Malaysian Journal of Economic Studies Vol. XXXIX Nos. 1 & 2, 2002 ISSN 1511-4554

# What Is and Is Not Measured by Total Factor Productivity Growth Studies for Malaysia: A Literature Survey

Renuka MAHADEVAN*
*University of Queensland*

***Abstract***: This paper surveys the major studies, both cross-sectional and inter-temporal, conducted on total factor productivity (TFP) growth in Malaysia. In particular, it critically analyses the conceptual and empirical aspects of the methodology used in these studies which has often centered on the growth accounting approach. The need for more accurate TFP growth estimates is highlighted in relation to drawing of more accurate policy implications. Future research using the stochastic frontier approach is suggested and further explained.

## 1. Introduction

Over the past four decades, the measurement of total factor productivity (TFP) growth has received considerable attention from both theoretical and applied economists. TFP growth which has long been an important measure of the growth potential of an economy, is fast becoming the buzzword for developing economies keen on adopting a sustainable growth development path. An example is that of Malaysia, a second-tier newly industrialising economy (NIE) which is envisaged to attain the status of an industrialised nation under Vision 2020. In fact, the focus on TFP growth is clearly set out in the Seventh Malaysian Plan (1996-2000) and the Second Industrial Master Plan (1996-2005) which strongly emphasise the need to move away from an investment-driven to a productivity-driven path. This calls for appro-priate policy formulation which in turn hinges on the accurate measurement of TFP growth.

In light of the focus on productivity in Malaysia's development strategy, this paper addresses the following issues: How useful are the existing TFP growth estimates for Malaysia? What are some of the problems encountered in the analysis of Malaysian TFP growth in cross-country and inter-temporal studies? What alternative measures can be used to improve TFP analysis for Malaysia? The paper is organised as follows: The next section reviews key cross-country and inter-temporal TFP growth studies on Malaysia. The third section suggests the use of the stochastic frontier method as an alternative approach to measuring TFP growth. The inaccuracy in policy implications from the methodologies used by previous studies is also highlighted. The last section provides a conclusion.

## 2. Review of TFP Growth Studies

The table below shows a summary of the main TFP growth studies on Malaysia. It can be seen that TFP growth estimates are wide ranging but this is not surprising given the use of different data and time periods, as well as differences in methodology and models specified. There is also no strong consensus on TFP growth trends over time.

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* Email: r.mahadevan@economics.uq.edu.au

**Table 1**: Summary of TFP growth estimates (%) for Malaysia

| Source | Time period | Aggregate economy | Manufacturing sector | Services sector |
|---|---|---|---|---|
| National Productivity Corporation of | 1987-91 | | | 5.5 |
| Malaysia as reported in Abdullah (1999) | 1992-96 | | | 2.4 |
| * Collins and Bosworth (1996) | 1960-73 | 1.0 | | |
| | 1973-84 | 0.4 | | |
| | 1984-94 | 1.4 | | |
| * Drysdale and Huang (1997) | 1950-90 | -0.5 | | |
| National Productivity Corporation of | 1986-89 | 0.6 | | |
| Malaysia as reported in Hoon and | 1990-95 | 0.54 | | |
| Muhamad (1996) | | | | |
| Gan and Soon (1996) | 1974-78 | 2.0 | | |
| | 1979-83 | 0.5 | | |
| | 1984-89 | 1.6 | | |
| | 1990-95 | 2.2 | | |
| Gan & Robinson (1993) | 1974-95 | 1.6 | | |
| Ghani and Suri (1999) | 1971-97 | Less than 0.04 | | |
| * Kawai (1994) | 1970-80 | 2.5 | | |
| | 1980-90 | 0.7 | | |
| Maisom, Mohd and Nor Aini (1994) | 1974-89 | | 8.13 | |
| * Nehru and Dhareshwar (1994) | 1960-90 | 0.96[a] | | |
| | | 0.09[b] | | |
| Okamoto (1994) | 1986-90 | | 0.3 | |
| National Productivity Corporation | 1988-92 | 3.32 | | of |
| Malaysia (1999) | 1993-98 | 0.06 | | |
| 1980-89 | | 2.79 | | |
| 1990-96 | | 1.60 | | |
| * Sarel (1997) | 1978-96 | 2.0 | | |
| | 1991-96 | 2.0 | | |
| * Syrquin (1991) as reported in | 1960-70 | 3.0 | | |
| Toh and Lim (1992) | 1970-82 | 3.0 | | |
| | 1980-89 | 0.5 | | |
| Tham (1995) | 1971-75 | -1.42 | | |
| | 1976-80 | 0.26 | | |
| | 1981-87 | -2.68 | | |
| Tham (1996) | 1986-93 | | 0.1 | |
| Tham (1997) | 1986-91 | | 0.3 | |
| * The World Bank (1989) | 1975-79 | | 3.8 | |
| | 1981-84 | | -1.9 | |
| * The World Bank (1993) | 1960-89 | 1.1[c] | | |
| | | -1.34[d] | | |
| * Thomas and Wang (1992) | 1960-87 | 1.95 | | |
| White Paper (1999) as reported in | 1987-90 | 2.9 | | |
| Ariff and Tan (1999) | 1991-96 | 0.9 | | |

*Note:* * refers to cross country studies
[a] Using first-differenced model

**Table 1**: Continued

| Source | Time period | Aggregate economy | Manufacturing sector | Services sector |
|---|---|---|---|---|

[b] Using error-correction model
[c] Using the full sample of 87 countries
[d] Using a sample of high-income countries

## *2.1 Cross-Country Studies*

Although TFP growth estimates varied widely among the nine cross-country studies, these studies showed that Malaysia's TFP growth is low and output growth is input driven. The World Bank (1989) showed that Malaysia's output growth is driven by intermediate input growth for a production function using data on gross output, capital, labour and intermediate inputs. Where the specified model used data on value added, capital and labour inputs, stu-dies conducted by, Drysdale and Huang (1997), Collins and Bosworth (1996), and Sarel (1997) showed that capital was the main contributor of output growth. TFP growth trend however, was quite different for these studies.

As in most cross-country TFP growth analysis, Malaysia, like many other economies, is lumped together with other developing and developed countries. The World Bank (1993) study clearly shows that using a different sample of countries would give different input shares and hence different TFP growth results. Nehru and Dhareshwar (1994) on the other hand obtained different results using different models with the same sample of countries. As echoed by Solow (1994:51), these international cross-section regressions 'seem altogether too vulnerable to bias from omitted variables, reverse causation, and above all to the recurrent suspicion that the experiences of very different national economies are not to be explained as they represent different 'points' on some well-defined surface'. Although some argue that there is a need to work from general hypotheses to specific issues, the results need to be interpreted with great caution.

Most of these studies also used economy-wide data and thus the results have very broad implications for each of the sectors of the economy. Since the economy is a weighted sum of the agricultural, manufacturing and services sectors, any shift in labour from a less productive sector to a more productive sector would result in an increase in overall TFP growth without any real change in TFP growth rates of either sector. This is especially important for Malaysia which has had quite a substantial change in the composition of its economy–the agricultural sector experienced a decline of 15 per cent of its GDP share of output from 1975 to 1996; the manufacturing sector, on the other hand, saw an increase in share from 16.4 to 34.2 per cent during the same time while the services sector registered a fall of about 7 per cent.

#### 2.1.1 Sarel (1997)

Sarel used data from Penn World Tables (based on the purchasing power parity concept) on five ASEAN countries and applied the growth accounting methodology to estimate TFP growth. He used an alternative method to estimate factor shares (often calculated from national accounts data) that are not affected by the industrial structure of the economy and its level of development. But obtaining these technological factor shares based on the sample to be used would be more appropriate than using those obtained from a random sample of 16 countries. Sarel also assumes that technologies are not fundamentally different across countries and over time and any such differences are fully captured by controlling for the average stock of capital per person across countries and over time. Stiglitz (1992:46), however, explains that effective technologies in countries are different due to differential knowledge in terms of usage and differences in economies of scale when used by small and large economies. Lastly, the adjustment by age-related productivity differences across labour is not without its limitations as it depends on whether age is expected to increase or decrease productivity and this varies across industries and occupations.

#### 2.1.2 Kawai (1994)

Kawai used a non-parametric approach with the translog-divisia index to estimate TFP growth for Malaysia. However, little explanation of the methodological procedure or the data issues involved was provided. The international comparative analysis on sources of TFP growth was also seen to suffer from simultaneity bias as the direction of causality between the factors and TFP growth was not established. This partly explains the insignificant effect of both import substitution and export promotion policies on Malaysia's TFP growth.

#### 2.1.3 World Bank (1993)

In this study, TFP growth was calculated from the estimation of a Cobb-Douglas production function where it was assumed that every country has access to the same production function, taken to represent the best practice. It was also assumed that the countries share the same elasticities of output with respect to inputs and are subject to the same unitary elasticity of substitution between the factors. The other strong assumption in this study was that, the rate of technological progress is constant (why?) and is given by the average TFP growth rate of high-income countries which is a very subjective benchmark.

As in the case of to the World Bank (1993) study, that of Drysdale and Huang (1997), Kawai (1994), Collins and Bosworth (1996) and Syrquin (1991) also worked on cross-country data to test hypotheses and made generalisations for Malaysia concerning TFP growth trends, the effect of policies implemented and the need for, as well as the impact of catch-up, among many other issues. The TFP studies raise the following questions – what about the initial conditions in the country? And how robust are the results? For instance, discussions led by DeLong and Summers (1991) and Peebles and Wilson (1996) point to the importance of capital measure (be it industrial equipment or total investment) and different depreciation values in TFP growth estimation.

One major critique of most of these cross-country studies is the use of the parametric approach of the growth accounting methodology, relying on a Cobb-Douglas production function to estimate TFP growth. First, the use of the Cobb-Douglas functional form results in the imposition of the constant returns to scale assumption without validating it with statistical testing. This was the case with about 80 per cent of the studies in Table 1. The nature of returns to scale has an important bearing on input shares and hence the magnitude of TFP growth estimates. Rodrik (1996:192) explains that if the true elasticity is below one, then the greater use of one input would cause the factor share of that input to fall over time and true TFP growth would increase correspondingly. Thus it is important not to impose the constant returns to scale assumption to obtain more reliable TFP growth estimates.

Second, the residual TFP growth estimate obtained under the growth accounting approach adopted in all these studies is difficult to interpret as it measures anything and everything of the output growth not accounted for by input growth. Thus, the more we know about the model, the smaller will be the TFP measure and this makes it very sensitive to model specification. Such a broad measure also has little to offer in terms of policy recommendations as it is not clear what exactly is being measured.

### *2.2 Inter-Temporal Studies*

These studies refer to those concerned with the Malaysian economy only. This section is divided into two parts, one focuses on the estimation of TFP growth while the other on a discussion on studies which attempted to determine factors affecting Malaysian TFP growth.

#### 2.2.1 Estimation of TFP Growth

Of the twelve such studies, five are sector-specific and use industry level data. These studies show that as in the aggregate economy, both the manufacturing and services sectors experienced a decline in their TFP growth over time and the source of output growth in these sectors was input growth. Although TFP growth for services appears to be higher than that of manufacturing, these estimates are not directly comparable due to differences in methodology and data. However, somewhat puzzling and hard to explain is the unusually high TFP growth estimates for the manufacturing sector described by Maisom *et al.* (1994).

With services, the emphasis on TFP growth is noted in the Seventh Malaysian Plan but as in most other economies, this issue has generated little research interest as Abdullah's study (1999) is the only one that provides some discussion on TFP growth of various service industries using Malaysian productivity reports. Often, with services, low measurable efficiency gains are expected due to limited opportunities to improve productivity through technology, compositional effects within service industries, data measurement problems or difficulties in measurement at a conceptual level in accounting for quality improvements in output measures.

The main critique of the inter-temporal studies (with the exception of Gan and Soon 1996) lies with the use of the non parametric approach of the translog-divisia index to estimate TFP growth. Although this approach does not require the explicit specification of a production function, the major drawback is that it is not based on statistical theory. Hence statistical methods cannot be applied to evaluate their reliability, casting doubts on the empirical results.

The study by Gan and Soon (1996) appears to be the only one which parametrically estimated the average production function for the aggregate economy using the ordinary least square regression. However, the problem with this non-frontier approach is that it unrealistically assumes that all firms or industries operate on the production function and that TFP growth results in the parallel shift of the production function over time. But TFP growth literature shows that TFP growth emanates from two sources. One is from technological progress (TP) which is represented by a shift of the production function and the other is gains in technical efficiency (TE) which is represented as a movement towards the production function. TE measures embodied technological change given by the knowledge with which a known technology is applied. This is influenced by accumulation of knowledge, learning-by-doing, improvements in the instructions for combining inputs, improved managerial practice etc. TP measures the disembodied technological change which occurs from improvements that are incorporated in the inputs, thereby increasing the innate quality of the input. By considering only shifts in the production function as TFP growth, the non-frontier approach assumes away the possibility of technical inefficiency. This means that the concept of TP and TFP growth are synonymous in the non-frontier approach, thereby providing erroneous TFP growth figures. Schultz (1975), and Kalirajan and Shand (1994) further explain that by ignoring technical inefficiency, the non-frontier approach assumes the condition of long run equilibrium. They go on to argue that the short run equilibrium is a more usual condition as it is necessary to understand how firms and industries proceed to equilibrium.

### 2.2.2 Studies on Factors Determining TFP Growth

Another problem with TFP studies on Malaysia lies with the way in which they attempt to determine the factors that explain TFP growth. Often the regression analysis suffer from multicollinearity between the explanatory variables or simultaneity bias. For example, in Tham's (1997) study, the dependent variable, TFP growth, could affect output growth which is one of the independent variables, thus causing simultaneity bias. The identification of Verdoon's law based on the relationship of output growth on TFP growth, could easily be reversed, thereby ruling out the use of output growth as a determinant of TFP growth. Also, the high possibility of a relationship between export growth and output growth, as well as that of foreign ownership of fixed capital assets on output growth, introduces multicollinearity in the regression analysis (as all these variables were used as regressors), thus weakening Tham's (1997) results. Another example of multicollinearity is found in Okamato's (1994) study where, the effect of effective rate of production on decision to invest by foreigners (as measured by fixed assets) is not considered, when including both the effective rate of production and the share of foreign fixed assets to total fixed assets as regressors in the determination of TFP growth.

The analyses on the determinants of TFP growth have also paid particular attention to the effect of foreign direct investment (FDI) on TFP growth, given the significant FDI inflows into Malaysia since 1987. While Okamato (1994) and Tham (1997) conclude that FDI has a positive effect on productivity, Menon (1998) found little empirical evidence of such a relationship. Although Menon (1998) also used the growth accounting approach (as in these studies), his data set was more disaggregated in that FDI and local industry level data on output and inputs was used to show that FDI-dominated industries were no better than the locally-owned industries. Thus, disaggregated data is far more informative and there is clearly a need to use firm level data to draw specific policy implications. Such data, however, is yet to be available in Malaysia.

## 3. An Alternative Approach

First, there is an urgent need to move away from the residual TFP growth estimate of the growth accounting approach underlying the non-frontier methodology used by both the inter-temporal and cross-sectional studies. One way is to use the stochastic frontier approach[1] where output growth is decomposed not only into input growth and TFP growth but TFP growth is further decomposed into technological progress and technical efficiency (see Appendix 1), of which the latter is often ignored in the TFP growth estimates for Malaysia.

Unlike the growth accounting approach, the stochastic frontier approach distinguishes between TP and TE as the concepts of TP and TE are analytically different and thus have different policy implications. Nishimizu and Page (1982) explain that high rates of TP can coexist with deteriorating TE and vice-versa. Therefore, policy actions intended to improve TFP growth might be badly misdirected if there is a lack of understanding of the interaction of these concepts in TFP growth. For example, if TP is high and low TFP growth is caused by deterioration in TE, then, focusing on accelerating the rate of innovation instead of obtaining a high rate of mastery of diffusion of best practice technology may not improve TFP growth.

Second, TFP growth should also be analysed parametrically with cost functions using input prices. Such analysis provides information on scale effect and cost efficiency such as allocative efficiency. To date, only Gan and Soon (1996) have estimated the production function to model the behaviour of the productive performance of the Malaysian economy but often, the estimation of a production frontier has been criticised on the grounds that it is not suitable when input quantities are likely to be endogenous.

## 4. Conclusion

As several studies have already discussed the general problems in estimating and interpreting TFP growth measures, the issues dealt here are specific to Malaysia. First, while studies on Malaysia have shown that there is much room for TFP growth, it is equally important to realise that there is also room for improving accuracy in TFP growth estimates for this next-tier NIE. Although conceptually straightforward, the issue of TFP growth and its determinants is enormously complex, analytically and empirically. The results are known to be sensitive to approaches of TFP growth estimation, choice of functional form, data used, level of aggregation, measurement of capital, and many others. Nevertheless, this should not discourage the use of an improved technique such as the stochastic frontier approach.

Second, two aspects of data problems persist. One, is the data on capital expenditure which is lacking in Malaysia and often studies have had to use fixed capital assets as a proxy. The lumpy nature of fixed assets would affect TFP growth via capital's contribution to output growth. The other is the availability of firm-level data for more specific policy analysis.

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[1] See Coelli *et al*. (1998) and Kalirajan and Shand (1994) for an introduction to the stochastic frontier analysis.

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## Appendix 1

Assume that the industry faces production frontiers $F_1$ and $F_2$ in period 1 and period 2 respectively. If the industry is technically efficient, output would be on the frontier, that is, industry would be able to produce output $y_1$* in period 1, using $x_1$ input level and output $y_2$** in

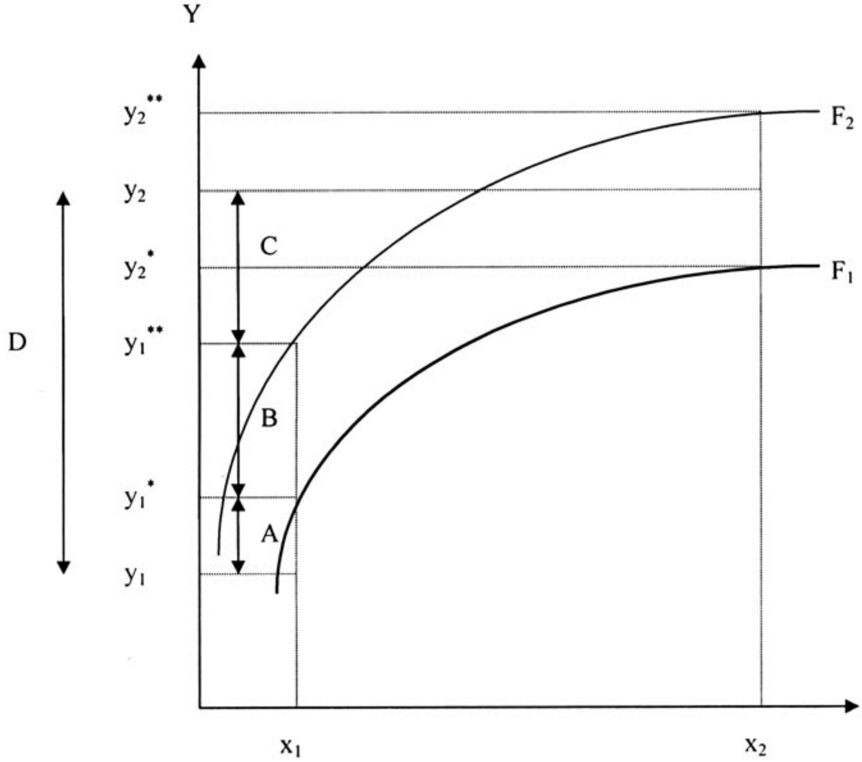


**Figure A1**: The Stochastic frontier approach to the decomposition of output growth and total factor productivity growth

period 2, using $x_2$ input level. However, in periods 1 and 2, industry may be producing output $y_1$ and $y_2$ respectively, due to technical inefficiency in production. Technical inefficiency in terms of output forgone is represented by the distance between the frontier output and actual output of a given industry in the figure. The industry in period 1 is said to experience TE1 in period 1 if it is able to increase production from $y_1$ to $y_1$* and TE2 in period 2 if it is able to increase production from $y_2$ to $y_2$**. Thus, change in technical efficiency over time is the difference between TE1 and TE2 and technological progress is measured by the distance between frontier 2 and frontier 1 given by, $y_1$** - $y_1$* evaluated at $x_1$ input level. The input growth between the two periods denoted by D$y_x$ causes output growth of $y_2$** - $y_1$**. This output growth can be decomposed into three components, i.e. input growth, technological progress and improvements in technical efficiency, the sum of the latter two constitutes total factor productivity growth.

The decomposition can be mathematically expressed as follows:

$$D = y_2 - y_1$$
$$= A + B + C$$

$$= [y_1^* - y_1] + [y_1^{**} - y_1^*] + [y_2 - y_1^{**}]$$
$$= [y_1^* - y_1] + [y_1^{**} - y_1^*] + [y_2 - y_1^{**}] + [y_2^{**} - y_2^{**}]$$
$$= [y_1^* - y_1] + [y_1^{**} - y_1^*] - [y_2^{**} - y_2] + [y_2^{**} - y_1^{**}]$$
$$= \{(y_1^* - y_1) - (y_2^{**} - y_2)\} + (y_1^{**} - y_1^*) + (y_2^{**} - y_1^{**})$$

$$= \dot{TE} + \dot{TP} + \dot{y}_x^*$$

$$= \dot{TFP} + \dot{y}_x^*$$

where $y_2 - y_1$ = output growth between two periods

$\dot{TE}$ = change in technical efficiency

$\dot{TP}$ = technological progress

$\dot{y}_x^*$ = change in output due to input growth

$\dot{TFP}$ = total factor productivity growth

*Source:* Renuka and Kalirajan (1999)