Chapter 2

Literature Review on Total Factor Productivity (TFP)

2.1 Introduction

In this chapter, research concerning TFP issues will be conducted. The review covers several journals in several areas such as manufacturing and services sector industry. The purpose of chapter 2 is to give a clear-cut view of what is TFP and why is TFP important to this analysis.

2.2 Definition of Productivity and TFP

Productivity measures the relationship between the output (the amount of goods and services produced) and input (the quantity of labour, capital and material resources used to produced the output). The lower the input, the larger the output, the higher the productivity (Maisom, 1998).

TFP is normally defined as the contribution of 'third factor input' other than capital and labour input. The 'third factor input' is normally refer to factors including the improvement of technology and know-how, innovation, superior management techniques, as well as workers education, skills and experience (Malaysia, 2001).

Therefore productivity and TFP itself relates to each other, where the TFP attempts to take into account the contribution of all inputs namely the services of plant and equipment, energy and other materials, as well as that of managers and their employees. TFP is more difficult to estimates but useful in determining changes in labour and capital productivity and the efficiency in industries and other sector.

TFP is normally estimated using Cobb-Douglas Production function as a residual of output less capital and labour contribution respectively.

2.3 Previous Studies of Total Factor Productivity (TFP)

Literature concerning the TFP have been conducted in various fields and sector. The pattern of TFP studies also varies in terms of variables and time since the early generation of productivity studies used modified Laspeyres or Paasche TFP index (Sudit, 1984).

Jorgenson, et.al (1987) analyzing the postwar pattern of the United States productivity and economic growth from 1948 to 1979. The study used the model of producer behaviour and explicit production function model for each sector in the U.S economy. Variables involved are output, time and capital, labour and intermediate inputs. The production function and necessary conditions for producer equilibrium are combined to generate index numbers of productivity and for capital, labour and intermediate inputs. They assumed that for each industry there exist a production function relating output to inputs, and time for the *i*th industry.

The model was developed based on accounting growth model for each of the n sector, characterized by constant return to scale:

$$Z_i = F^i (X_i, K_i, L_i T) \quad (i = 1,2,.....,n)$$

Where T denotes to time, $\{Z_i\}$ is output, $\{X_i\}$, $\{K_i\}$, and $\{L_i\}$ are the intermediate, capital, and labour. The share of each inputs, say $\{v^i_x\}$, $\{v^i_k\}$, and $\{v^i_L\}$ defined by

$v^i_x = p^i_x X_i / q_i Z_i$, $v^i_k = p^i_k K_i / q_i Z_i$ *and* $v^i_L = p^i_L L_i / q_i Z_i$ $\quad (i = 1,2,....n)$

Where $\{q_i\}$, $\{p^i_x\}$, $\{p^i_K\}$ and $\{p^i_L\}$ denotes the prices of output and intermediate, capital, and labour inputs respectively. In the producer equilibrium, share of each input in the value of output are equal to the elasticities of output with respect to that input:

$v^i_x = \partial ln\ Z_i / \partial ln\ X_i$, $v^i_K = \partial ln\ Z_i / \partial ln\ K_i$, *and* $v^i_L = \partial ln\ Z_i / \partial ln\ L_i$ $\quad (i = 1,2,...n)$

Under constant return to scale the elasticities and the value share of all three inputs sum to unity. Therefore, for value of output is equal to the sum of the values of intermediate, capital, and labour inputs:

$q_i Z_i = p^i_X X_i + p^i_K K_i + p^i_L L_i$, $\quad (i = 1,2,....n)$

The production function is *homothetically separable* since each of the aggregates is homogeneous of degree one in its components. Since all the data are separable and satisfy the equalities, therefore the rate of productivity growth, $\{v^i_T\}$ for each sector as the growth of output with respect to time, holding intermediate input, capital, and labour constant:

$v^i_T = \partial ln\ Z_i / \partial ln\ T\ (X_i, K_i, L_i, T)$

The definition of v^i_T does not impose any restriction on substitution pattern among intermediate, capital, and labour inputs. Therefore, consider data at any two discrete point of time, say T and T-1, the growth rate of output can be expressed as a weighted average

of the growth rates of intermediate, capital, and labour inputs plus the average rate of productivity growth:

$$\ln Z_i(T) - \ln Z_i(T\text{-}1) = \bar{v}_X^i [\ln X_i(T) - \ln X_i(T\text{-}1)] + \bar{v}_K^i [\ln K_i(T) - \ln K_i(T\text{-}1)]$$

$$+ \bar{v}_L^i [\ln L_i(T) - \ln L_i(T\text{-}1)] + \bar{v}_T^i, \qquad (i = 1,2,\ldots n)$$

Where the weighted are given by the average value shares:

$$\bar{v}_X^i = \tfrac{1}{2}\left[v_X^i(T) - v_X^i(T-1)\right]$$

$$\bar{v}_K^i = \tfrac{1}{2}\left[v_K^i(T) - v_K^i(T-1)\right] \qquad (i = 1,2,\ldots n)$$

$$\bar{v}_L^i = \tfrac{1}{2}\left[v_K^i(T) - v_L^i(T-1)\right], \quad \text{and}$$

$$\bar{v}_T^i = \tfrac{1}{2}\left[v_T^i(T) - v_T^i(T-1)\right]$$

The study found that the driving force behind the massive expansion of the U.S economy between the prevailing periods was a vast mobilization of capital and labour resources. The single most important contribution to U.S economy growth during the periods was made by capital input which accounted about 1.6 per cent per annum compare to 1.1 percent per annum of labour input contribution.

Oulton and O'Mohany (1994) conducted a study using the same framework as Jorgenson et.al (1987). A study on British industry, 1954 to 1986 has found some interesting answer on multi-factor productivity (MFP)[1]. The source for the estimates of MFP growth rates was the UK Census of Production. The authors' compare the MFP growth rates for more than 130 industries (nearly all in manufacturing) for at last some of the chosen period and

[1] Oulton and O'Mohany (1994) use terms MFP to refer as TFP since estimation of productivity involving more than one input factor i.e. capital,labour and intermediate inputs.

for 124 industries for the whole periods. Estimates were constructed for eight time periods within the overall span of 32 years: 1954-58, 1958-63, 1963-68, 1968-73, 1973-76, 1976-79, 1979-82, and 1982-86. The estimation of MFP growth is based on value added.

As an average across all industries, MFP grew at 0.88 percent per annum from 1954-73; thereafter it fell at 0.47 percent per annum. According to them, the MFP actually fell from 1973-82, but grew again from 1982-86. The MFP growth for the periods of 1954-86 was only 0.35 percent per annum, in which most of the contribution still depends on capital and intermediate inputs. The variation of productivity among output and inputs identified caused by the striking contrast between the two halves of the periods.

Maisom and Arshad (1992) in viewing the TFP in manufacturing industries (2-digit level) in Malaysia within the periods 1973 to 1989 has found that the TFP growth in Malaysian manufacturing sector is still relatively low (negative contribution), compared to other developing countries. Using model developed by Jorgenson et.al (1987)[1], the writers has identified that the TFP in Malaysian manufacturing industries revealed increasing and declining pattern. However in the recent years, majority of the Malaysian sub-sectors are experiencing an upward trend in TFP growth. The stipulation was based on classification of Malaysian manufacturing industries namely heavy industries, medium industries, light industries and RBI. An interesting TFP pattern revealed in RBI[2], where within the periods of 1973 to 1989, only Wood Products industry has experienced increase in TFP, while other RBI decrease in TFP. Most of the other industries viz. heavy industries, medium industries and light industries experienced an increasing TFP pattern except

[1] The model is derived from the neoclassical theory of production with assume Hicks-neutral production function.

[2] The estimation of TFP consists of three inputs namely labour, capital and intermediate inputs.

Industrial Chemical industry and Pottery China and Earthware in which classified in heavy and medium industry respectively.

Tham (1998) in his study on growth in productivity and impact on the competitiveness of the Malaysian manufacturing sector (3-digit level) within periods of 1986 to 1993 using growth accounting model approach of three factor including capital, labour and intermediate inputs, found that TFP in manufacturing sector accounted only 0.1 per cent. The contribution of capital, labour and intermediate input were 3.4, 0.8 and 10.3 percent respectively.

Out of the 28 industries, growth of TFP 3-digit level manufacturing industries, 10 experienced an average annual growth in TFP of over 1 percent. The primary source of growth for manufacturing sector is derived from the growth of intermediate inputs (10.3 percent), followed by capital (3.4 percent), and labour (0.8 percent). This outcome reveal that manufacturing industry in Malaysia mostly depend on input factor or input-driven sector.

Gan and Soon (1998) in their empirical analysis using Solow neoclassical model to predict TFP growth in Malaysian economy between 1974-1994, focuses on trend TFP, rather than its year-to-year changes. The writers found that, generally, capital and labour productivity pick up as the economy emerges from recession as the excess capacity is increasingly being utilized. According to them, during the downturn, labor hoarding together with lower capacity utilization of plant and equipment results in falling TFP. TFP growth fell sharply during 1985-1986 and recovered vigorously during 1987-1989. Gan and Soon finally conclude that Malaysian economic growth is primarily input-

driven. This was due to the incremental impact on growth from additional physical investment is still substantial.

Miller and Upadhyay (2000)[1] study the effect of openness, trade orientation and human capital on TFP growth for a pooled sample of 498 observations of developed and developing countries. By using the Cobb-Douglas production functions, one including and one excluding the stock of human capital, the writers found that opening the economy to trade generally benefits TFP.

The two production function are expressed as follow:

$$Y = AK^{\alpha} L^{\beta}, \qquad 0 < \alpha < 1 \text{ and } 0 < \beta < 1 \qquad (1)$$

And

$$Y = AK^{\alpha} H^{\gamma} L^{\beta}, \qquad 0 < \alpha < 1 \,, 0 < \gamma < 1 \text{ and } 0 < \beta < 1 \qquad (2)$$

Dividing equation (1) and (2) by the labour force (L) expresses output, the physical capital stock, and the human capital stock on a per worker basis. That is,

$$y = Ak^{\alpha} L^{\alpha+\beta-1}, \qquad (3)$$

and

$$y = Ak^{\alpha} h^{\gamma} L^{\alpha+\beta+\gamma-1} \qquad (4)$$

The production functions display increasing, constant, or decreasing return to scale as ($\alpha + \beta$) or ($\alpha + \beta + \gamma$) are greater than, equal to, or less than one, respectively.

Rewriting equations (3) and (4) in natural logarithms yields the following:

[1] Based on their study on tfp and tfph i.e. excluding and including human capital stock, United States is consistently ranked as 1; meanwhile Malaysia is ranked 36 and 34 respectively. Malaysian ranking is the highest among Southeast Asian Countries.

$$\text{Ln } y = \ln A + \alpha \ln k + (\alpha + \beta - 1) \ln L, \qquad (5)$$

and

$$\text{Ln } y = \ln A + \alpha \ln k + \gamma \ln h + (\alpha + \beta + \gamma - 1) \ln L \quad (6)$$

Thus, constant return to scale implies that the coefficient of ln L equals to zero.

Although using human capital as an input in the production function is controversial but theoretically and empirically advocates that approach and generate better fit with human capital.

The time-specific dummy variables, which is include in the function tell a consistent story. The estimate equations after inclusion of time is describes as follows:

$$\text{Ln } y = \ln A + \alpha \ln k + (\alpha + \beta - 1)\ln L + \sum_{i=1}^{6} \theta_i \text{ time}_i + \varepsilon, \qquad (7)$$

and

$$\text{Ln } y = \ln A + \alpha \ln k + \gamma \ln h + (\alpha + \beta + \gamma - 1) \ln L + \sum_{i=1}^{6} \theta_i \text{ time}_i + \varepsilon \qquad (8)$$

Where time $_i$ (i = 1,....6) represents the time dummy variables and the variables for each country measure deviations from their country means over time.

For estimation of country-specific fixed effects of intercepts (cint $_j$) the equation are as follows:

$$Cint_j = \overline{\ln y_j} - \hat{\alpha}\,\overline{\ln k_j} - \hat{\delta}_1\,\overline{\ln L_j} \qquad (9)$$

and

$$Cint_j = \overline{\ln y_j} - \hat{\alpha}\,\overline{\ln k_j} - \hat{\gamma}\,\overline{\ln L_j} - \hat{\delta}_2\,\overline{\ln L_j} \qquad (10)$$

Where a bar over a variable indicates the mean of that variable, a caret over a parameter indicates the estimate of that parameter, $\delta_1 = (\alpha + \beta - 1)$, $\delta_2 = (\alpha + \beta + \gamma - 1)$, and $j = \{1,2,3,\ldots 83\}$ is the index across countries. Note that the time-specific fixed effects appear directly as the respective coefficients of the time dummy variables.

TFP increase over each 5-years time span from 1960-1964 through 1975-1979. The last two time spans 1980-1984 and 1985-1989 suggest stagnation in TFP growth. Opening the economy to trade means increasing exports to GDP, improving the terms of trade, and lowering the real value of domestic currency. Moreover, the stock of human capital contributes positively to TFP in many but not all, specifications. Human capital based on their empirical results has a negative effect on TFP in high-income countries and a positive effect in middle-income countries. The effect of human capital on TFP in low-income countries moves from negative to positive as the country move from a low to a higher level of openness. The classification was made based on 83 countries using the two-production function specification that was stated earlier.

Lin and Virabhak (1998) discover the TFP in 17 services sector (comprises the SSIC 1990 two and three digits level industries) in Singapore from 1976 to 1992. Using the neoclassical theoretical framework namely accounting growth methods developed by

Gollop and Jorgenson (1979)[1], the writer found that the TFP growth (weighted by value-added shares) for the services sector in Singapore was –0.4 percent for the stipulated periods. The TFP growth for each of the 17 service industries was mostly very low or even negative during the same period. The effect of the 1985-1986 recession on services showed that weighted TFP growth for all 17 service industries exhibited a cyclical trend, averaging –3.78 percent during 1976-1984, while falling to –6.0 percent during 1985-1986, before raising to 6.5 percent during 1987-1992. This cyclical trend underlines the significance of demand side factor on TFP growth performance.

2.4 Some Preliminary Findings

Jorgenson et. al (1987), Oulton and O'Mahony (1994), Maisom and Arshad (1992) and Tham (1998) has draw an attention of TFP growth using accounting growth model in which the estimation of TFP differ in terms of sign and its intensity. While Gan and Soon (1998) and Miller and Upadhyay (2000) using solow growth model to estimates the TFP growth. The different approach (model) used in the various country, economic sector and time by different economist obviously shows that the estimation of TFP can take any form, view and assumptions.

Study conducted by Miller and Upadhyay (2000) has highlights interesting issues, that is human capital stock has (empirically) contributes significantly to the overall growth of economy especially for middle to low-income countries.

[1] The framework by Gollop and Jorgenson was quite similar to model developed by Jorgenson et. al (1987)