Total Factor Productivity and the Use of Flexible Weight Indexing Procedures – A Critical Appreciation

Bilkis Raihana*

Abstract

Total factor productivity (TFP) is defined as the ratio of output to all inputs. This measure has become popular in recent years and is a better indicator of physical (or technical) efficiency gains in production. For constructing the index of productivity, the flexible weight approach of which the Divisia index and its discrete Tornqvist approximation are the most well-known. This study attempts to examine the adequacy of TFP indexes based on flexible weight indexing procedures for the productivity studies. This study reveals the superiority of Total factor productivity (TFP) indexes and flexible weight indexing procedures and suggests that there is a need of these approaches to enhance the productivity studies in Bangladesh agriculture sector.

Key words: Total Factor Productivity, flexible weight indexing procedures.

Introduction

Recent research developments in the study of productivity measurement (Christensen, 1975; Dievert, 1976; Brown 1978; Ali, 1991; Sharma, 2004; Kiani, A. et.al. 2008; and Ali, A. et al. 2009) have emphasized two things: the superiority of Total factor productivity (TFP) indexes and the use of flexible weight indexing procedures. Despite these developments and some work in these directions on the agricultural sectors of various countries, existing research work on Bangladesh agriculture has not incorporated both these approaches simultaneously.

Bangladesh is predominantly an agricultural country. In the post independence period, a rapid expansion of fertilizer, irrigation and modern variety seeds caused a breakthrough in Bangladesh agriculture and Bangladesh made steady progress in crop production. The ultimate goal of input reallocation and technical change is to increase output and thereby to raise productivity. Changes in productivity in Bangladesh agriculture are issues of continuing research and policy interest. In Bangladesh, several studies have been done in the field of agricultural productivity and most of these studies are not conceptually or methodologically same. Though in recent years, as improved measures, the application of total factor productivity and flexible weight indexing procedures in Bangladesh agricultural Productivity studies are limited but the works of Dey and Evenson (1991), Pray and Ahmed (1991), Jahan (1997), Rahman (2007) and Baset et.al (2009) are noteworthy for adopting the TFP approaches and flexible weight indexing procedures.

The present study will reveal the current scenario of these approaches and how much it is being introduced and recognized to the researchers and used as a tool for productivity studies.

*Assistant Professor, Department of Economics, Asian University of Bangladesh
Objectives and Methodology of the Study

The objective of this study is to understand the adequacy of Total factor productivity (TFP) indexes and to analyze the benefits of flexible weight indexing procedures based on the theoretical interpretations. It also aims to explore the critical appreciation of these two approaches from the different research studies. This study is descriptive in nature. The present study is conducted on the basis of the secondary data and it is concerned with Bangladesh agricultural sector. On the basis of availability of data, accuracy of data, time span and cost factor of the study, secondary data play significant role in research (Sekaran, 2002). By considering the advantages and the limitations of using secondary data, this study is pursued. Data has been collected from the published research articles, different books and dissertations concerning the study.

Limitations of the study

The limitation of this study is that this study did not use primary data. Despite this limitation, the collected data have been processed manually and present form has been prepared in order to make the study more informative, analytical and useful for the users. These findings can be helpful for designing productivity studies in Bangladesh agricultural sector.

Literature review

There has been extensive literature survey on TFP and flexible weight indexing method in agricultural sector.

Lee and Chen (1978) studied both TFP and PFP approaches for productivity growth in the Taiwan agriculture. In this study, he applied the Tornqvist approximation to the Divisia index.

Brown (1978) examined the productivity changes in U.S. agriculture using the TFP approach. In this study, the Tornqvist and Star-Hall implementations of the Divisia index were applied and the results compared for the period 1947 to 1975.

Lawrence and McKay (1980) conducted a study of productivity in the Australian sheep industry. Both TFP and PFP approaches and the Divisia indexing procedures were applied in the study. Estimation of the terms of trade and returns to cost was also done. He examined an annual rate of TFP growth from 1952-53 to 1976-77.

In his doctoral dissertation, Islam (1982) studied productivity growth in Canadian agriculture. He also separately examined the productivity change for Western Canada. In this study, both the TFP and PFP approaches were applied covering the period from 1961 to 1978. He used the Tornqvist and the Star-Hall approximations of the Divisia index to obtain productivity growth rates. In this study, based on manhours data, TFP is estimated and estimation of terms of trade and returns to cost ratio was also done in this study.
Whittaker (1983) conducted a study of productivity change in UK agriculture for the period 1964 to 1979. The partial labour productivity and the TFP indexes were employed in this study. The Tornqvist method of Divisia indexing procedure was applied to measure the TFP indexes as an improvement over the TFP index.

Ball (1985) updated Brown’s (1978) work in his study of agricultural productivity in US agriculture. He used the TFP indexes by using time series data for the period from 1948 to 1979. To measure productivity, Tornqvist-Theil implementation of the Divisia indexing procedure was used.

Bottomley et al. (1990) studied the productivity change in UK agriculture for the period 1962 to 1987. In this study, they employed the Tornqvist-Theil approximation to the Divisia index to estimate TFP. In all, data of 5 outputs and 9 inputs were considered in this study.

In his doctoral thesis, Ali (1991) studied productivity change in UK agriculture for the period 1967 to 1987. PFP and TFP estimates were obtained in this study. To construct the output and input indexes, the Tornqvist-Theil approximation to the Divisia index was applied. The estimates of terms of trade and the returns to costs ratio were also obtained in this study.

Rahman (2007) studied productivity growth in Bangladesh agriculture. In this study, TFP approaches and Tornqvist and the Star-Hall approximations of the Divisia index are applied to obtain productivity growth rates for the period 1961 to 1978.

Baset et. al (2009) conducted a study to measure productivity growth in modern variety potato in Bangladesh agriculture. By using Tornqvist –Theil index formulation, TFP index was estimated for the period 1981 to 2006.

**Concepts of Partial and Total Factor Productivity**

In physical terms, productivity can be defined as the relationship of output to the related inputs. When the growth of output exceeds the rate of growth of inputs, productivity increases and in the reverse situation, productivity declines. In the study of productivity, two types of productivity measures are basically used of which the first is partial factor productivity (PFP) and the other is total factor productivity (TFP). The ratio of output to a particular input is known as partial factor productivity such as the partial productivity of land, partial productivity of labour, partial productivity of fertilizer. On the contrary, the ratio of output to all productive inputs taken together is known as total factor productivity. In practice, it is not possible to include all the inputs in the production process. So, the ratios of the single aggregate output to the single aggregate set of the traditional inputs are used to measure total factor productivity.

Though the partial factor productivity (PFP) measure is widely used method, it faces several limitations. The PFP measure consists of a particular input and it is unable to represent the extent of productivity growth. It is, however, misleading to attribute increases in output solely to labour since this ignores the contribution of the increasing use of other inputs in production process. In Bangladesh agriculture, the increase in labour productivity which has been associated with the
The partial factor measure is widely used as a precise method but in recent years the TFP approach has gained popularity due to its ability to consider all productive inputs. Thus, TFP is regarded as a realistic measure and to obtain a significant result of productivity growth, the TFP measure is used in various productivity studies.

**Theory of Productivity Measurement**

Basically, the index of productivity can be defined as ratio of indexes of output and inputs. Thus to construct the indexes of output and inputs, generally two types of indexing procedures are used. Among these procedures, the first is the fixed-weight approach, that is, the Laspeyres and Paasche indexes and the other is flexible-weight approach of which the Divisia index and its discrete Tornqvist approximation are most popular in economic studies. Now the basic concepts of these two indexing procedures are discussed below.

**The Laspeyres or the Fixed-Weight Approach**

The Laspeyres indexing procedure is widely used for general purpose in most of the official statistics and in Bangladesh it is generally used by Bangladesh Bureau of Statistics (BBS). The Laspeyres quantity index can be constructed using the following formula,

\[
Q_t = \frac{\sum P_t Q_t}{\sum P_0 Q_0}
\]

where \(Q_t\) is the quantity index in period \(t\), \(Q's\) and \(P's\) are item quantities and prices, and \(0\) and \(t\) indicate the base year and current year, respectively. Following equation (1), the quantity index can be written as

\[
Q_t = \frac{\sum P_0 Q_0 (Q_t/Q_0)}{\sum P_0 Q_0}
\]

From these above stated equation, it is observed that the construction of the index requires only quantity data for subsequent years while price is considered fixed at the base period level. Due to its simplicity, the Laspeyres index is mostly used by government statistical organizations. Though the Laspeyres index is widely used, it has several shortcomings. The Laspeyres quantity index considers prices fixed at the base period level and it is able to compare the base period value of current period quantities with base period value of the base period quantities. It indicates a linear production function, showing perfect substitution between all factors. The Laspeyres index is sensitive to the choice of a base period. Like other countries, Bangladesh has also experienced wide ranging fluctuations in agricultural production and prices. Besides this, circumstances like floods, cyclones, droughts can affect agricultural production as well as it as its
prices. In this context, consideration of only a particular year as the fixed base of the index could be unsatisfactory.

**The Divisia or Flexible Weight Approach**

To overcome the above stated problems, the Divisia indexing procedure was proposed by Divisia (1926). It involves a flexible weight method. In continuous version, the Divisia index can be presented as

\[
\frac{Q_t}{Q_0} = \exp \left\{ \left[ \sum \left( W_i(t) \left( \hat{q}_i(t) / q_i(t) \right) \right) \right] \right\}
\]

The \( W_i \) implies the share of the \( i \)-th factor in total cost or the share of the \( i \)-th output in total value and a dot (.) over the variable indicates the logarithmic derivative of that variable. Equation (3) shows the continuous version of the Divisia index. But its empirical implementation requires a discrete approximation and the Tornqvist approximation is considered appropriate. This widely used approximation was proposed by Tornqvist (1936). Following equation (3), the Tornqvist approximation to the Divisia quantity index can be written as

\[
\ln Q_t - \ln Q_{t-1} = \sum W_i \left( \ln q_{it} - \ln q_{i,t-1} \right)
\]

where \( Q \) denotes quantity and \( i \) refers to sub components.

In case of both the price and quantity indexes, the weights (\( w \)) are the same. A given weight implies the arithmetic mean of the shares in two adjacent periods and the weight can be presented as

\[
\bar{W}_i = \frac{1}{2} (w_{it} + w_{i,t-1})
\]

The weights in (5) are flexible over time. The Tornqvist approximation is used to estimate productivity in several studies.

**Critical Appreciation of TFP and Flexible Weight Approach**

The present study supports the positive view of using TFP and flexible weight approach. TFP indexes capture the effect of improvement in technology as well as investment in infrastructure such as irrigation, roads and electricity in the form of research and development (Mukherji and Kuroda, 2003; Rahman, 2007). The application of TFP in relation to the PFP approach was discussed by Hossain (1973:3) in the following words, “One can measure as many productivity indices as there are factors of production but since land is the most scarce factor of production in Bangladesh we shall mainly be concerned here with the productivity of land, and the reasons of its variation among different size groups of farms. We shall also try to derive indexes of total productivity by size-groups by taking into account the marginal contribution of traditional factors land and labour and the growth augmenting modern factors – fertilizer and irrigation”.

The rationale for adopting the TFP approach for study of the Bangladesh agriculture sector was clarified by Hossain (1973:29) thus, “We also noted that the higher productivity of land in smaller farms was associated with the higher application of other factors per unit of land. And it can be
argued that while from the societies point of view land is the most scarce factor and land productivity should be maximized, it may not be so in the case of large farms who have abundant land relative to other factors of production. So in order to decide which size-group is the most efficient in using the available resources one should look at the index of total productivity rather than productivity of a particular factor”.

In calculating productivity growth, and in choosing the TFP measure, Gray (1987:1001) comments that “to reduce the impact of strong cyclical fluctuations in productivity, average TFP growth is calculated for periods covering several years, chosen to match the cycle of productivity fluctuations from peak to peak”.

The Divisia or flexible weight approach has been advocated by Christensen (1975) and the U.S. Department of Agriculture (1980) for productivity study in agriculture. In case of choosing the Tornqvist indexes, Christensen (1975: 911) notifies, “The basic difference between the Laspeyres and Tornqvist ( and other superlative ) indexes is that the Laspeyres index holds prices fixed at their base period levels, while the Tornqvist index uses the prices from both the base period and the comparison period. The use of fixed base period prices in Laspeyres index can be interpreted in terms of the linear production function. If there is perfect substitutability among factors of production, then an increase in the relative price of any input would cause discontinuation of its use”.

Research Findings

It is worth studying whether productivity in Bangladesh agriculture is growing in recent years and if so, to what extent and whether the growth in output prices is greater than the input prices. These questions can be answered by the recent developments of productivity measurement.

The analysis of this research work reveals the superiority of Total factor productivity (TFP) indexes and the use of flexible weight indexing procedures.

On the application of Total factor productivity (TFP) indexes and flexible weight indexing procedures, this study found that research on productivity measurement in agriculture have been carried out mostly in developed countries but the literature dealing with these approaches on Bangladesh agriculture is surprisingly very limited.

This research also found that TFP is regarded as a realistic measure due to its ability to consider all productive inputs. The Laspeyres index indicates a linear production function, showing perfect substitution between all factors and it is sensitive to the choice of a base period. Due to the deficiencies of Laspeyres index, the flexible weight indexing procedures is becoming popular in recent Productivity research.

In particular, this analysis has reflected that Total factor productivity (TFP) indexes and flexible weight indexing procedures may adequately represent the extent of productivity growth and as well as may be able to promote the productivity studies in Bangladesh agriculture sector.
Recommendations

With a view to enhance the productivity studies in Bangladesh agriculture, the following recommendations are made:

As an improved theoretical approach, the present analysis is suggesting to put the attention to the use of TFP and flexible weight approach in Productivity research. Particular attention be paid in future to the improvement of the basic data series, specially input series and it will be greatly facilitated if Bangladesh Bureau of Statistics (BBS) give more complete data on a yearly basis. Productivity research in Bangladesh might involve the correction of output for climate changes which may give more complete explanation of productivity.

Conclusion

It is clear from the discussion that TFP has become popular in recent years and is a better indicator of physical (or technical) efficiency gains in production. In the measurement of productivity growth, improved flexible weight indexing procedures can be used to estimate productivity growth more accurately. An inadequate research has been done in this area so far in Bangladesh agriculture sector. Thus, with a view to obtain a significant result of productivity growth, the use of TFP and flexible weight approach are important and therefore, it is hoped that future researchers may find this useful.

References


