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Full Length Research Paper

Measuring agricultural productivity growth in Developing Eight

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In this paper the agricultural productivity growth in Developing Eight (D-8) from 1993 - 2007 is examined using the data envelopment analysis (DEA). The study focuses on growth in total factor productivity and its decomposition in to technical and efficiency change components. It was found that, during that period, total factor productivity has experienced a positive evolution in D-8. Decomposition of TFP shows that technical change is the main source of this growth. The study also describes that technical efficiency change has been the main constraint of achievement of high levels of total factor productivity. Also, findings in pure and scale efficiency change show that, the cause of the low efficiency is that, these countries have not succeeded well in expanding of agriculture sector of their economy. Finally it was found that, all D-8 countries improved technology more than efficiency in the reference period.

Key words: Total factor productivity (TFP), data envelopment analysis (DEA), developing Eight (D-8).

INTRODUCTION

The D- 8 is a group of developing countries with large Muslim populations that have formed an economic development alliance in Istanbul in October 1996. The group consists of countries from South East Asia to Africa. The countries in Developing Eight are Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey. One of the main areas of D-8 cooperation is agriculture. The overall population of the D- 8 is about 60% of the Muslim people, or close to 14% of the world‟s population. The population and geographical location of these countries is shown in Table 2.

D- 8 is one of the largest producers and importers of food and feed grains in the world. D- 8 is also a major global market for agricultural and food products. One of these countries Egypt is the largest wheat importer in the world, and Turkey, one of the largest wheat producers. And, As a result, by the mid-1990s Indonesia had become the second largest exporter of rubber and oil palm, and the third largest exporter of cacao and coffee (Fuglie and Piggott, 2006).

Agriculture is one of the main sectors of the economy in developing countries such as Developing Eight. To understand why agriculture is important, we must see the Table 1. In 2007, GDP per worker and agricultural GDP per worker in D-8 have been compared with that of developed countries. A considerable difference was observed in aggregate labor productivity. However, for the same two groups of countries, the productivity difference in agriculture is even greater:

Agricultural GDP per worker in sampled developed countries is more different from D -8, on the other hand agricultural GDP per worker in D-8 is very low compared to developed countries, for example agricultural GDP per worker in USA, Australia, Germany, Canada, Sweden and some other developed countries is more than $30000, whereas in some of D- 8 countries such as Bangladesh, Indonesia, Pakistan is lower than $1000.

Why is Agricultural GDP per worker in D-8 very low comparing with other sampled countries? In spite of this the poorest countries allocate 90% of their labor force to agriculture, compared to only 5% in the richest countries (Restuccia et al., 2003). In order to answer this question we can review the productivity issue and analyze total factor productivity growth in these countries.

Aggregate productivity can be defined as the amount of output that can be obtained from given levels of inputs in a sector or an economy. “Given limited resources, productivity growth is the only way to sustain and

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Table 1. Agricultural GDP per worker and GDP per worker in D-8 and some of developed countries (2007).

Country	Agricultural GDP per worker	GDP per worker
Australia	32385.2	40209.5
Bangladesh	405	2846.1
Canada	47874.6	39532.8
Egypt	1847.1	6803.3
Germany	31365.3	33563.3
Indonesia	723	6055.8
Iran	4795.4	11780.3
Malaysia	5546	21325.3
Nigeria	2659.6	3196.8
Pakistan	961.3	4441.5
Spain	31634.2	33915.1
Sweden	73128.3	36004.3
Turkey	3407.5	8915.1
United States	71659.9	47701.7

Source: Calculated by author.

Table 2. (2007), location and population of D-8 countries.

Country	Location	Population
Bangladesh	'Southern Asia	152033861
Egypt	Maghreb	80335036
Indonesia	'South-Eastern Asia	234693997
Iran	'Southern Asia	65397521
Malaysia	'South-Eastern Asia	24835243
Nigeria	West Africa	143312101
Pakistan	'Southern Asia	169340538
Turkey	'Western Asia	74767836
Total(D-8 population)		944716133

Source: pwt stat.

increase standards of living" (Acs et al., 1999) .Increases in productivity occurs when output from a given level of inputs increases. This phenomenon is mainly attributed to improvements in the technical efficiency with which the inputs are used and innovations in technology that allow more output to be produced. Agriculture productivity growth in an economy is important because it is an essential source of overall growth (Belloumi and Matoussi, 2009), and it is a necessary condition for economic growth, as it allows a reallocation of labor from the agricultural to the industrial sector (Hayami and Ruttan, 1985).

As shown in this article, agricultural GDP per worker in D- 8 is very low compared with other sampled countries. In order to explain the cause of this phenomenon, agricultural productivity growth of D-8 was analyzed. DEA was used to measure efficiency change and total factor productivity growth in D-8 over the 1993 - 2007 periods.

Literature review

The DEA has been used in many articles. Some of these articles are mentioned here:

- Nkamleu (2004) using DEA method has examined the economic performance of a large number of African countries during the period 1970 - 2001. The result shows that, during that period, total factor productivity has experienced a positive evolution in sampled countries. This study shows that technical change has been the main constraint of achievement of high levels of total factor productivity during the reference period in sub-Saharan Africa. Contrariwise in Maghreb countries, technological change has been the main driving force of productivity growth. Also the results show that institutional factors as well as agro-ecological factors are important determinants of agricultural productivity growth.

- Belloumi and Matoussi (2009) have used a non parametric analysis to investigate The Patterns of agricultural productivity growth in Middle East and North Africa (MENA) countries during the period 1970 - 2000. Their findings showed, in average, agricultural productivity growth increased at an annual rate of 1% during the whole period. Their estimations demonstrate that technical change is the main source of this growth.
- Deliktas and Candemir (2007) used data envelopment analysis approach, to examine productivity performance of Turkish State Agricultural Enterprises over the 1999-2003 periods. Their finding demonstrated that, the agricultural enterprises experienced technical regress, on average, while the Technical efficiency improved by 1.5%. Also, the results of regression estimation indicated that irrigation rate, tractor as an indicator of existing technology, and the geographic positions of enterprises are important determinants of production efficiency.
- Kumar et al. (2004) have analyzed the trend in TFP for the aquaculture and marine sector of India. The TFP indices for aquaculture have revealed that the TFP indices grew by 4.4% annually and accounted for two thirds of the output growth. The growth in aquaculture was mainly technology driven. The TFP growth of fish in the marine sector moved with 2.0% annual growth and accounted for half of the output growth in the marine fisheries.

There is also a substantial body of literature measuring agricultural productivity growth, such as, Ruttan (2002); Coelli and Rao (2003); Deliktas et al. (2005); Nin et al. (2009) and Ludena et al. (2007).

METHODOLOGY

In this study the measure we use to analyze productivity growth of the Developing Eight is the DEA based on Malmqüist TFP indices. These indices were introduced by Caves et al. (1982). The innovation of Färe et al. (1994), shows that this index can be estimated using a nonparametric approach. Malmqüist indices allow for the decomposition of productivity growth into technical and efficiency change components:

- Improvement in technical efficiency with which the inputs are used (catching up), and
- The innovation in technology (technical change) (Belloumi and Matoussi, 2009).

TFP is measured in our study by the Malmquist index methods. We use the Malmquist Productivity index (MPI) as a measure of productivity change over time. The method has the advantage that it is parameter free; we do not presuppose a parametric functional form. Specifying a functional form imposes restrictions on the structure of technology, which could give rise to specification error (Nkamleu, 2004).

We consider here an output distance function. A production technology may be defined using the output set, $P_t(x_t)$ which represents the set of all output vectors, y_t which can be produced using the input vector x_t. That is,

$$P(x) = \{y : x \; can \; produced \; y\}$$

The output distance function is defined on the output set, $P_t(x_t)$ as:

$$d_0(x, y) = \min\{\theta : (y/\theta) \epsilon p(x)\}$$

Following Fare et al. (1994), the MI TFP change between a base period (s) and a period t can be written as:

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)}\left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)}\frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{1/2} \quad (1)$$

That notation $d_0^s(y_t, x_t)$ represents the distance from the period t observation to the period s technology. A value of „m_0" greater than one will indicate positive TFP growth from period s to period t while value less than one indicates a negative TFP growth. In (1),

$$Efficiency \; change = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \quad (2)$$

The first component (2) Measures the degree of catching up to the best- practice frontier for each observation between period t and period t+1. The efficiency change component can be decomposed into scale efficiency and pure efficiency change. (Deliktas and Candemir, 2007);

$$Technical \; change = \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)}\frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{\frac{1}{2}} \quad (3)$$

And the second component (3), Measures the shift in the frontier of technology or Innovation between two adjacent time periods. However, it does not tell us which unit actually caused the frontier to shift. In order to find out innovator enterprises, we can look at the component distance functions in the technical change index. This index tells us what happened to the production frontier at the input level and mix of each unit. Then, that unit has contributed to a shift production frontier between Period t and t+1. Fare et al. (1994) That is,

$$TC^k > 1$$

$$D_0^t(x^{k,t+1}, y^{k,t+1}) > 1 \; and$$

$$D_0^{t+1}(x^{k,t+1}, y^{k,t+1}) = 1$$

That k denotes each decision- making unit (Deliktas and candemir, 2007). Efficiency change component here refers to the improved ability of a country to adopt the global technology available at different points of time where as technical change measures the effect of shift in the production frontier resulting from technological advances on agricultural output. (Belloumi and Matoussi, 2009) Empirical applications require the computations of the four distance functions in (1). As suggested by Coelli (1996), the distance functions can be recovered by solving the following DEA-like linear programs assuming constant returns to scale (CRS) technology:

$$
\begin{aligned}
&[d_0^t(x_t, y_t)]^{-1} = Max_{\phi,\lambda}\,\phi \\
&\text{subject to} \quad -\phi y_{it} + Y_t\lambda \geq 0 \\
&x_{it} - X_t\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}
$$

$$
\begin{aligned}
&\text{subject to} \quad -\phi y_{it} + Y_{t+1}\lambda \geq 0 \\
&x_{it} - X_{t+1}\lambda \geq 0 \\
&\lambda \geq 0,
\end{aligned}
$$

Where λ, is a $N \times 1$ vector of constant and is a scalar with $1 \leq < \infty$. -1 is the proportional increase in outputs that could be achieved by the i-th unit, with input quantities held constant. (Nkamleu, 2004)

Data

To estimate the Malmquist indexes of efficiency and total factor productivity, a panel data on D-8 countries from 1993 - 2007 was used.

Following Balloumi and Matoussi (2009) and other studies, we use two outputs (crops and livestock production) and five inputs (land, animal stock, labor, fertilizer consumption and agricultural machinery (number of tractors)).

We use Output indices (1989 - 1991 = 100) for crops and livestock for the outputs. All data are obtained from the (WBI, 2008) and AGROSTAT system of FAO Statistics Division. Details of these variables are given below:

Labor

The economically active population in agriculture for each year, in each country. The economically active population in agriculture is defined as all persons engaged or seeking employment in agriculture, forestry, hunting or fishing sector, whether as employers, own-account workers, salaried employees or unpaid workers.

Agricultural land

the sum of area under arable land (land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow); permanent crops (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); and permanent pastures (land used permanently for herbaceous forage crops, either cultivated or growing wild).

Fertilizer

The sum of nitrogen, potash and phosphate content of various fertilizers consumed, measured in thousands of metric tons in nutrient units.

Tractors

This refers to total wheel and crawler tractors (excluding garden tractors) used for agricultural production.

Animal stock

The number of cattle measured in livestock units is used as a proxy for animal stock.

RESULTS

Mean overall technical efficiencies (Table 3), indicate a negative trend over time for Bangladesh, Egypt, Indonesia and Pakistan, and a positive trend for turkey only, and for other D-8 countries (Iran, Malaysia and Nigeria) there is no change over time. However the D-8 did not have good performance during the period excluding Turkey. (Greater than unity values for either of these Components suggest improvement, while less than 1 value suggest the opposite) . Table 3 includes mean values of measures of change in total factor productivity index and its components (efficiency and technical change).

Means are given for all of Developing Eight countries. Considering Figure 1 and Table 5, it is concluded that, the change in total factor productivity of the agricultural sector of the countries in question has been positive. On average, total factor productivity has increased by 0.2% annually.

Considering the component measures (Pure and Scale efficiency change), (Table 4), it seems that scale technical efficiency has been the main cause of the negative growth of overall efficiency. This suggests that, to achieve high levels of technical performance over time, technical efficiency is the main constraint. The negative evolution of the scale efficiency of that the agricultural sector did not succeed in taking advantage of the growing size of the sector, whereas on average, pure efficiency has not changed over time.

The component measurements of total factor productivity, efficiency and technical change show that technical change has been the main source of the total factor productivity. The average technical change was 1.5% annually, while the technical efficiency Change was negative (-0.4% annually).

This suggests that, for these countries, Technical efficiency change has been the Main constraint of achievement of high levels of total factor productivity

Table 3. Productivity index and components, 1993 - 2007.

Countries	Technical efficiency change (EffchC)	Technical change (TechchC)	Total factor productivity change (TfpchC)
Bangladesh	0.996	1.011	1.007
Egypt	0.989	1.020	1.009
Indonesia	0.995	1.006	1.001
Iran	1	1.002	1.002
Malaysia	1	1.029	1.029
Nigeria	1	1.012	1.012
Pakistan	0.981	1.024	1.004
Turkey	1.008	1.012	1.020

Source: Estimated by author.

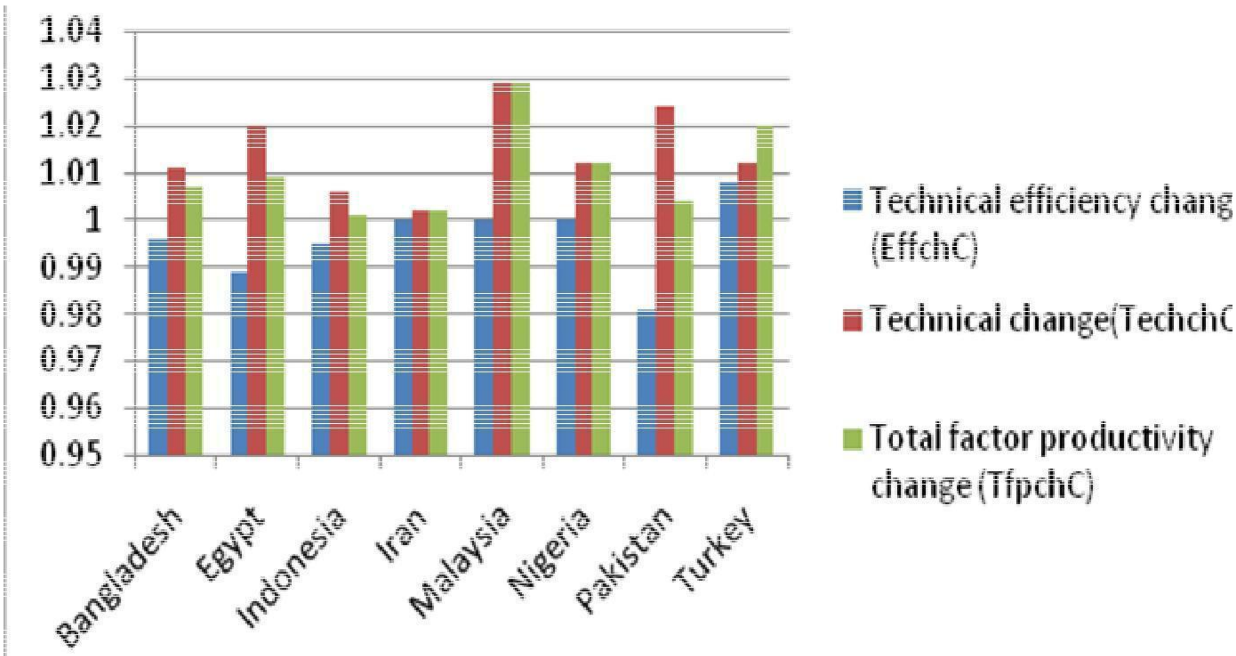

Figure 1. Annual mean efficiency change, technical change and TFP change (1993 - 2007).

Table 4. Mean technical efficiencies change (1993 - 2007).

Countries	Technical efficiency change	Pure technical efficiency change	Scale efficiency change
Bangladesh	0.996	1	0.996
Egypt	0.989	0.997	0.992
Indonesia	0.995	1	0.995
Iran	1	1	1
Malaysia	1	1	1
Nigeria	1	1	1
Pakistan	0.981	1	0.981
Turkey	1.008	1.01	0.998

Source: Estimated by author.

Table 5. Annual mean efficiency change, technical change and TFP change, 1993-2007.

Year	Technical efficiency change EffchC	Technical change TechchC	Total factor productivity change TfpchC
1994[1]	1.009	1.007	1.016
1995	1.022	0.997	0.998
1996	1.006	1.001	1.007
1997	1.006	0.992	0.997
1998	0.978	0.971	0.949
1999	0.983	1.044	1.026
2000	0.999	1.037	1.036
2001	0.998	0.983	0.981
2002	0.986	1.028	1.013
2003	0.991	1.018	1.009
2004	0.98	1.058	1.037
2005	0.985	1.042	1.026
2006	1.001	1.028	1.029
2007	1.003	1.022	1.025

Source: Estimated by author. [1] Note that 1994 refers to the change between 1993 and 1994.

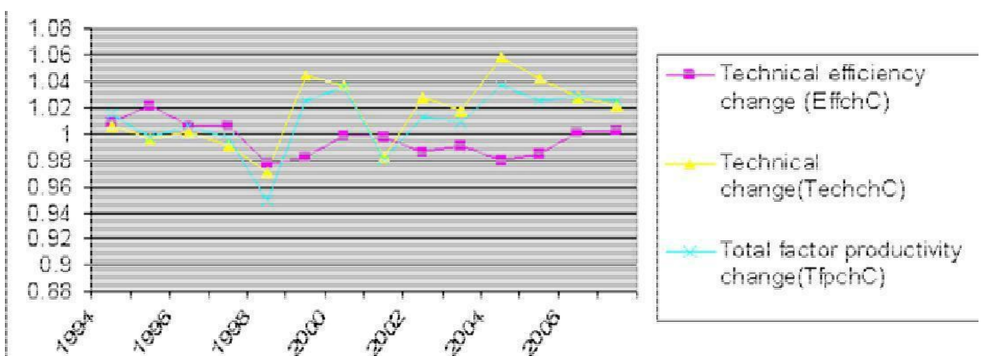

Figure 2. Evolution of efficiency change, technical change and TFP change over time.

during the reference period. It is compelling that in all D-8 countries Technical change is more than efficiency change. Figure 2, shows clearly that the technical change is the main source of total factor productivity fluctuation over time, because the technical change component has had more fluctuation, rather than technical efficiency change.

Figure 2 shows the rates of change in efficiency, technology and productivity, in the reference period. It seems that, during the 1993 - 2007 years, these countries succeed in improving the technology of the agricultural sector. The average annual growth rate of technical change during that period was 1.5%, while the technical efficiency was negative on average.

This average technical efficiency change gives us information only on the “catch-up” part of the productivity issue. In fact a country will have a positive efficiency change over time if it is catching up. The degree of catching up or the efficiency Change can be related to institutional factors, domestic and trade policies of specific countries. TFP change can also appear in the form of technical change (or frontier-shift) (Belloumi and Matoussi, 2009).

Conclusion

This paper analyses the agricultural productivity growth in D-8 over the period 1993 - 2007 using a nonparametric Malmquist index. It was found that, during the period, the total factor productivity experienced a positive evolution in these countries. Also, decomposition of TFP indicates that, the technical efficiency change is the main constraint of achievement of high levels of total factor productivity during the reference period in these countries. The cause of the low efficiency is that, these countries haven't succeeded well in expanding of this sector of their economies.

Also this phenomenon describes the lowering agricultural GDP per worker in D-8 countries. Findings show that one of the main challenges in agriculture sector in these countries is low productivity. Since one of the main areas of D -8 cooperation is agriculture and agriculture is also one of the main sectors in all developing economies, it seems that more cooperation in this sector and using the experience of successful countries in this field can help these countries to achievement of high levels of total factor productivity.

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