CHAPER 3

RESEARCH METHODOLOGY

3.1 Production and Growth Function Model

In the neoclassical production function or growth model used by Solow (1956), output (Y) is defined as a function of capital inputs (K) and labor inputs (L).

$$Y = f(K,L) \quad (1)$$

This basic model takes technology as a fixed, endogenous variable, which is represented in the function specification of the equation. That is, the available technology is implicit in the way this function can convert the inputs capital and labor into output. A change in technology would alter the production function.

It is generally assumed in equation (1) that Y is positive and diminishing marginal products with respect to each input, $f(K,L)$ is constant return to scale, and that the marginal product of each input approaches infinity as each input goes to zero (and approaches zero as each input goes to infinity). From this there are two main sources of economic growth. The first is growth in input (K, L) accumulation and the second is the exogenous change, e.g. change in production technology or change in factor productivity.

For the first cause, due to the diminishing in marginal productivity of both inputs (K, L), the depreciation of capital stock, and rate of population growth, long run growth rate of per capita output cannot be achieved by input accumulation. This leads to the consideration of the second source of economic growth: technology change or productivity growth. In this model, the technological change or the change in factor productivity is assumed to be an exogenous variable. Hence, long-run economic growth is contained in a variable that cannot be explained in this model. This exogenous growth explanation created the question of model validity and the need to create a new endogenous growth model.

The basic endogenous growth model consists of the model without diminishing return in a country's production function. However, generally, traditional inputs i.e. capital or labor are supposed to have the diminishing return property. Thus, instead of using physical capital as the definition of capital input, it is useful to assume broad capital, which includes human capital, as the new definition of capital input in this model. Once the residual factor is endogenized, productivity can be addressed directly. Generally, production productivity denotes the effectiveness of production technology, which may able to be measured by cost of production or input requirement for the particular product. The lower the cost of production, or the lower input requirement is the more production productivity. Thus, in the case of one output and many inputs, the ratio of output to weighted average input requirement shows the production productivity or the total factor productivity.

Since then, a significant amount of research has been spent on analyzing and evaluating TFP. This is because the effect of TFP on growth is not as easily explained as that of the two other factors, and its estimation has been the subject of rather continuous economic controversy.

The neoclassical framework can be taken further with the assumption that labor is not the only input factor. The neoclassical model attempts to measure productivity taking into account all factors of productivity. From this comes the concept of total factor productivity, which can be included as a third variable in the growth model in addition to factor accumulation. In other words, equation (1) becomes

$$Y = Af(K,L) \qquad (2)$$

where A denotes total factor productivity (also known as the productivity index or technological change), and is assumed to be greater than zero. That is to say, A is an index of all the factors other than labor and capital that are not explicitly accounted for in equation (1), but contribute to the generation of economic output. In this model, A is also considered an exogenous variable. In a regression equation analyzing a production function, A is simply the residual amount, or as put by some "the measure of our ignorance".

The Cobb-Douglas (CD) production function is a special case of the Constant Elasticity of Substitution (CES) production function. A Cobb-Douglas production function exhibits unitary elasticity of substitution. Therefore, the function is based on the assumption that elasticity of substitution between inputs is constant along the iso-quant curve and equal to one. However, though this assumption makes the CD function a very specific production function, its simplicity and convenience make it one of the most widely used for empirical studies in economic growth.

The general formula can be written as

$$Y = A \prod_{i=1}^{n} x_i^{\alpha_i} \qquad (3)$$

where Xi denotes input i, $0 < \alpha i < 1$, and

$$\sum_{i=1}^{n} \alpha i = 1$$

If it is assumed that production follows a Cobb-Douglas production function, then the equation (3) takes on the form of the geometric index

$$Y = AK^{\alpha}L^{(1-\alpha)} \qquad (4)$$

or

$$Y = AK^{\alpha}L^{\beta} \qquad (5)$$

where $\alpha + \beta = 1$.

Assuming competitiveness in K and L, and taking the natural logarithm of (5) gives

$$\Delta y = \alpha\Delta k + \beta\Delta l + \lambda \qquad (6)$$

where y is the growth rate of output for the given period, k is the growth rate of capital in the given period, l is the growth rate of labor in the given period, λ is the growth rate of A or total factor productivity in the given period, α is the output elasticity to capital, and β is the output elasticity to labor. Therefore TFP growth can be defined as,

$$\lambda = \Delta y - (\alpha\Delta k + \beta\Delta l) \qquad (7)$$

or, since β is sometimes practically easier to determine than α

$$\lambda = \Delta y - [(1-\beta)\Delta k + \beta\Delta l] \qquad (8)$$

3.2 TFP Growth Estimation

The two methodologies used in most research on productivity are the growth accounting method and the econometric estimation method. There are limitations to the growth accounting method, which depends heavily on marginal product of input and the factors price assumptions. As a result, the direct estimation of the production function and TFP growth is often taken as an alternative. The aim of using an econometric model is to calculate each factor's share of output with the particular production function. Then, by using the econometric results, TFP growth can be calculated as model intercept and its error term.

In this case, taking the regression of a Cobb-Douglas production function such as equation (6) will produce a residual term that can be used to estimate TFP growth (λ).

3.3 Analyzing Factors of TFP Growth

In order to develop a better understanding of the effect of trade on learning, and therefore TFP growth, a second equation will be necessary. Once the production growth function (6) has been used to estimate λ, another equation can be developed to analyze the factors that contribute to λ, such as

$$\lambda = f(a, \ldots, z) \tag{9}$$

where λ is now the estimated value of TFP growth obtained from the production function, and a through z are factors that may contribute to A. The relevance of variables a through z can then must be determined.

The intent of this work is to measure the indirect effect of trade on productivity, as one of the indirect effects of trade is learning at the industry and economy-wide level. Learning, a form of technology growth, is know to be experienced at the industry or economy-wide level as function of technology "spillover" (see Rosenberg (1982), Jaffe (1986), etc.). Equations are developed to measure the effect of trade-induced learning on productivity.

In order to facilitate handling of data and the regression analysis, I believe it will be easier to break trade up into separate components of imports and exports. From this I will make several equations to measure the effect of trade-induced learning from different trade variables separately.

As with all TFP analysis, output (Y) of the agricultural sector, and the primary factor inputs of agricultural labor (L) and capital (K) will be analyzed.

It has been suggested the technology upgrading embodied in investment in imported equipment could be an important engine of economic growth in developing countries. The ability of labor to use this new imported capital is dependent on one process of learning. Therefore, one variable to consider is imported capital (Km) used in the agricultural sector.

The effect of agricultural imports on productivity will be considered as a factor of trade-induced learning. All categories of agricultural imports (M) as well as two sub-groups can be considered. Imports are further defined as imports that compete (competitive imports) with the domestic industry (Mc) and imports that do not compete (non-competitive imports) with the domestic industry (Mn).

The value of considering these import categories is described in Lawrence and Weinstein where they note that there are two possible mechanisms by which imports may effect productivity growth. First, access to better intermediates (non-competing imports) may result in improved productivity. Alternatively, the presence of competing imports may encourage innovation or allow the producer to learn from examining imports.

Siamwalla (1996) gives a similar consideration of imported agricultural products. He divides agricultural crops grown in Thailand into three categories: exportables, import competing, and non-traded. His results indicate that the different categories experienced different productivity growth rates. He finds somewhat surprisingly that the import competing category experienced the fastest growth during the survey period. The explanation offered is that this fast growth may be due to the fact that some important crops within that category, for example the oil crops, are protected.

The second equation will be developed concerning export-induced learning. With regards to exports (X), it seems the learning would occur as a result of the experience gained from manufacturing products to export. Therefore, export-induced learning is probably a particular case of learning by doing. As such, the relationship of exports to output will depend on learning acquired for exports during past periods. Therefore the independent variable for exports should be lagged.

Although Arrow and Young argue that learning by doing is a bounded process experiencing diminishing returns, it is still important to measure in considering TFP. Assume as does Young, a continuum of goods, any of which could be produced at any given time, although in practice, only a small subset are produced at any one time. Further, though each good may be bounded in learning by doing, while learning is exhausted on one set of goods, it will continue on the remainder. Thus, across the continuum, learning does not diminish to the point of cessation. I believe this a logical assumption, particularly considering the market driving need for new products and the relatively higher bounds on learning that characterize new products as opposed to old products.

Liberalized trade or “openness” is considered a necessary, but not sufficient condition for rapid productivity growth (see Chuang, 1998; also Sach and Warner, 1995, and others). Openness is commonly defined as the ratio of imports plus exports to GDP (OPENXM) as in Sussangkarn (1997). However, in the case of Thailand's agricultural sector, openness is sometimes defined as the ratio of just exports to GDP (OPENX). This is because imports historically have made up such a small part of the Thai agricultural market that they are considered insignificant in determining the degree of trade liberalization in the sector. Though in general the exclusion of imports could potentially lead to the exclusion of contributors to productivity growth embodied in the import of capital goods or certain raw materials.

The area of land (LAND) under cultivation is sometimes used in place of capital (K) when analyzing productivity of the agricultural sector. This is typical in sectors that are not highly capital intensive. Therefore, it is important to consider land as well as, or as an alternative to K when doing analysis.

In review there are several variables that may be considered in analyzing the effect of various trade-related factors on factor productivity.

Y = agricultural sector output

L = labor input

K = stock of capital

Km = imported capital

M = imports, all crops

Mc = imports, competitive crops

Mn = imports, non-competitive crops

X = exports

OPENXM = openness proxy defined as (X+M)/GDP, or

OPENX = openness proxy defined as X/GDP

LAND1 = area of arable land, or

LAND2 = area of arable + permanent cropland

These variables can be used to create several equations to estimate TFP growth

$$Y = L^{\alpha_1} K^{\alpha_2} e^{\alpha_0} \tag{10}$$

$$Y = L^{\alpha_1} K^{\alpha_2} AREA1^{\alpha_3} e^{\alpha_0} \tag{11}$$

$$Y = L^{\alpha_1} K^{\alpha_2} AREA2^{\alpha_3} e^{\alpha_0} \tag{12}$$

and then to create several equations to consider trade effect on TFP growth.

$$A = Km^{\alpha_1} M^{\alpha_2} Mc^{\alpha_3} Mn^{\alpha_4} X^{\alpha_5} OPENX^{\alpha_4} OPENXM^{\alpha_5} e^{\alpha_0} \tag{13}$$

the above three equations are proposed where $\alpha1$ through $\alpha5$ are the output elasticities of each respective variable, and $\alpha0$ represents the rate of "pure technical change". (In other words, $\alpha0$ is the TFP that is still not specifically accounted for in the equation.)

From equation (10), a new equation is set up to express the total factor productivity growth of the agricultural industry, by taking the natural log.

$$\ln Y = \beta_0 + \beta_1 \ln L + \beta_2 \ln K + \varepsilon \qquad (14)$$

Equation (11) and (12) can be treated in the same manner.

$$\ln Y = \beta_0 + \beta_1 \ln L + \beta_2 \ln K + \beta_3 \ln AREA1 + \varepsilon \qquad (15)$$

$$\ln Y = \beta_0 + \beta_1 \ln L + \beta_2 \ln H + \beta_3 \ln AREA2 + \varepsilon \qquad (16)$$

In equations (14), (15) and (16) the β coefficients represent rates of return on the various factors of productivity, β_0 is the intercept (or "pure technical growth") and ε is the random error term. The sum of β_0 and ε make up TFP growth that is unaccounted for by specific factors in these equations.

Equation (13) is logged to determine the effect of the variables on the TFP growth estimate, giving

$$\ln\lambda = \gamma_0 + \gamma_1 \ln Km + \gamma_2 \ln M + \gamma_3 \ln Mc + \gamma_4 \ln Mn + \gamma_5 \ln X + \gamma_6 \ln OPENX + \gamma_7 \ln OPENXM + \varepsilon' \qquad (17)$$

The above variables can be considered in lagged form as well. In order to preserve statistical robustness with a limited number of data points, equation (17) can be divided into several smaller equations for analysis.

$$\ln\lambda = \gamma_0 + \gamma_1 \ln OPENXM + \gamma_2 \ln OPENXM_{t-1} + \varepsilon' \qquad (18)$$

$$\ln\lambda = \gamma_0 + \gamma_1 \ln OPENX + \gamma_2 \ln OPENX_{t-1} + \varepsilon' \qquad (19)$$

$$\ln\lambda = \gamma_0 + \gamma_1 \ln Km + \gamma_2 \ln Km_{t-1} + \varepsilon' \qquad (20)$$

$$\ln\lambda = \gamma_0 + \gamma_0 \ln X + \gamma_0 \ln X_{t-1} + \varepsilon' \qquad (21)$$

$$\ln\lambda = \gamma_0 + \gamma_0 \ln M + \gamma_0 \ln M_{t-1} + \varepsilon' \qquad (22)$$

$$\ln\lambda = \gamma_0 + \gamma_0 \ln Mc + \gamma_0 \ln Mc_{t-1} + \varepsilon' \qquad (23)$$

$$\ln\lambda = \gamma_0 + \gamma_0 \ln Mn + \gamma_0 \ln Mn_{t-1} + \varepsilon' \qquad (24)$$

Once the relationship between TFP growth and each trade-related variable has been determined, the individually relevant variables can be combined into a small equation describing TFP growth.

3.4 Data Collection

For the purpose of analysis, all data used in this thesis will be collected from secondary sources. These are authoritative sources of information on the agricultural sector and Thailand, including the NESDB, the Bank of Thailand, the NSO, the Customs Department, and the FAO.