the Cobb-Douglas function of the form

$$\Delta \ln X = r+\alpha\Delta \ln N+\beta\Delta \ln C \qquad (2.4.2).$$

In order to eliminate the effects of cyclical fluctuations and therefore to reduce the biases in the estimation, we instead estimate equation (2.4.3)

$$\Delta \ln X = r+\alpha\Delta \ln N+\beta\Delta(\ln S+\ln k) \qquad (2.4.3),$$

where X is the real gross product, N is the man days employed, S is the capacity utilization rate, and K is the real capital stock.[6] The regression results of equation (2.4.3) for different periods are summarized in Table III.

In the Cobb-Douglas world, during the entire period under consideration (1953-1972), the results show: (a) there is a 0.03 percent per year upward neutral shift in production; (b) with a one percent increase in labor input, output will be increased by 0.5956 percent, and a one percent increase in capital will increase output by 0.7086 percent; and (c) the sector is behaving under a situation characterized by increasing returns to scale.[7] As will be seen below, there are different structural epochs within the entire period. Therefore these features, which are the result of the aggregation of different structures, may not be very meaningful.

From the regression results presented in Table III, it seems, at first glance, that there is a clear division in the production characteristics between the first ten years and the last ten years. The first ten years (1953-1962) were associated with an upward neutral shift in the production function, with a more or less constant returns to scale production, and with a negative labor contribution to the production process. The latter ten years (1963-1972) showed a downward neutral shift in the production function and increasing returns to scale with positive contributions of both labor and capital to the production. However, when we apply Chow tests to search for the structural changes, the above impression of the sector is changed.

In searching for the structural changes, we begin by estimating equation (2.4.3) $\Delta \ln X = r + \alpha \Delta \ln N + \beta \Delta(\ln S + \ln k)$, with observations starting arbitrarily with the period 1953-1957. We set every five years as a subperiod. The results of the Chow tests in detecting the structural changes among the sub-periods are presented in Table IV. At the five percent level of significance we find that there are three different structural epochs -- 1953-1957, 1958-1967, and 1968-1972. The estimates of the Cobb-Douglas production function of the three epochs by using the dummy variable approach developed by D. Gujarati are summarized in Table V.

Among the three epochs, the estimated parameters differ significantly. In the first technological epoch, 1953-1957, the production was characterized by decreasing returns to scale with a very high output elasticity of capital (2.498) but a negative output elasticity of labor. The phenomenon can be interpreted to reflect the existence of a redundant labor force (disguised unemployment) and of a capital scarcity in the agricultural sector during that period.[8] Nevertheless, during that period the sector was enjoying the neutral type of technological progress at a rate of 4.03 percent annually.

As the sector evolved into the second epoch (1958-1967), the production characteristics changed. The output elasticity of labor increased sharply, although it still remained negative. On the other hand, the output elasticity of capital decreased from 2.498 to 0.878. It is a type of decreasing returns to scale, and the rate of neutral technological progress was reduced to 1.17 percent per year.

During the third technological epoch (1968-1972), production was in increasing returns to scale range, with positive output elasticities for both capital and labor. The output elasticity of labor (1.267) has surpassed the output elasticity of capital (0.616), and the rate of neutral technological progress is negative (-2.32 percent per year).

From the pure production point of view, under a Cobb-Douglas world, the factor's elasticity of production is also the factor's income share. In all of the three different production structures, the sizes of the elasticities of labor and of capital are different from what we would expect on the basis of their relative income shares (see Table II). This is due to the fact that our estimation of the elasticities of production is a technological relationship and the discrepancy may be explained by the market forces. However, since the output elasticity of labor increased relative to the output elasticity of capital in the three technical epochs, it suggests that the production in the agricultural sector was moving toward a labor using technology during the period 1953-1972. And since, during this period, the capital input was growing faster (5.26 percent per year) than labor (about 0.87 percent per year), the current labor using technological change was not in the right direction to stimulate the output growth. On the contrary, it was making a negative contribution to output growth.

3.3 The Agricultural Sector under a CES World

The estimation procedure of a factor augmenting CES function has been discussed in Section 2.3.2. The parameters of the CES function $X=[a(ke^{\delta t})^{-\rho}+b(Ne^{\lambda t})^{-\rho}]^{-1/\rho}$ are estimated in two steps by running the regression on the following two equations;

$$\ln(X/N)=-\sigma \ln b+\sigma \ln(W/P)+\sigma rD+(1-\sigma)\ t \qquad (2.4.8)$$

$$\ln[(K/X)^{\hat{\rho}}-\hat{b}(K/N.e^{\hat{\lambda} t})^{\hat{\rho}}]=\ln\ a-\hat{\rho}\delta t \qquad (2.3.9)$$

The regression results are summarized in Table VI.[9] Three interesting features are worth mentioning from the results of the regression on the period 1952-1972.

(1) During the entire period under observation, capital efficiency was declining at the rate of 0.96 percent per year while labor's efficiency was improving at 7.09 percent per year.[10] In section 2.2.4 we mentioned that $\frac{\partial R(t)}{\partial \delta}, \frac{\partial R(t)}{\partial \lambda} > 0$. In our present case, the declining efficiency of capital in the agricultural sector implies that the capital input was making a negative contribution to the output growth in the agricultural sector, although the marginal product of capital remains positive. Therefore, it leaves the increase in the efficiency of labor the main contributor to the agricultural growth.

(2) The elasticity of factor substitution is 0.55 in the period 1952-1972. This figure is rather small. The traditional rural sector is said to be engaged in present agricultural production with a wide range of techniques and alternative combinations of labor and capital. That is, the agricultural sector has a large magnitude of elasticity of

factor substitution. Our finding is contrary to such a general belief. However, at another point to be discussed below, we do confirm Baldwin's theory that as agriculture becomes more specialized in the course of development, one may expect its elasticity of factor substitution to be declining.[11]

(3) Based on the criteria $B = (1-\frac{1}{\sigma})(\delta-\lambda)$ in testing the bias of technical change during 1952-1972, the agricultural sector was experiencing a capital-using type technical change, since the elasticity of substitution was less than one and labor becoming more efficient relative to capital. Again, this is contrary to what has been believed in the literature--that agricultural techniques in lower income economies are endogenously developed with labor-using bias to reflect the existence of the relative abundance of labor.

The above three findings may not be meaningful, because during the twenty-one years of observation the production structure may have changed, and hence an aggregate of the different structures can distort the real picture. In fact, when we divide the entire period into two sub-periods, the estimated production parameters do differ (see Table VI).

The production in the first ten years shows the following features:

(1) The elasticity of factor substitution is substantially greater than one. This seems to confirm the theory that in the early stage of development agricultural production is usually characterized by a wider range of substitution between capital and labor, because the technology involved is primitive.

(2) The efficiency rate of capital (5.53 percent per year) is much higher than that of labor, which itself is not significantly

different from zero, in this subperiod. This may serve as evidence that there exists a labor surplus in the sector and the increase in the efficiency of capital is the leading factor contributing to output growth during that period.

(3) The art of production is biased towards being capital using, since the elasticity of factor substitution is greater than one and the rate of capital efficiency is higher than that of labor. This is a phenomenon that contradicts the general belief concerning lower income economies.

During the latter eleven year period, the elasticity of factor substitution fell to 0.337. Furthermore, not only has the efficiency rate of labor surpassed the efficiency rate of capital, but the efficiency rate of capital has become negative. Thus, reversing the previous trend, the increase in the efficiency of labor is the main factor contributing to the agricultural growth in the subperiod. In terms of the direction of the bias, the sector was continuously stayed in a state of capital using technological change.

3.4 Cobb-Douglas vs. Constant Elasticity of Substitution

In the above two sections, we have applied the same set of data to estimate the production functions in the Cobb-Douglas and CES forms in the agricultural sector. The conclusions we drew from these two production functions do not reinforce each other. Below is a brief summary of their differences.

(1) The findings from the estimation of the CES function do not confirm the presumption implied in the Cobb-Douglas function that the elasticity of factor substitution is equal to the value of one. (2) While the estimation of the Cobb-Douglas function shows that there was

a labor using technology during the period 1952-1972, the findings in the CES setting indicate that the technical change was becoming biased towards a capital using one in that period. (3) However, both settings suggest that in the earlier stage of development in the agricultural sector, capital was the main contributing factor to the output growth. But in the later stage, labor replaced capital as the main contributor to this growth.

In this study we make no attempt to explore the reasons that lead to the differences in the conclusions. Since there are different presumptions implied in the two production functions, which make them non-comparable in some respects, we do not attempt to reconcile the difference. However, it can be useful to again remind ourselves of some of the basic features of the two production functions.

Both of the production functions possess the desirable neoclassical production properties that the marginal product of each factor input is positive and declining. The Cobb-Douglas production function is attractive for its simplicity - it is easy to comprehend and is economical to apply. However, it gives us only the estimation of neutral technical change, unless we are able to detect differences in the periods of production structure, from which we may investigate the possible bias of technical change. Furthermore, the substitution between commodities or between factors of production is the primary point of emphasis of neoclassical economics, but the Cobb-Douglas production function compels the elasticity of substitution between labor and capital to take on a value only of unity. The CES production function relaxes this limitation.[12] But a less restrictive specification such as this is not without cost. As mentioned in Section 2.4.2, in the case of the CES specification, the production parameters cannot be directly estimated in a single step. Not only are extra assumptions and side relationships needed before we can actually fit the data to the production function, but in the ultimate reduced form derived above, it is still a non-linear function whose estimation liability still is not generally agreed upon. Of course one may argue that the CES function itself may not be responsible for such a disadvantage and that it is primarily a question of the state of the art of statistical technique.

It seems fair to say that between the two production functions, the short-comings of one are the merits of the other, and vice versa. Therefore, it becomes obvious that neither of them can claim superiority to the other. The less restrictive CES function has been severely reduced in its desirability by the complexity and gravity of its estimated fitting. In addition, the function releases only the restriction of a unitary elasticity, but does not allow the elasticity to vary with the ratio of factor inputs.[13] Perhaps the most valuable lesson learned in the comparison of the results of the Cobb-Douglas and the CES production functions is that it is quite possible for us to draw very different conclusions from the same set of data if we apply them to different specifications of production functions.

FOOTNOTES

1 For example, Arthur Lewis's "Economic Development with Unlimited Supply of Labor", and Fei-Ranis's "Development of the Labor Surplus Economy", all analyzed the accumulation of needed capital and relationship of agriculture and industry for development. Bruce F. Johnston and John W. Meller in the article "The Role of Agriculture in Economic Development", AER, September 1961, competently summarized five propositions to show the importance in which increased agricultural output and productivity contribute to over-all economic growth. They are:

A. Economic development is characterized by a substantial increase in the demand for agricultural products, and failure to expand food supplies in pace with the growth of demand can seriously impede economic growth.

B. Expansion of exports of agricultural products may be one of the most promising means of increasing income and foreign exchange earnings, particularly in the earlier stages of development.

C. The labor force for manufacturing and other expanding sectors of the economy must be drawn mainly from agriculture.

D. Agricultural sector can and should make a net contribution to the capital required for overhead investment and expansion of secondary industry.

E. Rising net cash incomes of the farm population may be important as a stimulus to industrial expansion.

2 T. H. Lee, Intersectoral Capital Flow in the Economic Development of Taiwan, 1895-1960, Cornell University Press, Ithaca, New York, 1971.

3 Such a test for the existence of non-neutral technical change is not adequate. See Footnote 7 of Chapter Two.

4 As Solow himself pointed out, 'this is not meant to suggest that the observed rate of technical progress would have persisted even if the rate of investment had been much smaller or had fallen to zero'. "Technical Change and the Aggregate Production Function", R. E. Statistics, August 1957, p. 316. Obviously, innovation must be embodied in new plant and equipment to be realized at all.

5 Solow's study for the American economy for the forty-year period beginning in 1919 shows that technical change accounted approximately for nine-tenths of the total change in labor productivity, the remainder being accounted for by the growth capital.

6
The correlation between the residuals of equation (2.4.3) and the capacity utilization rate is not significant (R^2=0.1749). We are therefore confident that the utilization rate we derived is proper for adjustment of capacity utilization.

7
Changes in the economies of scale can result from two sources--an expansion in the scale of operations for a given technology, or given the scale of operations, a change in technology. But we have no way of separating these two forces.

8
Rangnar Nurkse gave the simplest definition of "disguised unemployment" as that some labor could be withdrawn from the production without reducing the volume of output. In technical terms, the marginal productivity of labor is believed to be zero. "Excess Population and Capital Construction", Malayan Economic Review, October 1957. However, as A. Lewis describes it, in some situations the long run marginal productivity of labor could be zero or negative. Lewis. The Theory of Economic Growth, Homewood, 1955, pp. 327-328.

9
The regression on equation (2.4.8) was executed by the non-linear regression program written by D. A. Meeter, using D. W. Marquardt's maximum neighborhood method. The regression on equation (2.4.9) was executed by an ordinary least squared program. The standard output of the non-linear fitting does not include the R^2. We calculated the R^2 of the non-linear regression by running a regression of the observed in X/N against the estimated in X/N of equation (2.4.8). Besides, the t values of the non-linear regressions are below the usual standard. But as it is still an issue, the meaning of the t value in a non-linear regression is very vague.

10
We are aware that the regression in estimating the capital efficiency rate was performing poorly. The R^2 is as low as 0.28.

11
R. E. Baldwin, Economic Development and Export Growth--A Study of Northern Rhodesia, p. 59. When we partition the 1952-1972 into two sub-periods 1952-1961 and 1962-1972, the estimates of σ are 1.51 and 0.3367 respectively in the agricultural sector.

12
CES production function assumes that changes in relative factor input and prices do not alter the elasticity of factor substitution. The elasticity is determined by the underlying technology and remains constant during the observation period, but may not necessarily be equal to the value of one.

13 We do not intend to say that there is a sensible definite relationship between the elasticity of substitution and the ratio of factor inputs. However, several variable elasticity functions have been developed to take care of such problems.

CHAPTER FOUR

AN ANALYSIS OF THE MANUFACTURING SECTOR

Since the end of the second world war, the less developed countries have spared no effort in pursuing a rapid growth rate for their economies. Past history and prevailing facts suggest that there is a strong relationship between a country's strength and its degree of industrialization. Therefore, most nations in pursuing growth rank industrialization as one of their highest national priorities. To the less developed nations, industrialization is equivalent to economic development and is regarded as the best alternative to get rid of the shame of being poor and underdeveloped. It may be difficult to give one precise meaning to the term economic development. However, growth and development economists repeatedly point out that economic development is not equivalent to industrialization.[1] Not only because progress in industry is highly dependent upon agricultural development but the concentration of production in the primary sector is in itself not a cause of national poverty.

The rate of industrialization can be indicated by changes in the relative importance of manufacturing output in the production of the economy, or by the difference in the growth rates of manufacturing production and agricultural production as defined in Equation (2.2.14).[2]

Taiwan is one of the countries pursuing industrialization in the post war era. Since 1953 the nationalist regime in Taiwan has launched a series of four-year economic plans on the island. Industrialization and creation of an international trade market are points of nationalist chinese policy emphasis. Their efforts have shown favorable results.

During the period 1952-1972, the manufacturing sector in Taiwan was growing at an average rate of 12.77 percent per year. Although in 1952 manufacturing production was only about one third of agricultural production, in 1968 manufacturing production surpassed agricultural production. The nationalists thus were proud to announce that the Taiwan economy had reached the "state of take-off" in Rostow's sense and that Taiwan had stepped into and joined the club of the industrialized countries.[3]

In this chapter, as in the previous chapter, we attempt to examine features of manufacturing production and to identify the factors and the way these factors contribute to output growth. The results of productivity indexes, Solow's measure, production in the Cobb-Douglas world, and production in the CES world are presented in turn. In the last section we reviewed the process of the industrialization in Taiwan.

4.1 Productivity Indexes and Solow's Measure

During the period 1952-1972, the manufacturing sector was growing at a rate of 12.77 percent per year. As shown in Table VII, the factor inputs of capital and labor for the manufacturing sector were increasing at rates of 3.80 percent and 7.46 percent respectively during the same period. Obviously, the rapid output growth rate cannot be fully explained by the increases in the factor inputs.

According to Domar's formulation of the total productivity index, productivity in the manufacturing sector was growing 7.34 percent per year, as compared with 1.63 percent in the agricultural sector during the period 1952-1972. The partial factor productivities show that in the manufacturing sector the real output per worker was growing 5.32 percent per year and the real output per unit of capital was increasing

8.98 percent per year. The capital-labor ratio was declining at a rate of 3.66 percent per year. These figures suggest that the rapid growth in manufacturing production was largely due to improvement of production technology and that the technical change, as we discussed in Section 2.2.3, should be of capital saving type to give a positive contribution to the output growth.

Table VII also contains Solow's measures. According to Solow's approach, production efficiency in the manufacturing sector between 1953-1972 has increased by 29.54 percent. The production function has been neutrally shifted upward by a 4.37 percent per year. Solow's measure also indicated that the real gross domestic product per worker, net of the shift in technology (X/N)/A(t) , was growing at a rate of 1.10 percent per year, and that among the NT$ 35,579 (NT$54,351-NT$ 18,772) increase in the real gross domestic product per worker in 1952-1972, 13.80 percent of the amount can be inputed to increased capital and the remaining 86.20 percent to the improvement in production technology.[4] Thus technological change is the major contributor to the output growth.

These findings from Solow's measure in the manufacturing sector are different from what we found in the agricultural sector. In the same period using Solow's measure, agricultural production was enjoying an upward neutral shift in production by 1.057 percent per year, and 64 percent of the increase in the real gross domestic product per unit of labor was contributed by the increase in capital. The remaining 36 percent was contributed by improvement in production technology.

As was the case in the agricultural sector, Domar's formulation and Solow's measure each implied different degrees of increases in production in the manufacturing sector efficiency. Domar's formulation shows that there was a 7.34 percent annual shift in production efficiency, while Solow's measure shows that production efficiency shifted 4.37 percent per year. As explained in Section 3.1, such a discrepancy can be attributed to the actual type of technical changes prevailing during the period, and to the more restrictive assumptions underlying Solow's measure, namely that production was in the range of constant returns to scale and that there were only neutral technical changes in production. Should the prevailing technological changes be in the right direction, in our case a capital saving technology in the manufacturing sector, Solow's measure may have underestimated the contribution of technical change to output growth.

4.2 Manufacturing Production in the Cobb-Douglas World

The regression coefficients of equation (2.4.3) give the estimates of the parameters of the Cobb-Douglas production function specified as equation (2.4.1). The regression results of equation (2.4.3) for the manufacturing sector are summarized in Table VIII.[5]

During the period 1953-1972, production in the manufacturing sector under the Cobb-Douglas specification shows that efficiency of production was growing 9.58 percent per year with decreasing returns to scale and that the output elasticities of capital and labor are 0.6994 and 0.0711 respectively. If we arbitrarily divide the 20 years of observation into two sub-periods, 1953-1962 and 1963-1972, the results revealed by the regressions are similar to the observation for the entire period--that is, a high growth rate of production efficiency prevailed and capital was more important than labor in production (output elasticity of capital is higher than that of labor). However, when we apply the F tests as in the last chapter to detect the possible production structural changes, we find that there are two different structural epochs, 1953-1957 and 1958-1972.[6]

Using the dummy variable approach developed by D. Gujarati, we find that the Cobb-Douglas production function of the two structural epochs reveal the following properties in manufacturing production (see Table X):

(1) In both epochs the efficiency rate of production remained very high -more than 8 percent per year.

(2) Labor was more productive than capital in the first sub-period. In the second sub-period, labor productivity was reduced sharply and capital became more productive than labor.

(3) Increasing returns to scale were observed in production in the first sub-period but not in the second sub-period.

(4) Since the output elasticity of capital increased relative to that of labor in the two sub-periods, production technology had been moving toward a capital using type. And since the labor input was growing faster than that of capital, the underlying capital using technological change was not in a direction which would accelerate output growth. In other words, the capital using technological change in the manufacturing sector had made a negative contribution to output growth during the period 1953-1972.

The above findings for manufacturing production under the Cobb-Douglas specification are different from those of the agricultural sector. As mentioned in Section 3.2, in the agricultural sector there are three different structural epochs in the period 1952-1972. Agricultural production was characterized by decreasing returns to scale, and the marginal product of labor was negative in the first two structural epochs

(1952-1967). Marginal agricultural labor was unable to make a positive contribution to production until as late as 1968. Perhaps in comparing the empirical findings between the agricultural sector and the manufacturing sector under the Cobb-Douglas production specification, the most important revelation is that the agricultural sector experienced a labor using technological change while the manufacturing sector experienced a capital using technological change. Such a dualistic production phenomenon was widely predicted by many economists as a prevailing scene among the developing countries.[7] One of the most important effects of dualism is its influence on the pattern of employment. We will analyze this problem in the last chapter.

4.3 Manufacturing Production in the CES World

The production parameters of the CES function $X = [a(Ke^{\delta t})^{-\rho} + b(Ne^{\lambda t})^{-\rho}]^{-1/\rho}$ are estimated by regression on equations (2.4.4.) and 2.4.9).[8] These results are summarized in Table XI.

If we regard all the observations during the period 1952-1972 as a single production structure, then production in the manufacturing sector has the following three properties.

(1) The efficiency rate for capital is 8.27 percent per year and is 7.71 percent per year for labor. The two efficiency rates do not differ greatly. This means that the improvements in the efficiency of capital and labor have made an almost equal contribution to output growth. This is different from the conclusion we drew from the agricultural sector. Agricultural production indicates that the capital efficiency rate is a negative number, so that improvement in labor efficiency is the major contributor to output growth.

(2) The elasticity of factor substitution equals of 0.4366. The less elastic factor substitution gives support to the theory that because of specialization in production, the elasticity of factor substitution in the manufacturing sector is usually less than one. Our findings also support the theory that the elasticity of factor substitution in the manufacturing sector is less than that in the agricultural sector. In our case, the manufacturing elasticity of factor substitution is 0.4366 and the agricultural elasticity of factor substitution is 0.5487.

(3) We have shown in section 2.2.4 that in a purely factor augmenting model the type of technical bias is determined by the magnitudes of elasticity of factor substitution and the factor efficiency rate. The bias is expressed as $B(t) = (1-1/\sigma)(\delta-\lambda)$. Since in our case the capital efficiency rate is greater than the labor efficiency rate and the elasticity of factor substitution is less than one, the production technology involved in this period is of a labor using type ($B(t)<0$). Recalling our finding in the agricultural sector, it shows that agricultural production is of a capital using type.

Various interesting results were obtained when we bisected the period 1952-1972 into the two sub-periods, 1952-1961 and 1962-1972 (see Table IX).[9] The elasticity of factor substitution in the first ten year period and the later eleven year period are all around the value of 0.49. This figure is not very different from the value of 0.44 which was estimated for the entire period 1952-1972. However, in the first ten years, the labor efficiency rate is 17.27 percent per year which is higher than capital's 12.36 percent per year. Increases in both capital and labor's efficiency rates make great contribution to output growth in this period. In terms of the type of production technology involved, the first ten years were under capital using technology $(B(t)=(1-1/\sigma)(\delta-\lambda)>0)$. In the later eleven years, the production technology seems to be a neutral one $(B(t)=0)$ because of the almost equality of the two factor inputs' efficiency rates. The switch of the production technology from capital using to neutral seems to conflict with the conclusion drawn from the observation for the entire period that the production technology during 1952-1972 was a labor using type. However, we may put aside the conclusions drawn from the observations for the entire period 1952-1972 as a single production structure, because an aggregation of different production structures may distort the real picture.

In comparing the conclusions concerning the manufacturing sector and the agricultural sector drawn from the bisecting of the period 1952-1972, the following points are worth mentioning:

(1) The elasticity of factor substitution in agricultural production in the first ten years is 1.52, a value not only greater than that of 0.48 for the corresponding manufacturing production but greater than the value of one. This lends support to the theory that the elasticity of factor substitution is greater in agricultural production than in manufacturing production. However, in the later eleven years, the elasticity of factor substitution in the manufacturing sector is greater than that of the agricultural sector. This is a contradiction to the general belief.

(2) As for the rate of factor efficiency, it shows sectoral differentials. In the first ten years the labor efficiency rate of the manufacturing sector (17.27 percent per year) is higher than its capital efficiency rate (12.36 percent per year) and the labor efficiency rate of the agricultural sector which is not significantly different from zero. In the agricultural sector, the capital efficiency rate is

higher than that of labor in the first ten years. In the later eleven years, the agricultural labor efficiency rate is higher than that of capital (a negative figure) but still less than the labor efficiency rate of the manufacturing sector. In fact, both labor and capital efficiency rates in the manufacturing sector are higher than the corresponding rate in the agricultural sector.

(3) In the first ten years, the production technology is of a capital using type in both the agricultural sector and the manufacturing sector. In the later eleven years, the production technology in the agricultural sector still remains as capital using, but in the manufacturing sector it changes to a neutral type.[10]

4.4 The Process of Industrialization

It is true that industrialization may accelerate economic growth via improvement in productivity and hence raise the per capita GNP. However, economists agree that the concentration of a large percentage of production in the primary sector is in itself not a cause of poverty and that whether or not an industrial society enjoys a superior way of life is a non-economic question.[11] The question to be asked should be whether agricultural development or industrial development is the appropriate strategy to accelerate the country's economic development. In this section we analyze the factors affecting the industrialization process in Taiwan. The analysis is carried out solely from the production technology point of view.

Economists have suggested a great variety of industrialization strategies to the developing countries. The policy adopted by the Nationalist Chinese regime can be described by their slogan used in the 1950's and 1960's -- "Using agriculture to support industry"[7]. Rhetorically, such a policy emphasizes the industrial sector without depressing the agricultural sector. In reality it is equivalent to the well known policy of "squeezing agriculture to support industrial expansion". The theme of such a policy is concentrated on the acquisition of needed capital and the promotion of a high profit rate, through price manipulation, to facilitate industrial expansion. Evaluation of such a policy is not attempted here, for it involves not only economic analysis but also value judgments, such as the question of equity and the justification for maintaining a high rate of industrial profit at the cost of lowering the farmer's rate of profit. However, we would like to repeat the following facts: that under the policy of so called "using the agriculture to support industry", the manufacturing sector was able to grow at a rate of 12 percent per year; that manufacturing production, which was only one third of agricultural production at the beginning stage, surpassed agricultural production in fifteen years; that, instead of shrinking, agricultural production was growing at a rate of 4 percent per year during the same period.

The theoretical aspects of the impacts of agricultural and manufacturing production technologies on industrialization were discussed in section 2.4 of Chapter Two. Let us discuss the implications of the theory.

As derived in Section 2.2.4 the industrialization rate can be expressed by equation (2.2.15):[13]

$$R_M(t) - R_A(t) = E_M^c (\delta_M - \lambda_M) - E_A^c (\delta_A - \lambda_A) - (\lambda_A - \lambda_M)$$

It shows that if the value of the elasticity of substitution is less than one in both the agricultural sector and the manufacturing sector, the only sufficient condition for a successful industrialization is that the manufacturing sector makes use of a labor using technology, the agricultural sector makes use of a capital using technology, and the labor efficiency rate in the manufacturing sector be higher than in the agricultural sector. Otherwise, industrialization depends on the relative forces of δ_A, λ_A, δ_M, λ_M, E^C_M and E^C_A .

In Chapters Three and Four, the empirical findings of the CES production function indicated that there prevailed capital using technology in both subperiods in the agricultural sector, while in the manufacturing sector the first subperiod was characterized by capital using technology and the second subperiod was characterized by neutral technological change. The findings also provided us with the following information:

	σ_A	σ_M	δ_A	δ_M	λ_A	λ_M
1952-1961	1.51	0.4818	0.0553	0.1236	0.00001	0.1727
1962-1972	0.3367	0.4933	-0.0370	0.0633	0.0422	0.0639

Obviously, the above mentioned sufficient condition for a successful industrialization does not fit our situation. If we substitute the above estimated parameter values into equation (2.2.15), the following results are obtained:

$$R_M(t) - R_A(t) = E^C_M(\delta_M - \lambda_M) - E^C_M(\delta_A - \lambda_A) - (\lambda_A - \lambda_M)$$

1952-1961: $R_M(t) - R_A(t) = E^C_M(-0.04091) - E^C_A(0.05529) + 0.17269$

1962-1972: $R_M(t) - R_A(t) = E^C_M(-0.0006) + E^C_A(0.0792) + 0.0217$

Some conclusions can be drawn from these relationships.

(1) In both of the two subperiods, the labor efficiency rate is higher in the manufacturing sector than in the agricultural sector. This is a favorable factor in the industrialization of the entire period, for it has made the term $[(-\lambda_A - \lambda_M)]$ a positive number.

(2) In the second subperiod, the labor efficiency rate is greater than the capital efficiency rate in the agricultural sector. This is also a favorable factor in the industrialization of the second period, for the term $[-E_A^C(\delta_A - \lambda_A)]$ is a positive number.

(3) In the first sub-period, the term $[-E_A^C(\delta_A - \lambda_A)]$ is a negative number because the capital efficiency rate is higher than the labor efficiency rate in the agricultural sector. And in the manufacturing sector, the capital efficiency rate is higher than the labor efficiency rate in both sub-periods, so that the term $[E_M^C(\delta_M - \lambda_M)]$ is also negative in both subperiods. These are unfavorable forces in the industrialization process.

(4) Industrialization became possible because the unfavorable forces generated in the production process had been outweighed by the favorable forces.

FOOTNOTES

1
Just to give two examples here. Gunnar Myrdal conceives economic development to be "An upward movement of the entire social system", as expressed in Asian Drama, New York, 1968, p. 1869. C. E. Black expressed economic development as the attainment of a number of ideals of modernization such as a rise in productivity, social and economic equalization, modern knowledge, improved institutions and attitudes, and a rationally coordinated system of policy measures that can remove the host of undesirable conditions in the social system that have prepetuated a state of underdevelopment. The Dynamics of Modernization, New York, 1966, pp. 55-60.

2
However, others may simply define industrialization as the non-agricultural sector growing, not necessarily faster than the agricultural sector.

3
Professor W. W. Rostow, Stages of Economic Growth, Cambridge University Press, 1960. It is an historical stage approach in the course of development. According to Rostow, there are five stages of growth--traditional society, preconditions for take-off, the take-off, sustained growth, and mass consumption. The take-off is meant to be the central notion in Rostow's scheme, and has received the most attention.

4
See Footnote 4 in Chapter Three.

5
The regression results mostly satisfy general statistical standards. The dummy variable approach of the regression on the two structural epochs, 1953-1957 and 1958-1972, has further improved the statistical reliability as reflected in Table X.

6
The results of the F tests are presented in Table IX. The estimates of the parameters, using the dummy variable approach, are presented in Table X.

7
There are many views of dualism. Various arguments have been presented on the basis of differences in (a) social system, (b) racial or ethnic background, (c) production condition, (d) demographic behavior, (e) consumer expenditure and consumer savings behavior, and (f) the domestic and foreign sector. Ours is on the basis of production condition difference.

8
As previously noted, the regression on equation (2.4.8) was performed with the non-linear regression program designed by D. A. Mecter, using

D. W. Marquart's maximum neighborhood method. The regression on equation (2.4.9) was performed by an ordinary least squared program.

9
The division of the twenty-one years of observations into two groups is arbitrary and may not be a proper one. However, since there are two steps in the estimation of the parameters in the CES production function and one of the steps is a non-linear regression, the F tests performed in the Cobb-Douglas case cannot be duplicated here in detecting the structural changes.

10
Although the production technology is capital using in both of the two sub-periods in the agricultural sector, the degree of capital using in the second sub-period is deeper than in the first sub-period, as reflected by the value of $B(t)=(1-\frac{1}{\sigma}).(\delta-\lambda)$. The value of B(t) is 0.0186 for the first sub-period and is 0.156 in the second sub-period.

11
The answer to the question whether economic development always brings an increase in social welfare is never a clear one, let alone the question as to whether an industrial society enjoys a superior way of life. Granted that there are no measurement problems of GNP, e.g. quality and quantity, and exchange conversion, what development economists are concerned with is growth of output per capita of production, not satisfaction or happiness. The advantage of economic growth is not that wealth increases happiness but that it increases the range of human choice. It is very hard to correlate wealth and happiness. Further, output per capita may be increased by (a) prolonging the working hours, (b) enlarging the working population, (c) intervening in the market, (d) imposing compulsory saving and family planning . Without some kind of value judgment, a social welfare function cannot be constructed, and optimum welfare and happiness cannot be determined.

12
Taiwan's agriculture was well developed during the Japenese Occupation 1895-1945. This is a result of the Japanese colonial policy in Taiwan to build "an agricultural Taiwan, and an industrial Japan." The development of the agricultural sector in Taiwan during the Japanese occupation has been analyzed by Y. Ho, Agricultural Development of Taiwan, 1903-1960, Vanderbilt University Press, 1966, and S. C. Hsieh and T. H. Lee, An Analytical Review of Agricultural Development in Taiwan-An Input-Output and Productivity Approach, Chinese-American Joint Commission on Rural Reconstruction, 1958.

13
The notations in this equation were defined before. For convenience, we repeat them here. The subscripts M and A denote the manufacturing sector and the agricultural sector respectively. R(t) is the output growth rate. E^C is the output elasticity of capital. λ and δ are the efficiency rates of labor and capital respectively.

CHAPTER FIVE

PROBLEMS OF EMPLOYMENT AND INCOME DISTRIBUTION

There are two main purposes of this study--to measure technological change in the agricultural and manufacturing sectors and to access, at least qualitatively, the impact of technological change on output growth, employment, and income distribution. In the two previous chapters, we have measured technological change and its impact on the output growth of the agricultural and manufacturing sectors. In this chapter we will analyze the remaining two empirical applications of technological change--its impact on employment and income distribution.

The need to create employment while at the same time raising factor productivity and output by employing new technology is widely recognized in developing countries. In fact, all economic systems are concerned with employment and almost all economic theories have focused on this problem, for almost every measure of social well-being involves employment in some way. In the the Keynesian view, output has a substantial effect on employment. The classicists emphasize two factors relevant to employment--the rate of saving in relation to population growth and technological progress. The production function approach used in this study has the potential to handle both the forces of output and technological change affecting employment.

As for the problem of income distribution, i.e. the explanation of the behavior of the share of total income that accrues to labor relative to the share that goes to the owners of capital, a variety of traditional economic instruments have been considered in the literature. They are relative factor prices, product prices (influenced directly through price fixing, taxes, subsidies, degree of monopoly, and/or world prices), rationing of products and services, rationing of credit, trade policy, government taxes and transfer, inflation, and technology. Our analysis is again solely from the production technology point of view.

5.1 The Problem of Employment

Two forces generated by production technology may create unemployment: labor saving technology and increase in production efficiency.

It has been argued that induced labor saving technological change, especially in the industrial sector, has caused employment problems which are particularly acute in those countries facing rapid population and labor force growth, for the output expansion does not always have the capability to absorb the labor replaced by capital.[1] Our empirical study of the production of the agricultural and manufacturing sectors, using the specification of the Cobb-Douglas function, indicated that Taiwan fell into the category of dualism in production. The manufacturing sector was employing labor saving technology, while the agricultural sector was employing labor using technology. However, because of the huge expansion in manufacturing output, the negative effect on employment of the labor saving technological bias in the sector has been well offset.

The negative effect of an increase in production efficiency on employment can be shown in production with a Cobb-Douglas function specification. In Section 2.3.2 we indicated that labor demand is a function of production efficiency, output level, and economies of scale

$(N=(A_o e^{rt})^{-1/(\alpha+\beta)} \cdot (\beta/\alpha)^{-\beta/(\alpha+\beta)} \cdot X^{1/(\alpha+\beta)}$. Specifically, a one percent increase in production efficiency may reduce employment by $\frac{1}{\alpha+\beta}$ percent. However, this force can be offset by output expansion.[2] And since $\frac{\partial \ln N}{\partial r} \Big/ \frac{\partial \ln N}{\partial \ln X} = -1$, if the output growth rate is higher than the rate of production efficiency, the employment level can be increased. In our case, it has been shown that the output growth rates in both the agricultural and manufacturing sectors are greater than the production efficiency rates (see Table XIII). Therefore, employment in both sectors would be expected to rise. However, the increase in employment may not be able to absorb the increased labor force, and hence unemployment may increase.

In the situation that production is under the factor augmenting CES function specification, the demand for labor relative to capital depends on the magnitude of the factor efficiency rate and the magnitude of the elasticity of factor substitution, as indicated in Equation (2.3.8) $\frac{\partial \ln N/C}{\partial t} = \frac{1-\sigma}{\sigma 2} (\delta - \lambda)$. More specifically, technical changes increase demand for labor relative to capital only if (a) the capital efficiency rate is greater than that of labor when the elasticity of factor substitution is smaller than one, or (b) the capital efficiency rate is smaller than the labor efficiency rate when the elasticity of factor substitutionn is greater than one.

Utilizing the estimated production parameters and equation (2.3.8), the following conclusion emerges with regard to the agricultural sector-that in the period 1952-1961, the demand for labor decreased relative to the demand for capital, because there was a wide range of substitution between capital and labor and the capital efficiency rate was higher than that of labor. However, in the period 1962-1972, substitution between capital and labor was substantially reduced (maybe because of modernization in production), while labor efficiency was increased and capital efficiency tremendously decreased. Therefore, the demand for labor continued to remain low relative to the demand for capital.

The suppressed demand for labor resulting from production technology may exacerbate the unemployment problem in that sector. In terms of the industrialization of the economy, the reduced demand for labor in the agricultural sector may release labor force to the industrial sector, if the economy has reached the so-called "commerical point."[3] But in an economy with surplus labor, labor saving technology is unnecessary and may be undesirable. On the other hand, the relatively strong demand for capital in the agricultural sector will generate competition for capital between the agricultural and manufacturing sector.

In the manufacturing sector, because the substitution between capital and labor was low and the labor efficiency rate was higher than the capital efficiency rate during the period 1952-1961, the demand for labor decreased relative to capital. According to the induced innovation theory, such a capital using technology in the manufacturing sector is typical of the process of development. In the period 1962-1972, because of the near equality of the efficiency rates of capital labor, the demand for labor relative to capital remained the same.

Since both the agricultural and the manufacturing sector were employing capital using technology in production during the twenty one years of observations, our empirical findings using the CES specification do not support the induced innovation hypothesis. On the contrary, the degree of capital using in the manufacturing sector was slowing down in the period 1962-1972 while it was further accelerating in the agricultural sector. These factors not only stimulate an economy wide demand for capital but also exacerbate the problem of unemployment.

5.2 The Problem of Income Distribution

Some development strategists have argued that in order to expand industrial production a huge amount of capital investment is needed and a high rate of return is necessary to give incentive for investment. Consequently, there is concentration of wealth. But concentration of wealth is not worrisome according to these theorists. On the contrary, they further argue that concentration of wealth is favorable for reinvestment which will stimulate growth. The resulting poverty, they say, can be eliminated as the economy develops.

Not all are ignoring greater wealth equality in the process of development. Nor was it emphasized in specifying the goals of development, for it had been assumed that greater equality of wealth is positively correlated with growth. It is dubious to have such an optimistic view. Adelman and Morris proclaim "that the primary impact of economic development on income distribution is, on the average, to decrease both the absolute and the relative income of the poor. Not only is there no automatic trickle-down of the benefit of development; on the contrary, the development process leads typically to a trickle-up in favor of the middle classes and the rich. The absolute income of the poor begins to rise with development only when the nation moves well into the intermediate level of development. Furthermore, even here improvement is not automatic. The poorest segments of the population typically benefit from economic growth only when the government plays an important economic role and when wide-spread efforts are made to improve the human resource base."[4]

In the case of Taiwan, the capital share for the entire non-farm sector shows no trend but fluctuates between 47 percent and 51 percent of income during the period 1952-1972.[5] However, the stable relative factor income share during the twenty one years does not necessarily mean that there was no concentration of wealth in the development process in Taiwan. There is no definite relationship between relative factor share and wealth concentration. Wealth concentration can be the result of less persons holding a constant portion of national wealth. The ex-post stable relative factor income share in Taiwan reflects the final results of the influence of all the various factors listed at the beginning of this chapter. Nevertheless, investigation of the impact of technological change on relative factor income shares may help us understand the problem.

It was indicated in Section 2.3.2 that under an ideal situation[6] the rate of change in labor's relative share can be expressed as

$$\dot{S}/S=-(1-S)\left[B(t)+\left(1-\frac{1}{\sigma}\right)\frac{\dot{g}}{g}\right] \qquad (2.3.12)$$

That is, if the elasticity of factor substitution is less than unity and capital-labor ratio is increasing, then the rate of change in labor's relative share depends on the magnitude of the technological bias. If technological change is neutral, $B(t)=0$, an increase in the capital-labor ratio will be accompanied by an increase or a decrease in labor's relative share as $\sigma \lesseqgtr 1$. In the special case that $B(t)=0$ and $\sigma=1$, i.e.

the production is under the Cobb-Douglas specification, changes in relative factor supply will have no effect on the relative factor will have no effect on the relative factor shares, and the relative factor shares become stable.[7]

Utilizing the empirical findings in the agricultural and the manufacturing sectors under the Cobb-Douglas specification, we can draw two conclusions with regard to income distribution. (1) In the agricultural sector, during the period 1953-1972 a labor using technological change was occurring, hence it would be expected that labor's share of income would increase. If we believe that agricultural production can be truly described by the Cobb-Douglas function, then the ex-post stable income share of labor is a reflection of the fact that market forces and governmental policies together have offset the force created by the technical change in favor of the income share of labour. (2) In the manufacturing sector, the prevailing capital using technology during the period 1952-1972 would have increased the sector's capital share. This would have been a favorable force for industrialization, provided market forces and/or governmental policies had not interferred.

In the factor augmenting CES specification, the impact of technological change on income distribution can be expressed as

$$\partial\left[(qC)/(WN)\right]/\partial\delta = t(1-1/\sigma)\left[(qC)/(WN)\right] \qquad (2.3.14)$$

$$\partial\left[(q.C)/(W.N)\right]/\partial\lambda = -t(1-1/\sigma).\left[(q.C)/(W.N)\right] \qquad (2.3.15)$$

and

$$d\left[(q.C)/(W.N)\right] = t.\left[(q.C)/(W.N)\right].(1-1/\sigma).(d\delta - d\lambda) \qquad (2.3.16)$$

That is, a rise in the factor efficiency rate will increase (decrease) that factor's income share, as the elasticity of factor substitution is greater (less) than one; and the aggregate effect of changes in labor and capital efficiency rates on the factor share depends on the magnitude of the elasticity of factor substitution and the relative magnitudes of changes in the rates of factor efficiency.

In Chapter Three we obtained the following values of the CES function production parameters in the agricultural sector:

	σ	δ	λ
1952-1961	1.52	5.53%	0.001%
1962-1972	0.3361	-0.037%	4.22%

They imply that in the agricultural sector during the period 1952-1961 the rate of labor efficiency, which itself is not significantly different from zero, does not have a significant effect on the factor income share. The high capital efficiency rate increases capital's income share because of the wide range of factor substitution. In the period 1962-1972 both the increasing labor efficiency rate and the decreasing capital efficiency rate resulted in an increased income share of capital, as the elasticity of factor substitution is less than unity. In summary, production technology was continuously pushing up the income share of capital in the agricultural sector during the entire period 1952-1972.

The situation in the manufacturing sector is somewhat different from the agricultural sector. The manufacturing sector under the factor augmenting CES function had the following parameters during the period 1952-1961; $\sigma = 0.4818$, $\lambda = 17.27\%$, and $\delta = 12.36\%$. The labor efficiency rate was growing faster than the capital efficiency rate. Therefore, the income share of capital increased relative to the income share of labor. In the period 1962-1972, the CES production function parameters were as follows: $\sigma = 0.4933$, $\lambda = 6.39\%$ / $\delta = 6.33\%$. Since there is no significant difference between the capital efficiency rate, the relative income shares of the factors are expected to be stable.

One of the common scenes in a developing economy is the existence of an internal labor migration from the rural to the urban area and a rural-urban income differential. Taiwan is experiencing this pattern also. Perhaps our empirical findings in the factor income shares may provide a partial explanation for such phenomena. That is, the prevailing production technology has caused the relative income share of labor to decline in the agricultural sector during the later stage and the relative income share of labor in the manufacturing sector to remain stable. This implies that production technology was creating a force pushing up the unemployment level and/or pressing down the real wage level in the agricultural sector relative to that of the manufacturing sector. Therefore an incentive for rural labor to migrate into the urban area emerged.[8]

With regard to the impact of technological change on the distribution of income, the conclusions drawn from the Cobb-Douglas specification and the CES specification are different. Again, the discrepancies are due to the different assumptions used in the specifications of the two production functions, and it is not intended here to judge which one of the two functions is superior.

FOOTNOTES

1 For example, C. Kennedy, "Induced Bias in Innovation and the Theory of Distribution", Economical Journal, September 1964.

2 More specifically, $\partial \ln N/\partial r = 1/(\alpha+\beta)$ and $\partial \ln N/\partial \ln X = 1/(\alpha+\beta)$.

3 See Fei and Ranis, Development of the Labor Surplus Economy, Theory and Policy, pp. 200-211. When the agricultural sector reached this stage, the redundant agricultural labor force disappeared and the industrial employers had to compete with the landlord for the supply of labor.

4 I. Adelman, "Development Economics--A Reassessment of Goal", AER Paper and Proceedings, May 1975, cited from I. Adelman and C. T. Morris, Economic Growth and Social Equity in Developing Countries, Stanford, 1973.

5 The capital share for the farm sector is inobtainable. The only compensation to employees published by the government in the farm sector is available only to hired labor during the seasonal peak load period. Compensation to self-employees is not included.

6 Three assumptions were made in deriving equation (2.3.12). They are (a) the production function is homogeneous of degree one (b) the marginal products of factors are positive but declining, and (c) the input and output markets are competitive.

7 Many economies, Taiwan being one of them, are showing a stable relative factor income share over time. Some economists, therefore, have proposed that aggregate production can be described by the Cobb-Douglas function. However, it is worthwhile to repeat that the ex-post relative factor share is the final result of various influences, of which production technology is only one.

8 In the estimation of the CES function, we also constructed the relationship of the equilibrium wage and the observed wage as $W^* = W_e^{rD}$, where W^* is equilibrium wage, W is observed wage and D is idling rate (D = 1 - capacity utilization rate). It was estimated that in the period 1962-1972 the observed agricultural wage rate differs more from the equilibrium wage rate than that in the manufacturing sector. Numerically, r = 2.4312 for the agricultural sector and r = 0.8766 for the manufacturing sector (see Tables VI and XI).

CHAPTER SIX

SUMMARY AND CONCLUDING REMARKS

6.1 The Purpose and Methodology of this Study

The post-war economic development of Taiwan is very often cited as a successful example of developing countries. There are numerous, interacting factors influencing economic growth. Succintly, this study is an attempt to answer three questions from production point of view regarding Taiwan's economic development: 1/ the contribution of technological change to growth in the process of economic development, 2/ the types of technological changes involved during the twenty-one years of observations, 3/ the implications of technological changes in regard to the problems of unemployment and income distribution in development. As the agricultural and the manufacturing sectors play a central role in the process of development, we analyze the above three questions with respect to these two sectors.

Two sets of factors lead to an increase in production: the increases in the amount of factor inputs and the increases in the productivities of factor inputs. Many factors may increase the amount of factor inputs. For example, the discovery of natural resources, the mobilization of the existing resources through governmental policy, and changes in consumer and producer behavior. However, the increase in production due to the increase in the amount of factor input is not the concern of this study.

Rather, we are concerned with the second set of factors: the increases in the productivities of factor inputs which result from the changes of production technologies. We utilize two methods, productivity indexes and the Solow measure, to measure the so called production residuals.

In order to decompose the production residuals and to detect the types of production technology changes, we attempt to estimate the production functions of the agricultural and manufacturing sectors. For comparison purposes, we estimate the two most frequently used production functions, the Cobb-Douglas function and the CES function, for the two sectors.

The estimates of the production parameters not only reveal the types of technological changes, but also provide us with the foundation to analyze the problems of unemployment and income distribution in the process of development.

6.2 Summary of Empirical Findings

Productivity indexes and Solow's approach have been used to measure the production residuals. Different assumptions were implied in these two approaches, and we obtained different results. In the agricultural sector, the productivity indexes approach indicated that the production residual was growing by 1.63 percent per year during the period 1952-1972, while the Solow measure showed the production was shifting upward by 1.057 percent annually during the same period, of which 64 percent was contributed by capital increase and 36 percent was contributed by productivity increase. In the manufacturing sector, the productivity indexes indicated that the production residual was growing by 7.34 percent annually. The Solow measure indicated that there was a 4.37 percent annual upward shift in the production, of which 13.80 percent was contributed by capital increase, and the remaining 86.20 percent by productivity increase.

From the estimation of the Cobb-Douglas production function, we find there are three technological breaks in the agricultural sector, 1953-1957, 1958-1967, and 1968-1972. The output elasticity of labor was increasing while the output elasticity of capital was declining in these three technological periods implying that the technological change was labor using in the agricultural sector.

There are two technological breaks in the manufacturing sector, 1953-1957 and 1958-1972. Contrary to what was happening in the agricultural sector, the output elasticity of capital was increasing while the output elasticity of labor was declining in these two technological periods. Therefore we conclude that there was a capital using technical change in the manufacturing sector.

The assumptions implied in the CES production function are different from those implied in the Cobb-Douglas function. The estimate of the CES production parameters indicate that there was prevailing capital using technological bias in both the periods of 1952-1961 and 1962-1972 in the agricultural sector. In the manufacturing sector, based on the estimates of the CES production function, there was capital using technological change in the period 1952-1961. The production technology in the period 1962-1972 was of a neutral type.

It is clearly indicated by the estimation of the Cobb-Douglas production function that dualism prevailed in production: labor using in the agricultural sector and capital using in the manufacturing sector. The high rate of automation, i.e. the shift of the production efficiency parameter, in both sectors created the force to reduce employment. Fortunately this force was outweighed by the output growth rates in both sectors. However, based on the estimates of the CES production function, because of the natures of the elasticity of factor substitution and the efficiency rates of capital and labor, the demand for labor was reduced in both sectors relative to the demand for capital during the entire period of observation.

With regard to the distribution of income, the estimation of Cobb-Douglas production function showed that labor's income share should have increased in the agricultural sector, while capital's income share should have increased in the manufacturing sector. However, the conclusion drawn from the CES production function provided a different picture. That is, in the agricultural sector, capital's income share should have increased, and in the manufacturing sector, the capital's income share should also have increased in 1952-1961, while remaining constant in 1962-1972.

Assuming the CES production function was operating in the economy, two favorable forces have contributed to the success of industrialization in Taiwan. They are 1/ the labor efficiency rate was higher in the manufacturing sector than in the agricultural sector during the entire period 1952-1972, and 2/ in the period 1962-1972 the labor efficiency rate was greater than the capital efficiency rate in the agricultural sector.

6.3 Remarks

Different conclusions emerged when we applied the productivity indexes and the Solow measure in measuring the production residuals. This is due to the fact that the two approaches have used different assumptions in their formulations, although both approaches proved to be using the same concept of the Abramovitz residual. For example, Solow's measure is under the assumption that the production function is homogeneous with constant returns to scale, which the productivity indexes approach does not assume.

The estimates of the production parameters of the Cobb-Douglas function and the CES function have been used in determining the types of technological changes and their implications in employment and income distribution. In the process of the estimation of these two production functions, we find the merits of one function are the shortcomings of the other function. Therefore, we intend not to claim any superiority between these two functions. However, it is interesting to discover that the conclusions we draw from the estimates of the two functions do not reinforce each other. The discrepancies are due to the different presumptions implied in the two production functions, which make them non-comparable in certain respects. Hence, we do not attempt to reconcile the differences.

In the text of this study, we repeatedly emphasize that the analysis on the problems is carried out purely from the production point of view. We are aware of the limitation of such an approach and would like to repeat this point here. The author hopes the theme of this study can be analyzed in a more general model. In addition, the study is analyzing two highly aggregated sectors. When the same analytical techniques are applied to each less aggregated industry individually, perhaps somewhat different conclusions can be drawn.

APPENDIX A:

STATISTICAL TABLES

The following thirteen pages contain the Statistical Tables mentioned in this study.

Table I. General Statistics of the Taiwan Economy

Year	1 Gross Domestic Product* (Mil.NT$)	2 Agricultural Gross Domestic Product* (Mil.NT$)	3 Mfg. Gross Domestic Product* (Mil.NT$)	4 Population (1000 prs)	5 Gross Domestic Product per Person* (NT$)	6 Percentage of Col. 2 to Col. 1 (%)	7 Percentage of Col. 3 to Col. 1 (%)	8 Gross Domestic Capital Formation* (Mil.NT$)	9 Persons of Working Age 15-59** (1000 prs)
1952	42,077	13,171.6	4,221.9	8,128	5,176	31.30	10.03	6,226	4,352
1953	45,887	15,288.4	4,759.5	8,438	5,438	33.31	10.37	6,700	4,493
1954	49,669	13,309.7	6,491.4	8,749	5,677	26.79	13.06	7,575	4,630
1955	53,758	14,845.5	6,673.2	9,078	5,921	27.61	12.41	6,362	4,772
1956	56,262	14,787.5	7,337.5	9,390	5,991	26.28	13.04	7,508	4,892
1957	60,407	15,774.8	8,522.2	9,690	6,233	26.11	14.10	7,439	5,013
1958	64,395	16,607.7	8,911.4	10,039	6,414	25.79	13.83	8,780	5,157
1959	69,090	17,511.3	10,873.2	10,431	6,623	25.34	15.73	10,352	5,330
1960	73,351	20,171.2	11,132.5	10,792	6,796	27.49	15.17	12,576	5,439
1961	78,714	20,932.9	12,086.5	11,149	7,060	26.59	15.35	14,395	5,568
1962	84,495	20,406.0	12,767.5	11,512	7,339	24.15	15.11	15,397	5,729
1963	92,577	20,831.6	16,347.1	11,884	7,790	22.50	17.65	16,502	5,926
1964	103,799	24,806.3	19,542.7	12,257	8,468	23.89	18.82	20,111	6,148
1965	115,990	26,465.8	21,075.9	12,628	9,185	22.81	18.17	26,154	6,393
1966	125,883	27,403.0	23,052.0	12,993	9,688	21.76	18.31	29,155	6,682
1967	138,735	28,628.7	26,128.2	13,297	10,433	20.63	18.83	35,713	6,918
1968	151,841	29,904.5	29,563.7	13,650	11,123	19.69	19.47	41,341	7,203
1969	164,817	27,508.2	33,373.6	14,335	11,497	16.69	20.24	44,124	7,838
1970	183,271	29,035.5	38,354.2	14,676	12,487	15.84	20.92	54,454	8,120
1971	204,097	29,281.5	46,863.3	14,995	13,611	14.34	22.96	60,675	8,419
1972	226,442	31,535.8	54,308.0	15,289	14,810	13.92	23.98	63,975	8,668
Annual Growth Rate	8.41%	4.36%	12.77%	3.15%	5.25%				3.44%

* The figures are in terms of 1966 NT$ value.

** Since 1969 the figures include military personnel, hence the 3.44% annual growth rate of persons of working age is overestimated.

Date source: Columns 1, 2, 3 and 8 are compiled from National Income of the Republic of China, 1973. Column 4 is digested from Taiwan Statistics Abstract, 1973.

Table II. The Productivity Indexes and the Solow's Measure of the Agricultural Sector

(All the monetary terms are at 1966 N.T.$ value.)

	1	2	3	4	5	6	7	8	9	10	11
Year	Real Gross Product (Mil.NT$)	Man Days (Mil. Days)	Real Capital Input (Mil.NT$)	Real Product Per Man-Day 1/2	Output per Unit of Capital 1/3	Capital-Labor Ratio 3/2	Capital* Share %	Total Factor Productivity Index	Residual	A(t)	$\frac{X}{N}$/A(t) 4/10
1952	13,171.6	241.9	14,596.3	54.45	0.902	60.34	48.02	100.00			
1953	15,288.4	246.6	14,970.7	61.99	1.021	60.70	50.33	103.25	.1186	100.00	61.99
1954	13,309.7	246.1	15,817.4	54.08	0.841	64.27	46.48	102.73	-.1721	111.86	48.33
1955	14,845.5	242.8	16,057.5	61.14	0.924	60.13	47.32	110.65	.1021	94.65	64.60
1956	14,787.5	251.7	16,773.9	58.75	0.881	66.64	46.15	111.27	-.0442	104.86	56.03
1957	15,774.8	268.6	17,331.5	58.72	0.910	64.52	47.18	108.16	.0151	100.44	58.46
1958	16,607.7	275.5	17,803.7	60.28	0.932	64.62	46.97	111.91	.0250	101.95	59.13
1959	17,511.3	274.7	18,096.8	63.74	0.967	65.87	50.89	99.52	.0446	104.45	61.02
1960	20,171.2	269.7	18,271.8	74.79	1.103	67.74	47.00	135.63	.1346	108.91	68.67
1961	20,932.9	267.0	19,167.3	78.40	1.092	71.78	47.75	133.99	.0191	122.37	64.07
1962	20,406.0	267.8	19,647.6	76.19	1.038	73.36	46.80	134.25	-.0389	124.28	64.31
1963	20,831.6	275.0	20,803.5	75.75	1.001	75.64	49.91	115.00	-.0209	120.39	62.92
1964	24,806.3	283.0	22,077.6	87.65	1.123	78.01	48.81	137.48	.1210	118.30	74.09
1965	26,465.8	300.7	23,445.2	88.01	1.128	77.96	46.53	152.50	.0043	130.40	67.49
1966	27,403.0	307.5	24,939.0	89.11	1.098	81.10	47.23	147.01	-.0059	130.83	68.11
1967	28,628.7	303.7	26,713.7	94.26	1.071	87.96	47.53	147.66	.0175	130.25	72.37
1968	29,904.5	304.7	29,957.8	98.14	0.998	98.31	48.01	142.64	-.0110	132.00	74.35
1969	27,508.2	298.6	31,585.9	92.12	0.870	105.78	48.91	123.96	-.0998	130.90	70.37
1970	29,035.5	295.5	33,474.5	98.25	0.867	113.28	49.58	123.87	.0296	120.92	81.25
1971	29,281.5	299.0	34,821.8	97.93	0.840	116.46	47.46	134.69	-.0163	123.88	79.05
1972	31,535.8	288.1	41,794.3	109.46	0.754	145.06	47.04	138.51	.0125	122.25	89.53
Annual Growth Rate	4.36%	0.87%	5.26%	3.49%		4.39%		1.63%		1.057%	1.94%

*This is a figure for the entire non-farm sector. A reliable figure for the farm sector was not obtainable.

Data Sources: Columns 1 and 7 are compiled from National Income of the Republic of China, 1973.
Columns 2 and 3 are the estimated figures by T.H. Lee and Y.E. Chen, "Growth Rate of Taiwan's Agriculture, 1911-1972," Paper presented in the Conference of Agricultural Growth in Japan, Korea, and the Philippines, Feb. 1973, Honolulu, Hawaii.

Table III. Summary of the Regression Results of the Cobb-Douglas Production Function: $\Delta \ln x = \gamma + \alpha \Delta \ln N + \beta \Delta (\ln S + \ln k)$

– Agricultural Sector–

Year	$\hat{\gamma}$ (t value)	$\hat{\alpha}$ (t value)	$\hat{\beta}$ (t value)	R^2	Durbin-Watson Stat.	Degree of Freedom
1953-1972	0.0003 (0.020)	0.5956 (1.295)	0.7086 (4.341)	0.5328	2.22	17
1953-1962	0.0151 (0.807)	-0.1563 (-0.240)	1.2997 (4.285)	0.7242	2.65	7
1963-1972	-0.0222 (-1.565)	1.1049 (3.212)	0.6843 (5.708)	0.8405	2.46	7
1953-1957	0.0403 (3.345)	-1.6002 (-4.009)	2.4984 (10.353)	0.9820	2.48	2
1958-1967	0.0117 (1.162)	-0.1389 (-0.463)	0.8788 (7.422)	0.8874	1.67	7
1968-1972	-0.0232 (-1.484)	1.2678 (1.7480)	0.6165 (4.734)	0.9185	2.28	2

Table IV. Subsidiary F Tests for Structural Breaks in the Cobb-Douglas Production Function - Agricultural Sector -

Years	Sum of Squared Residuals	Degree of Freedom	Calculated F	Theoretical F
1953-57 vs. 1958-62				
1953-1957	0.000916			
1958-1962	0.00139	3/4	9.1667	6.59
1953-1962	0.01816			
1958-62 vs. 1963-67				
1958-1962	0.00139			
1963-1967	0.00038	3/4	1.2263	6.59
1958-1967	0.00339			
1958-67 vs. 1968-72				
1963-1967	0.00038			
1958-1962	0.00139			
1968-1972	0.00126	3/6	9.6303	4.76
1958-1972	0.01762			

Table V. Epochal Estimates of the Cobb-Douglas Production Function: $\Delta \ln X = \gamma + \alpha \Delta \ln N + \beta \Delta (\ln S + \ln K)$

\- Agricultural Sector -

Epoch	$\hat{\gamma}$ (t ratio)	$\hat{\alpha}$ (t ratio)	$\hat{\beta}$ (t ratio)	R^2	$\hat{\alpha} + \hat{\beta}$	$\frac{\hat{\beta}}{\hat{\alpha} + \hat{\beta}}$	Durbin-Watson Stat.	Degree of Freedom
1953-57	0.0403 (3.180)	-1.6002 (-3.811)	2.4984 (9.843)	0.9456	0.8982	2.7815	2.11	11
1958-67	0.0117 (1.137)	-0.1389 (-0.463)	0.8789 (7.263)	0.9456	0.7399	1.1877	2.11	11
1963-72	-0.0232 (-1.656)	1.2678 (1.951)	0.6165 (5.282)	0.9456	1.8843	0.3271	2.11	11

Table VI. Summary of the Regression Results of the CES Production Function: $X = [a(Ke^{\delta t})^{-\rho} + b(Ne^{\lambda t})^{-\rho}]^{-\frac{1}{\rho}}$

- Agricultural Sector -

	$\ln \frac{X}{N} = -\sigma \ln b + \sigma \ln \frac{W}{P} + \sigma \gamma D + (1-\sigma)\lambda t$					$\ln[(\frac{K}{X})^{\rho} - b(\frac{K}{Ne^{\lambda t}})^{\rho}] = \ln a - \rho\delta t$		
Year	σ (t value)	λ (t value)	γ (t value)	R^2	Degree of Freedom	δ (t value)	R^2	Degree of Freedom
1952-1972	0.5487 (1.8)	0.0709 (1.4)	1.8338 (1.8)	0.978	17	-0.0096 (-2.687)	0.2754	19
1952-1961	1.51 (1.0)	0.00001 (0.2)	1.1164 (1.0)	0.252	6	0.0553 (4.784)	0.7410	8
1962-1972	0.3367 (0.9)	0.0422 (1.7)	2.4312 (0.8)	0.972	7	-0.0370 (-7.022)	0.8456	9

Table VII. The Productivity Indexes and the Solow's Measure of the Manufacturing Sector

(All the monetary terms are at 1966 N.T.$ value.)

Year	1 Real Gross Product (Mil.NT$)	2 Labor Input (1000 prs.)	3 Real Capital Input (Mil.NT$)	4 Real Product per Worker (NT$)	5 Output per Unit of Capital 1/3	6 Capital-Labour Ratio 3/2	7 Capital* Share %	8 Total Factor Productivity Index	9 Residual	10 A(t)	11 $\frac{X}{N}/A(t)$ 4/10
1952	4,221.9	224.9	112,221	18,772	0.038	498.98	48.02	100.00			
1953	4,759.5	247.7	113,443	19,214	0.042	457.99	50.33	92.58	.0680	100.00	19,214
1954	6,491.4	275.8	114,469	23,536	0.057	415.04	46.48	150.31	.2317	106.80	22,037
1955	6,673.2	277.7	115,737	24,030	0.058	416.77	47.32	145.60	.0185	129.97	18,489
1956	7,337.6	281.6	117,323	26,056	0.063	416.63	46.15	169.44	.0779	131.82	19,766
1957	8,522.2	283.0	118,793	30,113	0.072	419.76	47.18	183.38	.1312	139.61	21,569
1958	8,911.4	281.5	120,753	31,656	0.074	428.96	46.97	193.27	.0386	152.73	20,727
1959	10,873.2	284.4	122,242	38,231	0.089	429.82	50.89	183.86	.1709	156.59	24,384
1960	11,132.5	289.0	125.263	38,520	0.089	433.44	47.00	233.60	.0036	173.68	22,179
1961	12,086.5	375.8	128,539	32,162	0.094	342.04	47.75	208.67	-.0701	174.03	18,481
1962	12,767.5	375.2	131,427	34,028	0.097	350.29	46.80	230.77	.0438	167.02	20,374
1963	16,347.1	402.5	134,267	40,613	0.122	333.58	49.91	235.23	.1871	171.40	23,695
1964	19,542.7	478.0	139,038	40,884	0.141	290.87	48.81	269.87	.0782	190.11	21,505
1965	21,075.9	553.4	146,450	38,084	0.144	264.64	46.53	298.97	-.0273	197.93	19,241
1966	23,052.0	616.7	153,714	37,379	0.150	249.25	47.23	290.29	.0102	195.20	19,149
1967	26,128.2	695.7	164,783	37,556	0.159	236.86	47.53	293.91	.0295	196.22	19,139
1968	29,563.7	730.3	176,864	40,481	0.167	242.18	48.01	305.32	.0617	199.17	20,324
1969	33,373.6	816.0	188,146	40,899	0.177	230.57	48.91	300.74	.0348	205.35	19,916
1970	38,354.3	848.4	205,841	45,207	0.186	242.62	49.68	312.53	.0706	208.82	21,648
1971	46,868.3	873.1	221,748	53.680	0.211	253.98	47.46	407.98	.1366	215.88	24,865
1972	54,308.0	999.2	239,715	54,351	0.277	239.91	47.04	434.28	.0399	229.54	23,678
Annual Growth Rate	12.77%	7.46%	3.80%	5.32%	8.98%	-3.66%		7.34%		4.37%	1.10%

*This is a figure for the entire non-farm sector. A figure for the farm sector was not obtainable.

Data Sources: Columns 1 and 7 are compiled from the National Income of the Republic of China, 1973. Column 2 is compiled from Taiwan Reconstruction Statistics, 1973, and various issues of the Quarterly Labor Productivity Survey.

Column 3 is compiled from the Commercial and Industrial Census of 1966 and 1971, and National Income of the Republic of China, 1973.

Table VIII. Summary of the Regression Results of the Cobb-Douglas Production Function: $\Delta \ln x = \gamma + \alpha \Delta \ln N + \beta \Delta (\ln S + \ln K)$

- Manufacturing Sector -

Year	$\hat{\gamma}$ (t value)	$\hat{\alpha}$ (t value)	$\hat{\beta}$ (t value)	R^2	Durbin-Watson Stat.	Degree of Freedom
1953-1972	0.0958 (6.143)	0.0711 (0.476)	0.6994 (5.454)	0.6444	1.10	17
1953-1962	0.1048 (5.195)	0.2323 (1.098)	0.8887 (4.126)	0.7213	0.81	7
1963-1972	0.0857 (2.577)	-0.0356 (-0.157)	0.7563 (3.873)	0.7156	1.74	7
1953-1957	0.0883 (10.924)	1.1634 (9.311)	0.7415 (11.931)	0.9924	2.10	2
1958-1972	0.0817 (6.434)	0.0264 (0.256)	0.7720 (7.348)	0.8184	1.91	12

Table IX. Subsidiary F Tests for Structural Breaks in the Cobb-Douglas Production Function

- Manufacturing Sector -

Year	Sum of Squared Residuals	Degree of Freedom	Calculated F	Theoretical F
1953-57 vs. 1958-62				
1953-1957	0.000321			
1958-1962	0.002387	3/4	8.5864	6.59
1953-1962	0.02015			
1958-62 vs. 1963-67				
1958-1962	0.002387			
1963-1967	0.001316	3/4	0.7356	6.59
1958-1967	0.005746			
1958-67 vs. 1968-72				
1958-1962	0.002387			
1963-1967	0.001316			
1968-1972	0.002248	3/6	1.4683	4.76
1958-1972	0.01032			

Table X. Epochal Estimates of the Cobb-Douglas Production Function: $\Delta \ln X = \gamma + \alpha \Delta \ln N + \beta \Delta (\ln S + \ln K)$

- Manufacturing Sector -

Epoch	$\hat{\gamma}$ (t ratio)	$\hat{\alpha}$ (t ratio)	$\hat{\beta}$ (t ratio)	R^2	$\hat{\alpha} + \hat{\beta}$	$\frac{\beta}{\hat{\alpha} + \hat{\beta}}$	Durbin-Watson Stat.	Degree of Freedom
1953-1957	0.0883 (5.022)	1.1634 (4.280)	0.7415 (5.485)	0.8957	1.9049	0.3892	2.13	14
1958-1972	0.0817 (6.844)	0.0264 (0.272)	0.7720 (7.816)	0.8957	0.7984	0.9669	2.13	14

Table XI. Summary of the Regression Results of the CES Production Function: $X = [a(Ke^{\delta t})^{-\rho} + b(Ne^{\lambda t})^{-\rho}]^{-(1/\rho)}$

- Manufacturing Sector -

	$\ln \frac{X}{N} = -\sigma \ln b + \sigma \ln \frac{W}{P} + \sigma \gamma D + (1-\sigma)\lambda t$					$\ln[(\frac{K}{X})^{\rho} - b(\frac{K}{Ne^{\lambda t}})^{\rho}] = \ln a - \rho \delta t$		
Year	σ (t value)	λ (t value)	γ (t value)	R^2	Degree of Freedom	δ (t value)	R^2	Degree of Freedom
1952-1972	0.4366 (0.4)	0.0771 (0.5)	0.3278 (0.2)	0.844	17	0.0827 (26.074)	0.973	19
1952-1961	0.4818 (0.6)	0.1727 (0.6)	2.8122 (0.6)	0.941	6	0.1236 (14.240)	0.962	8
1962-1972	0.4933 (0.3)	0.0639 (0.3)	0.8766 (0.3)	0.666	7	0.0633 (25.226)	0.9861	9

Table XII. <u>Capital Stocks and the Utilization Rates in the Agricultural and the Manufacturing Sectors</u>

Year	Agricultural Sector		Manufacturing Sector	
	Capital Stock*	Utilization Rate	Capital Stock*	Utilization Rate
1952	14,596.3	.9760	112,221	1.0000
1953	14,970.7	1.0000	113,443	.8814
1954	15,817.4	.8820	114,469	1.0000
1955	16,057.5	.8890	115,737	.9055
1956	16,773.9	.8499	117.323	.8948
1957	17,331.5	.8715	118.793	.9365
1958	17,803.7	.8834	120,753	.9187
1959	18,096.8	.8980	122,242	1.0000
1960	18,271.8	.9961	125,263	.8906
1961	19,167.3	1.0000	128,539	.8452
1962	19,647.6	.9151	131,427	.7980
1963	20,803.5	.8790	134,267	.9236
1964	22,077.6	.9883	139,038	1.0000
1965	23,445.2	1.0000	146,450	.9537
1966	24,939.0	.9929	153,714	.9409
1967	26,713.7	.9941	164,783	.9641
1968	29,957.8	1.0000	176,864	1.0000
1969	31,585.9	.9079	188,146	.9322
1970	33,474.5	.9427	205,841	.9154
1971	34,821.8	.9385	221,748	.9744
1972	41,794.3	1.0000	239,715	1.0000

*In million NT$ at 1966 price level.

TABLE XIII

The Output Growth Rates and Production Efficiency Rates in the Agricultural and Manufacturing Sectors

	Agricultural Sector		Manufacturing Sector	
	Production Efficiency Rate	Output Growth Rate	Production Efficiency Rate	Output Growth Rate
First Epoch	4.03%	0.63%	8.83%	11.65%
Second Epoch	1.17%	5.45%	8.17%	18.97%
Third Epoch	-2.32%	1.06%		

Sources: See Table II and Table VII

APPENDIX B:

LIST OF SELECTED ENGLISH PUBLICATIONS ON TAIWAN'S DEVELOPMENT

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