CHAPTER 4
EMPIRICAL RESULTS

4.1 The Data

Though it appears that TFP can be easily measured by the traditional growth model, research, including this study, have run into data measurement and data availability problems. Finding appropriately detailed information on a sector of the economy is not an easy task. In this case of examining Thailand's agricultural sector, the following data and estimates were used.

For the purpose of this study, agriculture is defined as cultivated crops (rice, maize, etc.) and excludes forestry and aquaculture. Output (Table 1) is measured by the real value of gross domestic product at 1988 prices (Thai baht). The data comes from the Bank of Thailand and the National Economic and Social Development Board (NESDB).

Labor (Table 2) in the agricultural sector is measured by employment during the rainy season (survey Round 3), as surveyed annually by the National Statistical Office (NSO).

Capital (Table 1) input to agricultural output is measured by the real value of gross fixed capital stock, at 1988 prices (Thai baht). This data has been estimated by the NESDB.

Imported capital (Table 1) deployed in the agricultural sector is "imported agricultural machinery" as defined and recorded by the Food and Agriculture Organization of the United Nations (FAO), having been reported to FAO by the government of Thailand. All FAO data, reported in US dollars, is converted to Thai baht in real terms (1988 prices).

Agricultural imports (Table 3) are measured as all agricultural products excluding livestock, animal products and byproducts, fish and fishery products, and forestry products as recorded by the FAO.

Competitive and non-competitive agricultural imports (Table 3) are subsets of the total agricultural imports as recorded by the FAO. Items were selected for each category by comparing Thailand's imports and production of selected crops. A crop that was continuously imported over the past twenty years but not produced domestically in any significant quantity was classified as a "non-competitive" import. A crop that was both produced domestically and imported regularly over the past twenty years was defined as "competitive".

Non-competitive imports are specifically defined as apples, cloves, hops, pears, and ramie. Note that hops is the only crop not produced domestically, however, production of the other four crops in Thailand is very minimal relative to the imported amount.

Competitive imports are defined as barley, coffee (green), cotton lint, grapefruit, grapes, groundnuts (in shell equivalent), jute, maize, nuts (nes), oranges and mandarins, pepper, pimento (allspice), potatoes, pulses, sesame seed, sisal, sorghum, soybeans, tea, tobacco, vegetables (fresh, nes), and wheat.

Agricultural exports (Table 3) are measured as all agricultural products, not including forestry and fisheries products. The data is from the Thailand Customs Department.

Trade liberalization (Table 4), or the openness proxy is calculated from the values of total imports, exports and GDP. There are two forms used: OPENXM is the sum of agricultural exports and imports over agricultural GDP; OPENX is agricultural exports over agricultural GDP.

Land (Table 5) used in production is measured by the total cultivated area of rice and other crops. The data comes from the FAO and is reported in hectares. Two measurements are used. First, "Arable Land" (LAND1) is defined as land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. (This data is not meant to indicate the amount of land that is potentially cultivable.)

The second land measurement is "Arable and Permanent Crops" (LAND2). This is defined as the sum of arable land (above) and permanent cropland. Permanent cropland is land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee and rubber. This includes land under flowering shrubs, fruit trees, nut trees and vines, but excludes land under trees grown for wood or timber (i.e. forestry).

4.2 Analysis

As noted in the section above, there are at least two common methods to estimate TFP. The growth accounting approach and the direct estimation of the aggregate production function. In the direct estimation case, the production takes on a definite form with an assumption about A. Due to its simplicity, the most widely used form has been the Cobb-Douglas. This way, technical change is viewed as a shift of the production function over time at a reasonably smooth rate. The coefficient of the trend measures the average rate of TFP growth. Thus, the standard form used has been

$$\ln Y = A + \ln L + \ln K + \varepsilon$$

where A measures the average growth rate of output holding inputs constant, and ε is the disturbance term. This equation has been directly estimated in most cases using OLS, and thus OLS is used in this study.

First, TFP growth is estimated from taking the natural logarithm of equation (5) and then the regression with respect to y (GDP growth).

$$\Delta y = \alpha \Delta k + \beta \Delta l + \lambda \qquad (25)$$

In this case of Thailand's agricultural sector, which is not particularly capital intensive, it has been suggested that land also plays a key role in determining output. Therefore, a second production equation including land as a factor was analyzed in the same manner.

$$\Delta y = \alpha\Delta k + \beta\Delta l + \delta\Delta land + \lambda \qquad (26)$$

In both equations (25) and (26), the residual of the econometric output will serve as an estimate of TFP growth (λ).

The estimated value of λ is then used in equations (18) through (24) to determine the relationship of the various trade-related variables on TFP growth. These shorter equations have been used in place of equation (17), because of the limited number of data points in the sample size of thirty years annual data. This will also reduce the likely problems of multicolinearity that would be encountered with equation (17).

4.3 Results and Discussion

The analysis of the production growth function indicates that capital and labor do, as would be expected, explain a high percentage of the agricultural sector's output growth in Thailand. Individual OLS regression outputs are shown in Table 6. The growth of agricultural labor (L) and gross fixed capital stock (K) have a strong (0.01 level of significance), positive relationship to output growth (Table 6.1). These independent variables, labor and capital, on the right side of equation (25) are sufficient to explain more than 90 percent (R^2 = 0.9137) of output growth.

With the addition of land as a factor in the output growth equation, the explanatory power of the model becomes even greater. Growth of agricultural labor (L), capital (K) and land use (LAND1 or LAND2) all have strong (0.01 level of significance), positive relationship to agricultural output growth. When the area of arable land (LAND1) is considered (Table 6.2), these independent variables from the right side of equation (26) are sufficient to explain more than 98 percent (R^2 = 0.9806) of output growth. When the area of arable and permanent cropland (LAND2) is considered (Table 6.3), these independent variables on the right side of equation (26) are sufficient to explain more than 98 percent (R^2 = 0.9869) of output growth. In this particular study, the use of the variable LAND2 seems most appropriate, as the definition taken for agricultural crops includes both those grown on arable and permanent cropland. These results indicate that the equation below is well suited to explaining the agricultural sector's output growth, and therefore also for estimating TFP growth in the agricultural sector.

$$\Delta y = \alpha \Delta k + \beta \Delta l + \delta \Delta land2 + \lambda \qquad (27)$$

With the equation above explaining about 98 percent of output growth, there is only about two percent remaining that can be attributed to total factor productivity growth. This number is low possibly as a reflection of the relatively low amount of new research and technology investment in agriculture. It is lower than the level of TFP proposed by some research, but similar to that of Siamwalla (1996) and others.

From equation (27), TFP growth is estimated as the residual from the OLS output for each period, as shown in Table 7. These estimated values are then used in the regression analysis of equations (18) through (24) to determine the relationship between trade-related variables and TPF growth.

The effect of trade liberalization, where the openness proxy is the sum of agricultural exports and imports over agricultural GDP (OPENXM; Table 8.1) has a positive relationship to TFP growth when lagged by one period, which is significant at 0.05 level. The relationship to TFP growth is negative (significant at 0.10 level) during the same period. Considering the openness proxy of agricultural exports over agricultural GDP (OPENX; Table 8.2), there is again found to be a positive relationship to TFP growth when lagged by one period (0.05 level of significance) and a negative relationship to TFP growth (0.05 level of significance) during the same period. This shifting relationship can be explained by a hypothesis that the immediate effect (same period) of trade liberalization is purely a source of competition, however, in the longer term with time to respond to competition, trade liberalization can positively effect the growth of TPF through learning from competitive pressures and technology enhancement.

Imported capital machinery used in the agricultural sector (Km; Table 8.3) has a positive relationship to TFP growth (0.10 level of significance). It has been suggested the technology upgrading embodied in imported equipment investment should be an important engine of economic growth in developing countries. It would appear that the results in table 8.3 confirm that this is true concerning the import of agricultural machinery (mainly tractors) for use in Thailand's agricultural sector. It would be expected to have an even stronger effect in sectors that are more active in importing high tech capital.

Agricultural exports (X; Table 8.4) do not show a significant relationship to TFP growth during the same period, but do exhibit a positive relationship (0.05 level of significance) when lagged one period. These results support the common hypothesis that the increase in demand for Thai agricultural exports over time will lead to increasing productivity (i.e. TFP growth). This is explained in the literature as learning by doing.

The variables used to represent various elements of agricultural imports including total imports (M; Table 8.5), competitive imports (Mc; Table 8.6), and non-competitive imports (Mn; Table 8.7) do not show any significant relationship to TFP growth either in the same or in lagged periods. This is not unexpected, as imports are and always have been a relatively minor factor in Thailand's agricultural sector. It might be possible to find some effect of imports in smaller segments of the agricultural sector, such as with specialty fresh vegetables, but that is beyond the scope of this thesis.

These three factors showing a significant relationship to TFP growth, trade liberalization, imported capital machinery and exports, can account for 40 to more than 70 percent of TFP growth (based on R^2 of the OLS estimates in Tables 8.1 – 8.10). However, it needs to be pointed out that in the model equations containing more than one variable, (Tables 8.8 – 8.10) multicollinearity becomes an issue, so precise interpretation of the exact relationship and fit of the models is difficult to say with full assurances.

Other important determinants of TFP in Thailand's agricultural sector that were not measured may have been more significant than those chosen in this study. Possibilities could have included disease outbreaks, research and development, managerial improvement, business reorganization, and government policies and/or regulatory measures. All these can affect the utilization of resources and hence productivity, but were not measured in this study, in part due to lack of availability.