CHAPTER 3

THEORETICAL FRAMEWORK

The following is the framework concerning the production function, labor productivity, human capital and technical approach to production function, in order to seek the proper model and thus estimate the role of public and private capital to the labor productivity.

3.1 Labor Productivity

3.1.1 The Definition

The productivity has many definitions. The definition by International Labor Organization (ILO) is the ratio of the input of the various elements of production to the output derived from that input.

The following equation may perform a true picture of productivity.

$$\text{Productivity} = \frac{\text{Physical Output}}{\text{Physical Input (+ invisible input)}} \qquad (3\text{-}1)$$

Productivity can be classified into 2 kinds

1. **The partial productivity** is the ratio of output divided by each factor of production. This method can identify the value of production in each factor of production in a period of time. But, this method can not determine the productive efficiency, which result from factor substitution, and advanced technology. The formular is shown in equation (3-2).
2. **The marginal productivity** is the amount of the last unit of output that a unit of input can produce.

The Total Factor Productivity (TFP) is claimed as the indirect method to calculate the change of real output that is not initiate by real input. Its implication is the quality or the effect of factor of production and the improvement of technology, and the indirect labor productivity.

The labor by means of production is the intelligence, knowledge, idea and other factors originated by people or labor to produced goods and services. However, nowadays the issues of intelligence, knowledge, and idea have been discussed that it should be defined as the "Human Capital" and classified as a factor in production function, which will be discussed in 3.2.2.1.

3.1.2 The Measurement

Average labor productivity or partial labor productivity can be calculated by the following equation.

Labor Productivity = Q/L (3-2)

Q = the value of output

L = the number of labor; unit, hour of work

The measurement of productivity can be computed by many methods, different by weighted value.

1. The labor productivity which is the ratio between output and total man-hour.
2. The labor productivity that is the ratio between output and total man-hour weighted by wage.
3. The labor productivity which is the ratio between output and the factor of production which each factors is then weighted by unit of work. The labor weight is the efficiency and quality of labor. The capital weight is the size of enterprise, machine, and other kinds of capital.

The cost of production is a certain amount of "Element of production" consumed for per unit of output, as the following equation:

Cost of production = physical input / physical output (3-3)

where, Productivity = Physical output / Physical input (3-4) and, Cost of production = 1/productivity (3-5)

The relation shows the reciprocal between 2 factors: the more productivity, the less cost of production.

3.2 The Theory of Production

3.2.1 The Definition

A production function is a schedule (or table, or mathematical equation) showing the maximum amount of output that can be produced from any specified set of inputs, given the existing technology or "States of the art". In short, the production function is a catalog of output possibilities.

Bland and Will(2001) mention that the factor of the general production is divided into 3 categories:

1. Labor, the other name is "Manpower".
2. Capital, All the machinery, equipment, machines, tools, and plants come under the head of capital. Capital is derived from savings or, to be exact the savings of stockholders or the reserve of the company itself. The capital equipment ratio or the intensity of capital bears directly upon the level of productivity.
3. Natural resource, included in this category is landed property, forestry, mineral and water resource and such other natural substance.

There are the "invisible inputs" involved in the process of the production, as the following aspects,

1. Motivating Power, optimum is the prime mover of enterprising spirit.
2. Knowledge, It is about to gain more efficacy in the employment of material and technology. Education is the most important factor to accelerate economy.
3. Technology, the application of scientific and technological knowledgement in meeting problems. In follows that the improvement on the actual technical know-how such as the maintenance of machinery equipment. The improvement of technology could yield a higher level of productivity.

4. Organization, the organizational structure and excellent leadership is an important factor.

However, generally, the invisible inputs are considered in the studies of firm level, because the individual opinion must be applied in the estimation. In the macro view, it is impossible to launch the questionnaires to every firm in the considering frame, especially, in the kingdom perspective. In additional, there might be other factors to determine and influence the macro economy as well. The common factors of production being used are capital and labor. The universal references are education, human capital, and technology.

The most common production functions are the Cobb-Douglas and the Fixed-coefficients (Leontief) production function. The first one exists with unitary elasticity of substitution the other one assumes a zero elasticity of substitution.

The simplest kind of production function is Leontief's form. He put inputs related in the fixed proportion to output as in the following equation.

$$\frac{X_j}{Y} = a_j \tag{3-6}$$

Where a_j = the input-output coefficient for the j_{th} factor of production and is constant for all the time points.

X_j = the amount of the j_{th} factor

Y = the level of output

This rigid description of the productive process of an economy is once a certain level of output for the economy as a whole, the input requirement for that level is determined by a constant input-output proportion. This system sequence is convergent, current production is the source of inputs, outputs are used as inputs and they use inputs, and then go on back wards through the system until an infinite sequence is generated.

The production function of the neoclassical theory does not depend on Leontief production function except in a very special case. The two factors of production generally used in the production function is labor and capital. Let us define maximum output, Q, to be a function of the usage of the various inputs. Generally, we use the capital variable as the fixed one because the more hour of work can be fast to do, while we can not immediately ''discharge" a building or a blast. As the result, the short-run production function is

$$Q = f(K, \bar{L}) \tag{3-7}$$

In the long run, the inputs can be substituted for one another to maintain the constant level of output.

$$Q = Q(K, L) \tag{3-8}$$

The widely used forms of production function are Cobb-Douglas production function and Constant Elasticity of substitution (CES) production function. The elasticity of substitution was first picked up by J.R. Hicks(1963), measuring the degree which performs a substitute value of a factor of production with the others.

The Cobb-Douglas production most frequently employed in early empirical work. Douglas working in the late 1920s remarked that the share of total US national output going to labor had remained well-nigh constant over time.

A number of properties of the Cobb-Douglas production function provide a convenient fruitfulness to economist's analysis. However, it has many restricts as well as the good points such as the elasticity of substitution is constant and always equal to unity. It is widely assumed in two factor of production L, and K, is as follow:

$$Y = \alpha L^{\beta_1} K^{\beta_2} \tag{3-9}$$

Where	Y	=	The unit of output
	L	=	The labor input
	K	=	The capital input
	α	=	The scale of operation , or the efficiency parameter

β_1 and β_2 perform the scale of return to scale. If $\beta_1+\beta_2$ is equal to, greater than, or less than unity implies to the constant, increasing, or decreasing returns to scale, respectively.

The other production function is CES production function, it has been utilized by the neoclassical economists as a basis of production function and distribution theory, as follow:

$$Y = \upsilon[\delta L^{-\rho} + (1-\delta)K^{-\rho}]^{-\nu/\rho} \quad (3\text{-}10)$$

Where Y = The unit of output

L = The labor input

K = The capital input

υ = The scale of operation

ν = The parameter of return to scale

ρ = The elasticity of substitution between labor and capital which equals $(\nu/\sigma)-1$

The parameter υ is known as the efficiency parameter or the scale of operartion or the state of technology and plays the same role as the cofficient A in the Cobb-Douglas production function. The parameter ρ, the substitution parameter, is the determinant of the value of the constant elasticity of substitution.

According to the objective of this study, compare, analysis and select functional form between Cobb-Douglas Production function and Constant Elasticity of Substitution Production function, the elasticity of substitution is required.

The elasticity of substitution is the proportionate change in the input ratio divided by the proportionate change in the factor price ratio. Note that the profit maximization model as well as the cost-maximization model also implies that factors will be combined so as to equate the marginal rate of substitution with the ratio of factor price. For the example, the elasticity of substitution between capital and labor can be described as when the price of labor rises relative to that of capital, in order to maintain the maximum attempt to substitute capital for labor and increase the capital/labor ratio.

The elasticity of substitution can be calculated as the elasticity of substitution. It can be measured by the following expression to calculate the point elasticity.

$$\sigma \equiv \frac{\frac{d(X_j/X_i)}{X_j/X_i}}{\frac{d(P_{x_i}/P_{x_j})}{P_{x_i}/P_{x_j}}} = \frac{\frac{d(X_j/X_i)}{d(P_{x_i}/P_{x_j})}}{\frac{X_j/X_i}{P_{xi}/P_{x_j}}} \tag{3-11}$$

where σ = The elasticity of substitution

X_i, X_j = input at i and j th

P_{Xi}, P_{Xj} = price of input

The larger the σ, the greater the substitutability between the inputs. The value of σ lies between 0 and ∞. The σ = 0 is where the two inputs must be used in a fixed proportions complements to each other; in contrast, the σ = ∞ is where the two outputs are perfect substitutes for each other.

For any specification of Cobb-Douglas production function, no matter α+β=1 or not, the generalized Cobb-Douglas production function is characterized by a constant, unitary elasticity of substitution.[1]

3.2.2 The Augmented Factors of Production

The production function is normally assumed that there are 2 kinds of factor of productions, labor and Capital. However, there are 2 other important factors claimed as parts of the production function. These are human capital, and technical progress.

3.2.2.1 Human Capital

Wangudom (2001:4) cited that human capital was initially stated by Adam Smith in 1937 whom studied about the ability or educational level of workers and productivity, while Alfred Marshall (1922) emphasized on the labor was a kind of capital as he stated that the most valuable of all capital is that invested in human being. Schooling was defined as an institution

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[1] The calculated value of the input-output ratio and the marginal-product ratio which characterized a constant, unitary elasticity of substitution to Cobb-Douglas production function of 3 variables which is used in the study is demonstated in appendix 1. This distinguished charecter willl be employed as a tool to choose CD and CES production function in a later chapter.

specializing in the production of training. Backer sharply emphasized that on-the-job training and schooling were substitutable.

3.2.2.1.1 Human Capital as Input Factors

Lucus(1988) introduced human capital as an additional factor that could be accumulated into Solow model and endogenized the workers' decision that they could choose to allocate their time between production and human capital in this period increase over time. The production function and the law of motion for the accumulation of human capital are

$$Y = K^{\alpha}(uH)^{1-\alpha} \tag{3-12}$$

Where,

$$\dot{H} = B(1-u)H \tag{3-13}$$

Where $B>0$ and $(1-u)$ is the portion of time devoted to accumulate more human capital. He concluded that the output growth was driven by the rate of human capital accumulation.

There are many studies attempt to clarify and signify the role of human capital as an input factor; for example, Haskel, and Martin(1993)'s study which report that skilled labors or educated persons, used as the proxy of human capital in their studies, are significant to output and economic growth.

However, some studies verified that putting down human capital as an input factor is not significant to output. Such as Pritchett(1996)'s work, used pool data on average year of schooling across 42 countries and time series data during 1965 – 1985, indicates the result similar to Benhabib and Spiegel(1994)'s article: human capital is negatively related and insignificant to output growth.

3.2.2.1.2 Human Capital as the Source of Technology Progress.

Owning to the argument about the insignificance of human capital as the input factor, the alternative model, believed that human capital be the source of adaptation and utilization technology, is generated. It is so called "Catch-up technology approach".

Nelson and Phelps'(1966) studies are well known in this approach. They developed the model on the rationale that the human capital stock can affect technology progress through technology innovation and technology adoption.

Benhabib and Spiegel(1994) followed the research of Nelson and Phelps because they treated human capital as an ordinary input by average year of schooling in the production function but the growth of human capital has an insignificant effect to the economic growth.

Hence, they assumed that the ability of nations to innovate new technologies is measurabled by a function of its domestic human capital stock. The domestic innovation and catch up is taken into consideration. They determines the direct affect of human capital to aggregate factor productivity through Cobb-Douglas production function with domestic innovation, catch up, and ancillary variables (political instability and income distribution for investment rate).

Their method reveals the reason why the country with a very low level of human capital has a much higher growth rate than the leader; it is caused by the catch-up effect. The other countries, which are closer to the leader nation than that with very low level of human capital, might have the slow economic growth. It is due to the catch up effect making the difference to the growth.

In their model, human capital influences the growth of total factor productivity through the rate of domestically produced technological innovation, and the speed of adoption of technology from aboard. The human capital is an important feature in attracting physical capital. But, the result performs that the ancillary variables have a poor relation; however the human capital levels are highly correlated with these ancillary variable. The catch up model is as the following equation:

$$\frac{A_i(t)}{A_i(t)} = g_i(H) + c(H_i)\left[\frac{A_m(t) - A_i(t)}{A_i(t)}\right] \qquad (3\text{-}14)$$

Where, $A_m(t)$ = the technological level of the leading country which grows at the rate of g_m *(H)* (The income level is used as a proxy)

g_i *(H)* = The growth rate of human capital as the proxy of innovation (It might be proxied by educated person or average year of schooling, and etc.)

c (H) = The level of Human capital

Yuji Kubo and Hong-dall Kim (1996) examined the role of human capital in economic growth by using annual data of Korea and Japan and evaluate the 'technological diffusion' effect of 'imported technology' on output growth. The result shows the that the level of human capital and import technology played important roles in the process of economic development. Also, Bernard and Charles (1996) were employed catch-up approach to TFP function and found the similar result.

3.2.2.2 Technological Progress

The technological progress is provided by such technological advances, research and development to enhance the quality or quantity of the goods and services. The issue of how to introduce exogeneous technological progress into model becomes interesting. There are various types of technological approach and can be classified into 5 catagories, 10 classes.[2]

1. **Product Augmenting**

1.1 Hicks neutrality: This kind of function is generally used in many production function. He believes that the same amount of product produced by the less amount of factor of production from Y_t to Y_{t+1} is the result of technical advancement.

$$Y = A(t)\,F(K,L) \qquad (3\text{-}15)$$

The better technological advancement, the less amount of input in the same proportion of capital and labor, while gains the same amount of output from point A to pointB. In other words, the

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[2] For further details Ghosh, K. S.1991. Econometrics: Theory and application. Prentice Hall, NJ.: 115 and empirical study of M. Beckman and R. Sato. 1969. Production functions and technical progress. American Economic Reviews (59):91-92

relationship between the marginal rate of substuitution and the factor proportion is unchanged.

1.2 Labor additive:

$$Y = A(t)\,L + F(K,L) \qquad (3\text{-}16)$$

The increase in product is here proportional to the amount of labor used.

1.3 Capital additive:

$$Y = A(t)\,K + F(K,L) \qquad (3\text{-}17)$$

The increase in product is here proportional to the amount of capital used.

2. Labor Augmenting

2.1 Harrod neutrality:

$$Y = F(K, A(t)\,L) \qquad (3\text{-}18)$$

The technology is approach with the labor. The relationship between the capital-output ratio and the interest rate does not change.

2.2 Labor combining:

$$Y = F(K, A(t)\,K+L) \qquad (3\text{-}19)$$

The augmentation of labor, as measured in efficiency units, is proportional to the amount of labor used.

3. Capital Augmenting

3.1 Solow neutrality:

$$Y = F(A(t)\,K,L) \qquad (3\text{-}20)$$

By contrast to the behave of Harrod neutrality, the technical change is called Solow when the relationship between output per worker and the wage rate is invarient.

3.2 Capital combining:

$$Y = F(K + A(t)\,L, L) \qquad (3\text{-}21)$$

The augmentation of capital is proportional to the amount of labor used.

4. Input Decreasing

4.1 Labor decreasing: The inverse production function

$$L = G(K, Y) + C(t)Y \qquad (3\text{-}22)$$

Where C(t) is decreasing with time. G(K,Y) is the function of capital and output. The reduction of the labor input is thus proportional to output.

4.2 Capital decreasing

$$K = H(L, Y) + C(t)Y \qquad (3\text{-}23)$$

Similar to the Labor Decreasing, the reduction of capital is proportional to output. H(K,Y) is the function of labor and output.

5. Factor Augmenting Technical Progress

$$Y = F[A(t)\,K, B(t)L] \qquad (3\text{-}24)$$

The capital-output is seperable function of labor's share.[3]

It should be noted that the neutrality is defined in terms of relative share. When the technological is not neutral, it is either labor saving or capital saving. For example, if it is labor saving, the relative share of labor becomes lower after the technology, other things remaining the same. Hence, the Hicks

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[3] Factor-augmenting technical progress can be calculated by a more general way from the invariant relationship between the share and the elasticity of factor substitute.

neutrality might be labor saving, capital-saving or neutral. It behaves the same as Harrod neutrality and solow neutrality.

To reveal the bias of technical change in each neutrality, the elasticity of substitution is the key. Since the elasticity of substitution indicates the degree of change of relative share among the inputs, it implies to the change in relative share when an input change. For instance, if the elasticity of substitution is more than one, the relative share of a factor increases. A Hicks neutral invention is Harrod labor saving when the elasticity of substitution is greater than unity; the parallel arguments can be used for showing the relationship between the elasticity of substitution and the nature of inventions in Hicks, Harrod, and Solow framework.

The neutrality and bias of technical change of Hicks, Harrod and Solow are presented in the below table.

Table 4 Neutrality and bias of technical changes

Neutrality		Hicks	Harrod	Solow
Hicks Neutral	$\sigma > 1$	Neutral	Labor-saving	Capital-saving
	$\sigma = 1$	Neutral	Neutral	Neutral
	$\sigma < 1$	Neutral	Capital-saving	Labor-saving
Harrod Neutral	$\sigma > 1$	Capital-saving	Neutral	Capital-saving
	$\sigma = 1$	Neutral	Neutral	Neutral
	$\sigma < 1$	Labor-saving	Neutral	Labor-saving
Solow Neutral	$\sigma > 1$	Labor-saving	Labor-saving	Neutral
	$\sigma = 1$	Neutral	Neutral	Neutral
	$\sigma < 1$	Capital-saving	Capital-saving	Neutral

Source: Ahmad (1991:47)

Remark: σ represents the elasticity of substitution

The models applied to estimate will be selected according to Beckman and Sato(1969)'s empirical result. The reasons are demonstrated in section 5.1.2 and Table 5 in this study.