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ANALYSIS OF THE AGRICULTURAL SECTOR GROWTH USING MALMQUIST TOTAL FACTOR PRODUCTIVITY INDEX FOR 165 COUNTRIES

[34]

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ABSTRACT

This study was conducted to estimates the Malmquist productivity indices using the data envelopment analysis (DEA) for 165 countries over 8 regions and classified across 8 groups based on agricultural gross production value during the study period (1980-2007). The total factor productivity including and measure the efforts in the resource allocation, modernization, the technological change, and catch-up efforts in the agriculture sector in any country. While, Malmquist TFP index measures total factor productivity change between two data points by calculating the ratio of the distance function of each data point relative to a common technology. The data used in this study was drawn from the Food and Agriculture Organization of the United Nations. This paper also estimated the technical efficiency, technical efficiency change and technical change for countries in each group and for all those countries as one group.

INTRODUCTION

In the last six decades, productivity growth in agriculture has been considered the essential interest of the agricultural economists due to the increase of the demand for food and raw materials out of the agricultural sector output. The development economists conducted many researches to study the sources of productivity growth of the cross-countries differences over specific periods.

The economical studies in the productivity and development that had pioneer role in investigating the sources of productivity growth in different countries are conducted by **Hayami & Ruttan (1970, 1971); Kawagoe & Hayami (1983, 1985); Kawagoe et al (1985); Capalbo & Antle (1988) and Lau & Yotopoulos (1989).** Most researches in this field focused firstly on the study of the total factor productivity **(Abramovitz (1962); Nadiri (1970); Solow (1957); Ruttan (1960) and Griliches (1963).** The studies conducted later focus more on productivity decomposition **(Afriat, 1972, Caves, 1993), Fare, 1994, Fare, 1995, Fare, 1997, Arnade, 1998 and Coelli, 1998)**.

While **Shephard (1953)** introduced the input distance function in the context of production analysis, **Malmquist (1953)** introduced the input distance function in the context of consumption analysis and developed a standard of living index as a ratio of pair of the input distance function. In the context of production analysis, Malmquist standard of living index becomes an input quantity index. There is an analogous output quantity index based on output function introduced by **Shepherd (1970).** Two approaches have been developed: The first approach is partially oriented, being based either on, a) a ratio of output distance function or b) a ratio of input distance function; this approach was pioneered by **Caves et al (1982)** and called Malmquist productivity index.The second approach is simultaneously oriented, being based on a ratio of output distance function contained in the output quantity index and the ratio of input distance function contained in the input quantity index; this approach is called Malmquist total factor productivity index.

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The information revolution that hit all life aspects had an essential role in developing new economical methodologies and allowed more data sets that helped in estimating productivity decomposition in the most recent studies rather than using the old techniques applied with total factor productivity. In the last three decades, the productivity growth measurement literature has been extended from the standard calculations TFP employing production function towards more refined decomposition methods. These techniques, which are based on the Decomposition of TFP index, have been developed that are. Malmquist method becomes the most common approach to measure the productivity growth. Caves, **Christensen and Diewert (1982)** developed non-parametric perspective to measure the output produced per unit of input. However, **Fare et al (1994)** developed the output distance function method of **Shepherd (1970).**

The studies in the area of growth productivity in agriculture have been conducted for several countries and regions over time courses using different common economical techniques such as Cobb-Douglas production function **(Fulginiti & Perrin, 1993, Craig et al 1997, Wiebe et al 2000 and Fulginiti & Perrin, 1998).** Data Envelopment Analysis **(Fulginiti & Perrin, 1997), Lusigi & Thirtle, 1997, Rao & Coelli, 1998, Arnade, 1998, Chavas, 2001, Suhariyanto et al 2001, Suhariyanto & Thirtle, 2001, Trueblood & Coggins, 2003, Nin et al 2003 and Coelli et al 2005,** Fisher Index and other techniques. **(Bureau et al 1995 and Ball et al 2001).**

MATERIAL AND METHODS

Research problem

Many of the growth studies in the agricultural sector were conducted to estimate and decompose the total factor productivity index using several methods such as Data Envelopment Analysis. However, most of these studies had some problems in the estimation of this index which led to give unprecise results. The majority of these studies that estimated the TFA index included all the countries of their studies as a one group regardless the big difference between them in the agricultural production values, stock of technology and technical efficiency. Moreover, most of these studies didn't include the capital stock data as a production input in their consideration to estimate the TFA index. Therefore, the current study aims to estimate the TFA index with new prospective to overcome the previous hurdles.

Research objective

The aim of this study is to estimate and decompose the total factor productivity (technical efficiency change - technical change - scale efficiency change) during the period (1980-2007) for countries in each group and for all countries as one group.

Methodology

As noted by **Kumar (2006) and Collie (2003),** the total factor productivity (TFP) estimation are based on average production function and growth accounting methodology. They assume that a firm is operating on its production frontier, TFP is treated analogous to technical change. This approach use several restrictive assumptions such as Constant return to scale, and Allocative and technical efficiency have to be made. However, some papers use nonparametric linear programming technique to construct the Malmquist productivity index. The Malmquist productivity index was introduced as a theoretical index by **Caves et al (1982)** and popularized as an empirical index by **Fare et al (1994), the Malmquist index has several features:**

1- It is a TFP index
2- It can be constructed using distance function, which primal measure based only on input and output quantity rather than prices.
3- The index can be decomposed into technical efficiency change, technical change, and scale component.

These studies use Linear programming as an approach to construct the Malmquist productivity index. **This approach has two advantage over the econometrics one in measuring productivity change:**

1- It compares the country to the best practice technology rather than average practice technology as it is done by econometrics studies.
2- It dose not require the specification of an ad hoc function form or error structure.
3- The LP approach allows recovery of various efficiency and productivity measures in an easily calculable measure. It is able to answer question related to technical efficiency, scale efficiency and productivity change.

Malmquist TFP index measures total factor productivity change between two data points by calculating the ratio of the distance function of each data point relative to a common technology. The Malmquist is defined using distance function, which describes a multi-input multi-output production technology without the need to specify a behavioral objectives. Input distance function characterize the production technology by looking at minimal proportional contraction of the output vector given an output vector.

Output distance function considers a maximal proportional expansion of the output vector, given an input vector. Production technology may be defined using the output set, p(x), which represents the set of all output vector (y), which can be produced using the input vector (x).

$$\boldsymbol{P(x) = \{y: x\ can\ produce\ y\}}$$

The input distance function is defined on the output set $P(x)$ as:

$$\boldsymbol{D_o(x,y) = min\{\delta: (y/x) \in P(x)\}}$$

The distance function will take value that:

1- Is less or equal to one if the output (y) is an element of the feasible production set $P(x)$.
2- A value of unity if the output (y) is located on the outer boundary of the feasible production set $P(x)$
3- A greater than one if y is located outside the feasible production set $P(x)$.

DEA like method are used to calculate the distance measure and Malmquist TFP index measures the TFP change between two data points by calculating the: Raito of the distance function of each data point relative to a common technology. Following **Coelli et al (2005),** the required distance measure for the Malmquist TFP index are calculating using DEA like liner programming For the ith country four distance functions are calculated in order to measure the TFP change between two period t, t+1, This requires the solving of four liner programming LP problems.

Fare et al (1994) assume a constant return to scale (CRS) technology. This very important in TFP measurement, A CRS technology used in this study for two reasons

1- Given that the analysis involve the use of aggregate country level data.
2- Is applicable to both firm level and aggregate data.

Measure the change in output oriented

Table (5) shows that how to create the output distance function between two points data and two technology to calculate the output Malmquist TFP index. The output Malmquist TFP change between two data points is estimated by calculating the ratio of distance of each data point relative to a common technology. Following **Fare et al (1994),** Malmquist TFP change index (output-oriented) between period (t) and period (t+1) is shows in **Table (5)** given by :

$$\boldsymbol{Malmquist\ output\ index\ or\ total\ factor\ productivity} = \left[\frac{\boldsymbol{D_o^{t+1}(y^{t+1},x^{t+1})}}{\boldsymbol{D_o^{t+1}(y^{t},x^{t})}} * \frac{\boldsymbol{D_o^{t}(y^{t+1},x^{t+1})}}{\boldsymbol{D_o^{t}(y^{t},x^{t})}}\right]^{\boldsymbol{0.5}}$$

The equation is geometric mean of two TFP indices :

1- Is evaluated with respect to period (t) technology
2- Is evaluated with respect to period (t +1) technology

If Malmquist output index or total factor productivity (MALM) is

- More than (1): it indicates positive TFP growth from period (t) to period (t+1).
- Less than (1) : it indicates TFP decline from period (t) to period (t+1).
- Equal (1) : it indicates TFP have no change from period (t) to period (t+1.)

$Malmaquist\ Total\ factor\ Productivity\ Index\ =$

$MALM = \left[\frac{Df4}{Df2} * \frac{Df3}{Df1}\right]^{0.5}$ ……..(1)

Multiplier equation (1) by $\frac{Df4}{Df4} * \frac{Df1}{Df1}$

$MALM = \left[\frac{Df4}{Df2} * \frac{Df3}{Df1}\right]^{0.5}$= ……..……(2)

$MALM = \left[\frac{Df4}{Df1} * \frac{Df4}{Df1} * \frac{Df3}{Df4} * \frac{Df1}{Df2}\right]^{0.5} = \left[\left(\frac{Df4}{Df1}\right)^2 * \frac{Df3}{Df4} * \frac{Df1}{Df2}\right]^{0.5}$ ……..……..(3)

$Malmquist\ index MALM = \frac{Df4}{Df1} * \left[\frac{Df1}{Df2} * \frac{Df3}{Df4}\right]^{0.5}$ …..(4)

$Technical\ efficiency\ change\ (T_{ef.ch.})$ is equivalent to the ratio of the $Technical\ efficiency\ (T_{ef.})$ in period (t+1) to the $Technical\ efficiency$ in period (t) and the Geometric mean of the shift in technology between the two periods evaluated at X_{t+1} , X_t .

$Technical\ efficiency\ change\ \left(T_{ef.ch.}\right) = \frac{Df4}{Df1}$ ….(5)

Following **Kumar (2006), and Collie (2003):**

$T_{ef.ch.} =$

$Pure\ Technical\ efficiency\ change(\ PT_{ef.ch.}) *$

$Input\ Scale\ efficiency(S_{ef.ch.})$……..(6)

$Technical\ Change(T_{ch.}) = \left[\frac{Df1}{Df2} * \frac{Df3}{Df4}\right]^{0.5}$ ……(7)

From equation (5), equation (7)

$MLMA = T_{ef.ch.} * T_{ch.}$ ……..…… (8)

from **equation (6)**

$MLMA = PT_{ef.ch.} * S_{ef.ch.} * T_{ch.}$ ……(9)

This paper uses the Malmquist index method to measure total factor productivity growth depend on Data Envelopment Analysis (DEA) to construct a piece-wise linear production for each year. As noted by Collie et al. (2005) DEA is a liner programming method, which uses data on the input and output of the countries under study to construct a piece –wise liner surface over the data points. The distance between the observed data point and the frontier refer to the degree of technical inefficiency of each country.

Data: the present study use the data which drawn from the faostat system of the statistics division of the Food and agricultural Organization in Rome and the statistics division of the world bank.

Output: Gross Production value constant million international dollar base year 2005.

The value of gross production has been compiled by multiplying gross production in physical terms by output prices at farm gate. Thus, value of production measures production in monetary terms at the farm gate level. Since intermediate uses within the agricultural sector (seed and feed) have not been subtracted from production data, the value of production aggregate refers to the notion of "gross production". The value of gross production is provided in constant terms and is expressed in international dollar[1] Value of production in constant.

Input: Labor in agriculture

Economically active population in agriculture (agricultural labor force) is that part of the economically active population engaged in or seeking work in agriculture, hunting, fishing or forestry. This variable refers to the economically active population in agriculture. This population is defined as all persons engaged or seeking employment in an economic activity, whether as employers' own-account workers, salaried employees, or unpaid workers, assisting in the operation of a family farm or business. The economically active population in agriculture includes all economically active people engaged in agriculture, forestry, hunting or fishing; this variable obviously overstates the labor input used in agriculture production.

Gross capital stock (constant million USA dollar base year 2005)

The estimate of capital stock in agriculture refers to a value that is attached to the total physical capital capacity available for repeated use in the production of other goods, in existence at specific point in time in the economy of agriculture sector. The estimates of investment in agriculture have indirectly been derived by the FAO Statistics Division using physical data on livestock, tractors, irrigated land and land under permanent crops, and the average prices for the year 1995. These data enabled the derivation of the capital stock in agriculture which is the gross, and the annual change in the latter is taken to reflect investment in agriculture. The FAO Statistics Division has compiled an updated dataset series of capital stock in Agriculture from 1975-2007 using 2005 constant prices as the base year. The dataset on capital stock in agriculture is important for analyzing a number of policy issues related to sustainable growth of agriculture and achieving food security. The dataset has been developed by multiplying unit prices by the quantity of physical assets in use compiled from individual countries.

Time period, **Region and Countries**

The study use data for the period 1980 to 2007 for 165 countries, **Table (1)** shows that the agricultural gross production value(Q), labor (L) and capital (K) for these countries, which account for 91%, 96%, and 88% of the world's agricultural gross production value; world's agricultural labor; and world's stock capital respectively.

Table (1) shows that the 165 countries are classified on 8 groups based on agricultural gross production value in contestant million international dollars basis year 2005. For instance, **Table (1)** shows that there are 33 countries in group (1); the agricultural gross production value for each country on group (1) is less than (I$ 100 million).

[1] As noted by FAO Organization: International Dollar prices are international prices expressed in a common currency that were developed within the framework of GDP international comparisons. The Geary –Khamis international average price are based on prices (in national currency units) and quantities of 185 agriculture commodities in 103 countries. International prices are useful in computing comparable value aggregates for different commodities groups. International prices are a function of production of the different commodities in different countries, of their national prices and of the exchange rates between national currencies. The Geary-Khamis approach that has been chosen by the UN to define the international prices and exchange rates derived from the data through a system of interdependent equations. In the equation system international prices of commodities are weighted averages of national prices converted into a common currency and weighted by national outputs. Exchange rates are equal to the ratio of the value of production of a given country at international prices divided by the value of production of the same country in national currency.

Table 1. The annual average and percentage of Agricultural gross production value (Q), labor (L) and gross capital stock (K) for groups under study during (1980-2007).

Groups	Sets		Q		L		K	
		Countries	(million I$)	%	million worker	%	(USD million)	%
Group 1	Less than 100	33	1082	0.07	1.4	0.12	5585	0.11
Group 2	100-500	25	5893	0.36	7.0	0.61	23507	0.47
Group 3	500-1000	16	12833	0.79	17.4	1.50	67745	1.35
Group 4	1000-2000	20	28970	1.79	44.2	3.81	110713	2.20
Group 5	2000-4000	21	60654	3.75	49.3	4.25	274460	5.46
Group 6	4000-8000	16	78601	4.86	48.0	4.14	285389	5.67
Group 7	8000-16000	13	139030	8.59	100.9	8.70	478580	9.51
Group 8	More than 16000	21	1143315	70.64	845.5	72.90	3183339	63.27
total	165	165	1470378	90.85	1113.7	96.02	4429319	88.04
World			1618413	100	1159.9	100	5031076	100

Source: selected and calculated from FAO (food and agricultural organization), faostat website

Similarly the total agricultural gross production value for those countries in group (1) is estimated to be around (I$ 1.08) billion annually on average which posted the lowest groups of 0.07% of the world's agricultural gross production value during the study period. In addition, those countries on group (1) had 0.12% and 0.11% of world's agricultural labor and world's stock capital respectively on average. On the other hand, **Table (1)** shows that there are 21 countries in group (8), and the agricultural gross production value for each country is more than (I$ 16 billion). The total agricultural gross production value for those countries in group (8) is (I$ 1143) billion annually on average which posted the highest group of 70.6% of the world's agricultural gross production value during the study period. Also those countries on group (8) had 72.9% and 63.3% of world's agricultural labor and world's stock capital respectively on average during 1980-2007.

Table (2) shows that 165 countries distributed on 8 regions. For instance, there are 37 countries located in Asia. On the other hand, the total agricultural gross production value for these countries is (I$ 677) billion annually on average, which posted the highest region of 42 % of the world's agricultural gross production value during the study period. These Asian countries understudy posted of 78% and 35% of world's agricultural labor and world's stock capital respectively on average. While the total agricultural gross production value for 22 countries located in Europe was I$ 252 billion on average which posted of 15.5 % of the world's agricultural gross production, those countries under study over Europe region posted of 1.6% and 14% of world's agricultural labor and world's stock capital respectively on average during the study period.

Table (2) shows that there are 53 countries over Africa region; the total agricultural gross production value for those countries is I$ 115 billion on average, which posted of 7.1 % of the world's agricultural gross production. In addition, those countries posted of 11.7% and 7.8% of world's agricultural labor and world's stock capital respectively on average during the study period.

Table (2) includes 17 countries located in American Caribbean. As well as, the total agricultural gross production value for these countries was (I$ 7.8) billion annually on average which posted the lowest region of 0.49% of the world's agricultural gross production value during the study period, However those countries under study located in Asia posted of 0.36%and 0.88% of world's agricultural labor, and world's stock capital respectively.

According to **Table (2)** there are only two countries under study in North America. The total agricultural gross production value for those countries was (I$ 213) billion annually on average which posted of 13.2% of the world's agricultural gross production value during the study period. These two countries in North America posted of 0.34% and 14.1% of world's agricultural labor and world's stock capital respectively on average.

Table (3) shows that 165 countries are distributed on 8 regions and 8 groups in the same time, while, **Table (4)** shows that the agricultural gross

Table 2. The annual average and percentage of Agricultural gross production value (Q), labor (L) and gross capital stock (K) for regions under study during (1980-2007).

		Q		L		K	
	countries	(million I$)	%	million workers	%	(USD million)	%
Asia	37	676684	41.81	907.7	78.26	1776661	35.31
Africa	53	115055	7.11	136.2	11.74	392236	7.80
Europe	22	251633	15.55	18.7	1.61	710314	14.12
North America	2	213111	13.17	3.9	0.34	710364	14.12
South America	13	140675	8.69	27.2	2.34	479886	9.54
American Caribbean	17	7893	0.49	4.2	0.36	44220	0.88
Central America	8	34118	2.11	13.4	1.15	138640	2.76
Oceania	13	31208	1.93	2.5	0.22	176997	3.52
total	165	1470378	90.85	1113.7	96.02	4429319	88.04
World		1618413	100	1159.9	100	5031076	100

Source : selected and calculated from FAO (food and agricultural organization), faostat website

Table 3. Distributed 165 countries under study over regions and groups during (1980-2007).

Regions/ groups	Groups 1	Groups 2	Groups 3	Groups 4	Groups 5	Groups 6	Groups 7	Groups 8	total
Asia	3	6	4	2	7	1	6	8	37
Africa	8	12	6	12	6	6	2	1	53
Europe	2		1	1	4	5	3	6	22
North America								2	2
South America	1	2		1	2	4	1	2	13
American Caribbean	10	3	2	1	1				17
Central America		1	3	2	1			1	8
Oceania	9	1		1			1	1	13
Total	33	25	16	20	21	16	13	21	165

Source : selected and calculated from FAO (food and agricultural organization), faostat website

production value, agricultural labor and stock capital on average over 8 regions and 8 groups in the same time. For instance, **Table (3)** shows that there are 37 countries over Asia distributed in 8 groups. There are (3), (6), and group (4) countries in groups (1), (2) and (3) respectively. On the other hand, **Table (4)** shows that the agricultural gross production value for countries, which located in Asia and distributed in group (1), (2) and 3 is I$ 60, 1416, and 3237 million, respectively.

RESULT AND DISCUSSION

This part of study presents the results of the Malmquist productivity indices for 165 countries, countries are distributed over 8 regions. Those countries also divided into 8 groups based on annual average of agricultural gross value during the period 1980-2007. This paper attempts to estimate the Malmquist productivity indices for countries in each group separately, and for all 165 countries as one group. The results will be presented in two sections, First: The results depend on estimation for countries in each group, Second: the results depend on estimation for all countries as one group.

1- The results depend on estimation for countries in each group.

a. Results for groups :

1- Technical efficiency

Table (6) shows the mean of the technical efficiency for each group during 1980-2007.

Table 4. The annual average and percentage of Agricultural gross production value (Q), labor and gross capital stock for countries distrusted by region and groups during (1980-2007).

regions	Items / groups	g1	g2	g3	g4	g5	g6	g7	g8	total
Asia	Q (million I$)	60	1416	3237	2591	18487	4699	67001	579194	676684
	% world	0	0.1	0.2	0.2	1.1	0.3	4.1	35.8	41.8
	Labor (million man)	0.03	0.8	3.6	3.5	19.7	1	85.7	793.4	907.7
	%	0	0.1	0.3	0.3	1.7	0.1	7.4	68.4	78.3
	Capital (million $)	215	4974	20226	6991	100644	18279	170894	1454439	1776661
	%	0	0.1	0.4	0.1	2	0.4	3.4	28.9	35.3
Africa	Q (million I$)	291	3109	4772	16088	18442	28096	22702	21555	115055
	% world	0	0.2	0.3	1	1.1	1.7	1.4	1.3	7.1
	Labor (million man)	1	4.2	9.6	36.1	25.1	39.5	8.1	12.6	136.2
	%	0.1	0.4	0.8	3.1	2.2	3.4	0.7	1.1	11.7
	Capital (million $)	1587	14275	24873	69640	55227	107792	73715	45127	392236
	%	0	0.3	0.5	1.4	1.1	2.1	1.5	0.9	7.8
Europe	Q (million I$)	164		809	1461	12436	27136	31237	178390	251633
	% world	0.0		0.0	0.1	0.8	1.7	1.9	11	15.5
	Labor (million man)	0		0.7	0.1	1.4	1.7	3.6	11.2	18.7
	%	0		0.1	0	0.1	0.1	0.3	1	1.6
	Capital (million $)	1112		5371	9630	54791	72313	80104	486994	710314
	%	0		0.1	0.2	1.1	1.4	1.6	9.7	14.1
North America	Q (million I$)								213111	213111
	% world								13.2	13.2
	Labor (million man)								3.9	3.9
	%								0.3	0.3
	Capital (million $)								710364	710364
	%								14.1	14.1
South. America	Q (million I$)	18	397		1970	5221	18670	10087	104314	140675
	% world	0.0	0.0		0.1	0.3	1.2	0.6	6.4	8.7
	Labor (million man)	0	0.1		1.3	0.8	5.8	3.5	15.6	27.2
	%	0	0		0.1	0.1	0.5	0.3	1.3	2.3
	Capital (million $)	37	1747		7169	30188	87005	96235	257504	479886
	%	0	0		0.1	0.6	1.7	1.9	5.1	9.5
American Caribbean	Q (million I$)	261	634	1446	1858	3694				7893
	% world	0	0	0.1	0.1	0.2				0.5
	Labor (million man)	0.1	0.6	2.1	0.6	0.8				4.2
	%	0	0.1	0.2	0	0.1				0.4
	Capital (million $)	469	1426	6456	8855	27014				44220
	%	0	0	0.1	0.2	0.5				0.9
Central America	Q (million I$)		116	2569	3125	2374			25934	34118
	% world		0	0.2	0.2	0.1			1.6	2.1
	Labor (million man)		1.2	1.3	1	1.5			8.4	13.4
	%		0.1	0.1	0.1	0.1			0.7	1.2
	Capital (million $)		154	10819	6298	6597			114772	138640
	%		0	0.2	0.1	0.1			2.3	2.8
	Q (million I$)	287	222		1877			8004	20818	31208
	% world	0	0		0.1			0.5	1.3	1.9
Oceania	Labor (million man)	0.3	0.1		1.5			0.2	0.4	2.5
	%	0	0		0.1			0	0	0.2
	Capital (million $)	2165	932		2130			57631	114139	176997
	%	0	0		0			1.1	2.3	3.5
Total	Q (million I$)	1082	5893	12833	28970	60654	78601	139030	1143315	1470378
	% world	0.1	0.4	0.8	1.8	3.7	4.9	8.6	70.6	90.9
	Labor (million man)	1.4	7	17.4	44.2	49.3	48	100.9	845.5	1113.7
	%	0.1	0.6	1.5	3.8	4.3	4.1	8.7	72.9	96
	Capital (million $)	5585	23507	67745	110713	274460	285389	478580	3183339	4429319
	%	0.1	0.5	1.3	2.2	5.5	5.7	9.5	63.3	88

Source : selected and calculated from FAO (food and agricultural organization), faostat website

Table 5. Create the output distance function between two data points and two technology.

	$Output\ Distance\ Function\ D_o$	
$Technology$	$Data\ point\ (t)$	$Data\ point\ (t+1)$
(y^t, x^t)	$D_o^t(y^t, x^t)$……($Df1$)	$D_o^{t+1}(y^t, x^t)$ ……..……($Df2$)
(y^{t+1}, x^{t+1})	$D_o^t(y^{t+1}, x^{t+1})$……($Df3$)	$D_o^{t+1}(y^{t+1}, x^{t+1})$……($Df4$)

$Do = Output\ distance\ function, t: period\ t, t+1: period\ t+1, y: output\ vector, x = input\ vector$

Table 6. Means of technical efficiency, technical efficiency change, technical change, pure technical efficiency change scale efficiency change,and TFP change for groups, 1980-2007 (based on estimation for countries in each group)

Groups	Agricultural gross production value (millions I$)	countries	technical efficiency	pure technical efficiency change	scale efficiency change	Technical efficiency change	technical change	total factor productivity change
Group 1	Less than 100	33	0.766	1.003	0.986	0.989	1.123	1.110
Group 2	100-500	25	0.676	1.000	0.980	0.980	1.099	1.077
Group 3	500-1000	16	0.873	1.000	0.994	0.994	1.112	1.105
Group 4	1000-2000	20	0.851	1.000	0.996	0.996	1.090	1.086
Group 5	2000-4000	21	0.864	1.000	0.994	0.994	1.120	1.114
Group 6	4000-8000	16	0.950	1.000	0.996	0.996	1.106	1.101
Group 7	8000-16000	13	0.888	1.000	0.993	0.993	1.059	1.052
Group 8	More than 16000	21	0.831	1.000	0.998	0.998	1.065	1.064
Mean			0.817	1.001	0.991	0.992	1.100	1.091

Source : calculation from table (14)

The overall mean of the technical efficiency for all groups is 0.817, which explains that those groups are producing 81.7% of the potential output that could be produced using the observed input. On the other hand, **Table (6)** shows the mean of the technical efficiency of each group. For instance, group (2) posted the lowest mean of the technical efficiency (0.676), which illustrates that those countries in group (2) are producing 67.6% of the output that could be potentially produced using the observed input. Group (6) achieved the highest technical efficiency (0.950). This implies that the countries in group (6) are producing 95% of the output that could be potentially produced using the observed input.

2- Technical efficiency change

The technical efficiency change is affected by two powers, pure technical efficiency change and scale efficiency change. **Table (6)** shows the overall mean of the technical efficiency change for all groups is 0.992 which implies that these decline in technical efficiency during 1980-2007 by 0.8% annually. The pure technical efficiency change decline due to the decline in scale efficiency change on average (0.9% annually), but pure technical efficiency change (0.1% annually) plays the positive role to improve this ratio. **Table (6)** also shows that all groups have no change in pure technical efficiency change except group (1), and all groups have a decline in scale efficiency during 1980-2007.

3- Malmquist total factor productivity change index.

Table (6) shows the technical efficiency change, technical change, and TFP change in each group. The Malmquist total factor productivity index is affected by two powers, the technical efficiency change and the technical change. **Table (6)** shows that the countries in Group (5) posted the highest TFP growth (11.5%) which is mainly due to the technical change growth of 12% followed by Group (1) which posted TFP growth of 11% due to the technical change growth of 12.3 %, followed by Group (3) which posted TFP growth of 10.5% due to the technical change growth of 11.2 %, followed by Group (6), Group (4) and Group (8). Meanwhile, Group (7) posted the lowest TFP growth of 5.2% due to the technical change growth of 5.9%. T**able (6)** also shows that the main effect drives the total factor productivity growth due to the technical change.

b. Results for regions

1- Technical efficiency

Table (7) shows the means of the technical efficiency for each region during 1980-2007. For instance, the lowest technical efficiency posted for American Caribbean and North America of 0.750, 0.779 illustrates that two regions are producing 75% and 77.9% of the output that could be potentially produced using the observed input in each region respectively. On the other hand, South America and Central America posted the highest technical efficiency of 0.870 and 0.917 which implies this regions producing 87% and 91.7% of the output that could be potentially produced using the observed input during studying period respectively. The other regions are very close to one others such as Oceania, Africa, Asia, and Europe are recoded 0.802, 0.811, 0.815, 0.837 respectively.

Table 7. Means of technical efficiency, technical efficiency change, technical change, pure technical efficiency change scale efficiency change,and TFP change for regions,1980-2007 (based on estimation for countries in each group)

Regions	technical efficiency	pure technical efficiency change	scale efficiency change	Technical efficiency change	technical change	total factor productivity change
Asia	0.815	1.000	0.991	0.991	1.086	1.076
Africa	0.811	1.000	0.992	0.992	1.101	1.093
Europe	0.837	1.000	0.998	0.998	1.086	1.084
North America	0.779	1.000	1.000	1.000	1.097	1.097
Central America	0.917	1.000	0.994	0.994	1.108	1.101
American Carrabin	0.750	1.002	0.978	0.980	1.117	1.094
South America	0.872	1.000	0.993	0.993	1.109	1.102
Oceania	0.802	1.002	0.991	0.993	1.117	1.109
Mean	0.817	1.001	0.991	0.992	1.100	1.091

Source : calculation from table (14)

2- Technical efficiency change

Table (7) shows the means of technical efficiency change for regions. The overall mean technical efficiency change for Asia posted of 0.991 implies this decline in technical efficiency by 0.9% annually. This decline is mainly due to the decline in scale efficiency change on average (0.9%) annually during 1980-2007. While, the pure technical efficiency showed no change for countries in Asia under study, **Table (7)** also shows that all regions have no change in pure technical efficiency change except American Carrabin and Oceania. In the same time all regions have a decline in scale efficiency except North America during 1980-2007.

3- Malmquist total factor productivity change index.

Table (7) shows that the Oceania region posted the highest TFP growth of 10.9% due to technical change growth of 11.7% followed by South America posted TFP growth of 10.2% due to to technical change growth of 10.9 %, followed by Central America posted TFP growth of 10.1% due to to technical change growth of 10.8 %, followed by North America, American Carrabin, Africa, Europe and Asia. Asia has posted lowest TFP growth of 7.6% due to technical change growth of 8.6%.

c. The annual change average Malmquist total factor productivity change index

While **Table (9)** presents a good panorama about TFP change from year to year during 1980-2007, **Table (8)** summarizes the results of the Annual Mean of technical efficiency change, technical change, pure technical efficiency change scale efficiency change, and TFP change for groups 1980-2007. **Table (8)** shows the average TFP change during 1980-1990 declined from 16.9% to 7.2% during the period (1991-2000), and posted of 0.4% as the lowest value for TFP change during the period 2001-2007.

Table 8. Annual Means of technical change and TFP change for groups in some different periods (based on estimation for countries in each group)

	1980-1990			1991-2000			1980-2000			2001-2007			1980-2007		
	Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.
Group 1	0.983	1.010	0.993	1.010	1.127	1.138	0.996	1.067	1.063	0.968	1.297	1.255	0.989	1.122	1.110
Group 2	0.952	1.315	1.253	1.051	0.992	1.043	1.001	1.142	1.143	0.922	0.984	0.907	0.980	1.099	1.077
Group 3	0.967	1.322	1.277	1.040	0.953	0.992	1.003	1.122	1.126	0.969	1.081	1.048	0.994	1.111	1.105
Group 4	1.006	1.131	1.138	0.966	1.092	1.055	0.986	1.111	1.095	1.027	1.033	1.061	0.996	1.090	1.086
Group 5	0.938	1.306	1.226	0.983	1.133	1.114	0.960	1.216	1.168	1.097	0.886	0.972	0.994	1.121	1.114
Group 6	0.993	1.215	1.207	0.973	1.044	1.015	0.983	1.126	1.107	1.033	1.051	1.086	0.996	1.106	1.101
Group 7	0.947	1.227	1.162	1.055	0.985	1.039	1.000	1.099	1.098	0.976	0.954	0.931	0.993	1.059	1.052
Group 8	0.869	1.291	1.122	1.157	1.035	1.198	1.003	1.156	1.159	0.984	0.845	0.832	0.998	1.065	1.064
Mean	0.956	1.222	1.169	1.028	1.043	1.072	0.991	1.129	1.120	0.996	1.008	1.004	0.993	1.097	1.088

Teff.: technical efficiency, Teff.ch.: technical efficiency change,Tch.:, technical change, TFPch.: total factor productivity change,
Source : calculation from table (9)

Table 9. Annual Means of technical efficiency change, technical change, pure technical efficiency change scale efficiency change,and TFP change for groups 1980-2007 (based on estimation for countries in each group)

From	To	G	Teff.ch.	Tch.	TFPch.	G	Teff.ch.	Tch.	TFPch.	g	Teff.ch.	Tch.	TFPch.	G	Teff.ch.	Tch.	TFPch.
1980	1981	1	1.133	0.538	0.610	3	0.588	1.555	0.914	5	0.672	2.019	1.357	7	0.913	0.537	0.490
1981	1982	1	0.190	15.058	2.864	3	1.635	0.871	1.423	5	0.715	1.681	1.202	7	0.898	4.082	3.664
1982	1983	1	4.396	0.343	1.508	3	0.631	2.887	1.823	5	1.695	0.792	1.342	7	1.260	0.561	0.707
1983	1984	1	0.654	0.476	0.311	3	1.549	0.688	1.065	5	1.196	1.268	1.517	7	0.735	2.779	2.043
1984	1985	1	0.928	0.752	0.697	3	1.082	1.307	1.414	5	0.938	1.289	1.209	7	1.028	0.595	0.612
1985	1986	1	1.233	1.149	1.418	3	1.049	0.630	0.661	5	1.058	1.089	1.152	7	0.796	2.112	1.682
1986	1987	1	1.384	0.984	1.362	3	1.006	1.954	1.965	5	1.126	0.766	0.863	7	1.584	0.794	1.257
1987	1988	1	0.324	5.039	1.631	3	0.489	2.511	1.227	5	1.001	2.272	2.275	7	0.682	2.199	1.500
1988	1989	1	3.267	0.370	1.210	3	1.799	0.872	1.569	5	0.726	1.551	1.127	7	1.299	0.720	0.935
1989	1990	1	0.814	0.527	0.429	3	0.755	1.715	1.295	5	0.668	1.119	0.747	7	0.667	1.428	0.952
1990	1991	1	1.188	2.300	2.732	3	1.076	0.569	0.613	5	1.419	0.807	1.145	7	1.779	0.840	1.494
1991	1992	1	0.215	2.708	0.582	3	1.056	1.434	1.514	5	1.248	1.134	1.415	7	0.803	0.784	0.630
1992	1993	1	4.467	0.377	1.684	3	0.989	0.521	0.515	5	0.929	1.375	1.278	7	1.227	0.908	1.115
1993	1994	1	0.476	1.665	0.793	3	1.183	1.829	2.165	5	1.152	0.848	0.977	7	1.071	0.614	0.658
1994	1995	1	1.978	1.315	2.601	3	0.884	0.878	0.776	5	1.027	0.776	0.797	7	0.885	2.825	2.499
1995	1996	1	0.486	0.660	0.320	3	1.229	0.934	1.147	5	0.739	1.614	1.193	7	1.009	0.580	0.585
1996	1997	1	1.738	1.480	2.572	3	0.969	1.453	1.409	5	0.845	1.263	1.067	7	1.085	1.406	1.526
1997	1998	1	0.742	1.188	0.882	3	0.882	0.812	0.716	5	1.455	0.605	0.880	7	0.945	0.606	0.573
1998	1999	1	1.576	0.677	1.067	3	1.027	1.270	1.305	5	0.973	0.738	0.717	7	0.613	2.925	1.793
1999	2000	1	1.039	0.820	0.852	3	1.172	0.649	0.760	5	0.491	4.621	2.269	7	1.616	0.571	0.923
2000	2001	1	1.200	0.640	0.768	3	0.791	1.926	1.524	5	2.063	0.423	0.873	7	1.082	1.127	1.219
2001	2002	1	0.412	4.981	2.053	3	0.547	1.962	1.073	5	1.150	0.809	0.930	7	0.986	0.902	0.889
2002	2003	1	2.171	0.884	1.919	3	1.737	0.854	1.484	5	1.004	0.714	0.717	7	0.816	1.614	1.317
2003	2004	1	0.645	0.467	0.301	3	1.180	0.836	0.986	5	1.033	1.330	1.373	7	1.183	0.820	0.971
2004	2005	1	0.687	7.385	5.072	3	0.945	0.642	0.607	5	0.664	1.980	1.315	7	0.705	1.389	0.979
2005	2006	1	2.026	0.286	0.580	3	0.856	1.754	1.502	5	1.108	0.805	0.892	7	1.251	0.813	1.017
2006	2007	1	0.825	2.220	1.832	3	1.119	0.567	0.635	5	1.057	0.828	0.875	7	0.926	0.474	0.439
Mean		1	0.989	1.122	1.110	3	0.994	1.111	1.105	5	0.994	1.121	1.114	7	0.993	1.059	1.052
1980	1981	2	1.016	1.734	1.763	4	0.464	2.766	1.284	6	0.705	1.530	1.079	8	0.641	2.778	1.782
1981	1982	2	1.109	0.775	0.860	4	1.436	0.747	1.073	6	1.368	1.207	1.651	8	1.555	0.700	1.089
1982	1983	2	1.002	1.218	1.220	4	1.214	0.805	0.977	6	0.867	2.138	1.853	8	0.872	0.547	0.477
1983	1984	2	1.139	0.690	0.786	4	0.693	3.018	2.091	6	0.888	0.674	0.599	8	1.114	4.936	5.501
1984	1985	2	0.531	2.275	1.209	4	0.953	1.074	1.023	6	0.902	2.180	1.966	8	0.890	0.419	0.372
1985	1986	2	1.513	1.185	1.794	4	1.573	0.511	0.804	6	1.254	0.530	0.665	8	0.264	2.698	0.713
1986	1987	2	0.633	1.853	1.172	4	1.007	2.590	2.609	6	1.123	1.582	1.777	8	5.081	0.540	2.742
1987	1988	2	1.657	0.771	1.278	4	1.063	0.698	0.742	6	0.413	2.756	1.139	8	0.963	1.673	1.611
1988	1989	2	0.985	0.780	0.769	4	0.901	0.756	0.682	6	1.802	0.818	1.474	8	0.851	0.656	0.558
1989	1990	2	0.575	4.561	2.623	4	1.309	0.909	1.190	6	1.331	0.638	0.848	8	0.260	3.650	0.950
1990	1991	2	1.843	0.464	0.856	4	0.759	2.324	1.765	6	1.066	0.800	0.853	8	3.435	0.484	1.661
1991	1992	2	1.151	0.601	0.692	4	1.002	0.932	0.934	6	0.783	2.363	1.849	8	0.801	4.023	3.222
1992	1993	2	0.410	3.024	1.239	4	1.138	0.749	0.853	6	1.304	0.578	0.753	8	1.595	0.336	0.537
1993	1994	2	2.218	0.494	1.096	4	0.813	2.114	1.718	6	0.782	2.378	1.859	8	0.739	1.463	1.081
1994	1995	2	0.683	0.982	0.671	4	1.238	0.798	0.988	6	0.803	1.009	0.810	8	1.476	0.863	1.274
1995	1996	2	1.618	0.807	1.305	4	0.821	0.926	0.760	6	1.137	0.798	0.908	8	0.828	1.313	1.088
1996	1997	2	0.328	2.323	0.762	4	1.044	0.849	0.886	6	0.848	1.441	1.221	8	0.655	2.029	1.328
1997	1998	2	2.369	0.700	1.658	4	1.130	1.286	1.453	6	1.282	0.673	0.862	8	1.025	0.811	0.831
1998	1999	2	1.348	0.532	0.717	4	0.762	1.277	0.973	6	1.040	1.315	1.367	8	1.302	0.635	0.827
1999	2000	2	0.738	3.226	2.381	4	1.099	0.682	0.749	6	0.866	0.576	0.499	8	1.246	1.239	1.543
2000	2001	2	1.186	0.484	0.573	4	1.513	1.008	1.526	6	1.288	2.090	2.691	8	1.016	0.992	1.008
2001	2002	2	0.656	2.238	1.467	4	0.930	1.108	1.031	6	0.576	1.287	0.741	8	0.632	1.527	0.964
2002	2003	2	1.603	0.814	1.305	4	0.538	1.557	0.838	6	1.603	0.779	1.249	8	1.271	0.771	0.980
2003	2004	2	0.571	1.666	0.951	4	1.532	1.010	1.547	6	0.836	1.243	1.039	8	1.113	1.038	1.156
2004	2005	2	1.843	0.862	1.590	4	1.109	0.885	0.981	6	1.273	0.664	0.845	8	0.949	1.254	1.191
2005	2006	2	0.779	1.136	0.885	4	0.937	1.044	0.979	6	0.888	1.461	1.297	8	1.202	0.641	0.771
2006	2007	2	0.556	0.621	0.345	4	0.998	0.774	0.772	6	1.120	0.561	0.628	8	0.865	0.315	0.272
Mean		2	0.980	1.099	1.077	4	0.996	1.090	1.086	6	0.996	1.106	1.101	8	0.998	1.065	1.064

Teff.: technical efficiency, Teff.ch.: technical efficiency change,Tch.:, technical change, TFPch.: total factor productivity change,
Source :results of Data Envelopment Analysis (DEA)

Table (8) shows that the countries on group (2) posted the highest TFP change during period 1980-1990, while the countries on group (8) posted 19.8% as a highest TFP change during the period 1991-2000. On the other hand, the countries on group (5) posted highest TFP change during period (1980-2000), but the countries on group (1) posted the highest TFP change during period (2001-2007).

2- The results depends on estimation for all countries as one group

a- Results for groups :

1- Technical efficiency change

Table (10) shows that the overall means of the technical efficiency change for all groups is 1.014which implies that this growth in technical efficiency during study period by 1.4% annually on average. This is mainly due to the pure technical efficiency change (about 2.4% annually) which played a positive role to improve this ratio. On the other hand, **Table (10)** shows that the scale efficiency change on average is decline (about - 0.9% annually) in the same period. **Table (10)** shows that the Technical efficiency growth is positive for all groups except group (7), Group (8) posted the highest technical efficiency growth of 2.8% followed by Group (1) and group (5) which posted the technical efficiency growth of 2.1%,2% respectively, while group (3) and group (6) posted technical efficiency growth of 1.9,1.8% respectively.

Table 10. Means of technical efficiency, technical efficiency change, technical change, pure technical efficiency change scale efficiency change,and TFP change for groups, 1980-2007 (based on estimation for countries as one group)

Groups	Agricultural gross production value (millions I$)	countries	pure technical efficiency change	scale efficiency change	Technical Efficiency change	technical change	total factor productivity change
Group 1	Less than 100	33	1.026	0.995	1.021	1.139	1.163
Group 2	100-500	25	1.020	0.988	1.008	1.120	1.128
Group 3	500-1000	16	1.022	0.997	1.019	1.099	1.120
Group 4	1000-2000	20	1.029	0.983	1.011	1.104	1.116
Group 5	2000-4000	21	1.024	0.996	1.020	1.144	1.167
Group 6	4000-8000	16	1.024	0.994	1.018	1.150	1.171
Group 7	8000-16000	13	1.016	0.959	0.974	1.149	1.119
Group 8	More than 16000	21	1.026	1.002	1.028	1.113	1.144
Mean		165	1.024	0.991	1.014	1.127	1.143

Source: calculation from table (14)

2- Malmquist Total Factor Productivity change index.

Table (10) shows that the measures of TFP change by different groups. The main effect which drive the total factor productivity growth due to the technical change, **Table (10)** shows that the countries on Group (6) posted the highest TFP growth of 17.1% due mainly to technical change growth of 15% and 1.8% due to technical efficiency change, followed by group (5) which posted TFP growth of 16.7% due to the technical change growth of 14.4 %, followed by group (1) which posted TFP growth of 16.3% due to the technical change growth of 13.9 %, followed by group (8), group (2), group (3).While, group (4) posted the lowest TFP growth of 11.6% due to the technical change growth of 10.4%.

b- Results for Regions:

1- Technical Efficiency Change

Table (11) shows that the overall means of the technical efficiency change for all regions is 1.014 which implies that this technical efficiency growth during study period by 1.4% annually on average. This mainly due to the pure technical efficiency change (about 2.4% annually) which play a positive role to improve this ratio. On the other hand, **Table (11)** shows the scale efficiency change on average is decline.

Table 11. Means of technical efficiency, technical efficiency change, technical change, pure technical efficiency change scale efficiency change, and TFP change for regions, 1980-2007 (based on estimation for countries as one group)

Regions	pure technical efficiency change	scale efficiency change	Technical efficiency change	technical change	total factor productivity change
Asia	1.021	1.001	1.022	1.116	1.141
Africa	1.024	0.985	1.008	1.127	1.136
Europe	1.024	0.997	1.021	1.116	1.139
North	1.033	0.963	0.995	1.133	1.127
Central	1.026	0.985	1.011	1.110	1.122
American	1.027	0.996	1.022	1.127	1.152
South	1.031	0.987	1.018	1.166	1.187
Oceania	1.022	0.978	1.000	1.147	1.147
Mean	1.024	0.991	1.014	1.127	1.143

Source: calculation from table (14)

2- Malmquist total factor productivity change index.

Table (11) shows that the overall mean of TFP change for all regions is 14.3% due to the technical change growth 12.7%. **Table (11)** shows that South America posted the highest TFP growth of 18.7% mainly due to technical change growth of 16.6% and 1.8% due to technical efficiency change, followed by a American Carrabin posted TFP growth of 15.2% due to the technical change growth of 12.7 %, followed by Oceania which posted TFP growth of 14.7% due to the technical change growth of 14.7 %, followed by Asia, Europe, Africa. On the other hand, Central America posted the lowest TFP growth of 12.2% due to the technical change growth of 11%. **Table (11)** shows the main effect which drive the total factor productivity growth due to the technical change during the 1980-2007.

c- The annual change average Malmquist total factor productivity change index

Table (12) basically summarize **Table (13); Table (12)** shows the Annual Means technical efficiency change, technical change and TFP change for 165 countries during 1980-2007. **Table (12)** shows that the average TFP change during 1980-1990 was 32.3% due to the technical change growth of 26.4%. The TFP change declined to 3.7% during the period (1991-2000) due to the technical change growth of 4.7%, but TFP change is increase and posted of 6.6% due to the technical change growth of 6.2% during the period 2001-2007. On the other hand, the TFP change posted 17.1% during (1980-2000) and posted 14.3% during the period (1980-2007) due to technical change of 15.1%, 12.7% respectively.

Results for countries

1- Results for countries based on estimation for countries in each group.

Table (14) shows that there are 148 countries that had positive TFP growth from 1980 to 2007, while there are 16 countries that had TFP decline from 1980 to 2007 across groups. On the other, hand one country (Brunei Darussalam) had no change in TFP during the same period. Also, there are 154 countries that had positive technical change and 11 countries that had decline technical change from 1980 to 2007. While, there are 25 countries that only had positive technical efficiency change, 122 countries had a decline in technical efficiency. Also, there are 15 countries that showed no change from 1980 to 2007.

Table 12. Annual Means of technical change and TFP change for groups in some different periods (based on estimation for countries as one group)

1980-1990			1991-2000			2001-2007			1980-2000			1980-2007		
Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.	Teff.ch.	Tch.	TFPch.
1.047	1.264	1.323	0.990	1.047	1.037	1.003	1.062	1.066	1.018	1.151	1.171	1.014	1.127	1.143

Source : calculation from table (13)

Table 13. Annual Means technical efficiency change, technical change, pure technical efficiency change scale efficiency change, and TFP change for 165 countries (based on estimation for countries as one group)

from	to	Teff.ch.	Tch.	TFPch.	from	to	Teff.ch.	Tch.	TFPch.	from	to	Teff.ch.	Tch.	TFPch.
1980	1981	1.414	1.249	1.766	1990	1991	1.049	0.512	0.537	2000	2001	2.817	1.141	3.213
1981	1982	0.787	2.668	2.101	1991	1992	1.242	0.654	0.812	2001	2002	0.398	1.341	0.534
1982	1983	1.595	0.874	1.394	1992	1993	0.777	4.004	3.113	2002	2003	1.251	0.42	0.526
1983	1984	0.788	1.123	0.884	1993	1994	1.452	0.461	0.669	2003	2004	0.673	1.573	1.059
1984	1985	1.191	0.983	1.17	1994	1995	0.779	3.107	2.422	2004	2005	1.638	0.81	1.327
1985	1986	0.839	1.457	1.222	1995	1996	1.256	0.254	0.319	2005	2006	0.679	2.125	1.444
1986	1987	1.389	1.093	1.519	1996	1997	0.662	2.585	1.71	2006	2007	0.975	0.877	0.855
1987	1988	0.782	1.97	1.541	1997	1998	1.06	0.637	0.676	1980	2007	1.014	1.127	1.143
1988	1989	1.35	0.698	0.942	1998	1999	2.116	0.286	0.605					
1989	1990	0.771	1.482	1.143	1999	2000	0.424	6.908	2.93					

Source: results of Data Envelopment Analysis (DEA)

Table 14. Agricultural gross production value (Q), Means technical efficiency, technical efficiency change, technical change, pure technical efficiency change scale efficiency change, and TFP change for 165 countries, 1980-2007

G	Contries	Regions	Q	Estimation for countries in each groups						O1	Estimation for countries as one groups					O2
			IS million	Teff.	PTeff.ch	Seff.ch.	Teff.ch.	Tch.	TFPch.		PTeff.ch.	Seff.ch.	Teff.ch.	Tch.	TFPch.	
1	Sao Tome and Principe	Africa	19	0.458	1.013	1.005	1.018	1.161	1.183	1	1.007	0.995	1.001	1.163	1.164	73
1	Seychelles	Africa	6	0.502	1.011	1.004	1.015	1.162	1.180	2	1.007	0.995	1.002	1.174	1.176	59
1	Samoa	Oceania	48	0.430	1.014	1.007	1.021	1.152	1.176	3	1.007	0.994	1.001	1.172	1.173	63
1	Western Sahara	Africa	7	0.609	1.000	1.005	1.005	1.170	1.176	4	1.000	0.925	0.925	1.218	1.127	107
1	Maldives	Asia	11	0.554	1.009	1.005	1.014	1.153	1.169	5	1.000	0.922	0.922	1.093	1.007	151
1	Malta	Europe	71	0.674	1.006	1.000	1.006	1.162	1.168	6	1.000	0.915	0.915	1.090	0.997	157
1	Vanuatu	Oceania	63	0.609	1.000	1.006	1.006	1.155	1.162	7	1.000	0.924	0.924	1.250	1.155	79
1	Solomon Islands	Oceania	78	1.000	1.000	0.988	0.988	1.171	1.157	8	1.007	0.996	1.002	1.175	1.178	55
1	Guadeloupe	A. Carrabin	87	0.936	1.001	0.996	0.996	1.159	1.155	9	1.026	1.038	1.065	1.090	1.161	75
1	Grenada	A. Carrabin	19	0.954	1.001	0.996	0.996	1.157	1.153	10	1.026	1.023	1.050	1.099	1.153	83
1	New Caledonia	Oceania	22	0.622	1.007	1.002	1.009	1.141	1.151	11	1.003	0.901	0.904	1.128	1.019	144
1	Saint Kitts and Nevis	A. Carrabin	10	0.553	1.009	1.003	1.012	1.132	1.145	12	1.007	0.993	0.999	1.108	1.108	122
1	Kiribati	Oceania	17	0.846	1.002	0.996	0.999	1.145	1.143	13	1.026	1.111	1.140	1.027	1.171	66
1	United States Virgin Islands	A. Carrabin	3	0.636	1.000	1.005	1.005	1.130	1.135	14	1.000	0.931	0.931	1.228	1.143	92
1	Guam	Oceania	8	0.918	1.001	0.995	0.997	1.138	1.134	15	1.026	1.048	1.076	1.087	1.169	69
1	Qatar	Asia	32	0.574	1.009	1.002	1.011	1.118	1.130	16	1.007	0.989	0.995	1.081	1.076	78
1	Tonga	Oceania	27	0.764	1.000	0.998	0.998	1.133	1.130	17	1.000	0.950	0.950	1.218	1.157	132
1	Iceland	Europe	93	0.846	1.002	0.997	0.999	1.126	1.125	18	1.026	1.087	1.115	0.989	1.103	124
1	Saint Lucia	A. Carrabin	49	0.474	1.012	1.005	1.017	1.097	1.116	19	1.007	0.993	1.000	1.154	1.154	80
1	Comoros	Africa	54	0.966	1.001	1.000	1.000	1.114	1.114	20	1.041	0.979	1.019	1.176	1.199	42
1	Cape Verde	Africa	30	1.000	1.000	1.000	1.000	1.113	1.113	21	1.068	1.128	1.205	1.054	1.270	11
1	Saint Vincent and the Grenadines	A. Carrabin	28	0.489	1.012	1.004	1.016	1.092	1.110	22	1.007	0.994	1.000	1.168	1.169	70
1	French Polynesia	Oceania	22	1.000	1.000	0.996	0.996	1.112	1.108	23	1.041	0.996	1.036	1.139	1.180	4
1	Gambia	Africa	96	0.996	1.000	0.995	0.995	1.113	1.108	24	1.042	1.128	1.175	1.136	1.335	53
1	French Guiana	S. America	18	0.927	1.001	0.998	0.999	1.098	1.097	25	1.041	0.996	1.036	1.158	1.200	40
1	Dominica	A. Carrabin	35	0.998	1.000	0.998	0.998	1.094	1.092	26	1.041	0.993	1.033	1.204	1.244	22
1	Djibouti	Africa	43	1.000	1.000	0.999	0.999	1.080	1.079	27	1.041	0.992	1.033	1.220	1.260	14
1	Equatorial Guinea	Africa	36	0.995	1.000	0.998	0.998	1.070	1.067	28	1.041	0.995	1.035	1.208	1.251	19
1	Brunei Darussalam	Asia	17	0.998	0.999	0.906	0.905	1.106	1.000	29	1.067	0.995	1.062	1.124	1.194	47
1	British Virgin Islands	A. Carrabin	1	0.984	0.999	0.907	0.906	1.093	0.990	30	1.067	0.995	1.062	1.126	1.195	45
1	American Samoa	Oceania	3	1.000	0.999	0.915	0.914	1.075	0.982	31	1.067	0.980	1.046	1.094	1.144	91
1	Antigua and Barbuda	A. Carrabin	9	1.000	0.999	0.911	0.910	1.072	0.975	32	1.067	0.985	1.052	1.125	1.183	49
1	Bahamas	A. Carrabin	22	0.983	0.999	0.907	0.907	1.066	0.966	33	1.067	0.991	1.057	1.179	1.247	21
2	Botswana	Africa	213	0.939	1.000	1.001	1.001	1.120	1.121	1	1.067	0.994	1.061	1.153	1.223	31
2	Congo	Africa	242	0.987	1.000	0.998	0.998	1.119	1.117	2	1.041	0.983	1.023	1.173	1.200	41
2	Bhutan	Asia	110	1.000	1.000	1.000	1.000	1.112	1.112	3	1.067	0.993	1.060	1.162	1.231	28
2	Cyprus	Asia	409	0.981	1.000	0.999	0.999	1.108	1.106	4	1.041	0.990	1.030	1.206	1.241	24
2	Fiji	Oceania	222	0.996	1.000	0.991	0.991	1.110	1.100	5	1.041	0.995	1.035	1.172	1.213	35
2	Gabon	Africa	214	0.964	1.000	0.987	0.987	1.109	1.095	6	1.041	0.996	1.036	1.137	1.179	54
2	Guinea-Bissau	Africa	172	0.859	1.000	0.990	0.990	1.099	1.088	7	1.026	1.068	1.096	0.953	1.045	137
2	Belize	C. America	116	1.000	1.000	1.000	1.000	1.086	1.086	8	1.067	0.992	1.059	1.150	1.218	32
2	United Arab Emirates	Asia	451	0.385	1.000	0.982	0.982	1.106	1.086	9	1.000	0.940	0.940	1.192	1.120	117
2	Sierra Leone	Africa	435	0.492	1.000	0.970	0.970	1.110	1.076	10	1.007	0.996	1.002	1.179	1.182	50
2	Namibia	Africa	387	0.594	1.000	0.967	0.967	1.107	1.071	11	1.001	0.900	0.901	1.135	1.023	141
2	Suriname	S. America	116	0.448	1.000	0.975	0.975	1.097	1.070	12	1.007	1.087	1.094	1.237	1.353	3
2	Mauritius	Africa	240	0.640	1.000	0.965	0.965	1.107	1.069	13	1.000	0.909	0.910	1.119	1.018	146
2	Guyana	S. America	280	0.889	1.000	0.981	0.981	1.088	1.067	14	1.026	1.073	1.101	0.928	1.022	143
2	Trinidad and Tobago	A. Carrabin	139	0.449	1.000	0.976	0.976	1.092	1.065	15	1.000	0.948	0.948	1.188	1.126	109
2	Martinique	A. Carrabin	109	0.652	1.000	0.974	0.974	1.091	1.063	16	1.000	0.913	0.912	1.095	0.999	155
2	Lesotho	Africa	122	0.762	1.000	0.977	0.977	1.085	1.061	17	1.026	1.087	1.115	1.050	1.170	67

Table 14. Cont

G	Countries	Regions	Q	Estimation for countries in each groups						O1	Estimation for countries as one groups					O2
			IS million	Teff.	PTeff.ch	Seff.ch.	Teff.ch	Tch.	TFPch		PTeff.ch.	Seff.ch.	Teff.ch	Tch.	TFPch	
2	Liberia	Africa	332	0.781	1.000	0.973	0.973	1.090	1.061	18	1.000	0.950	0.950	1.012	0.961	103
2	Oman	Asia	226	0.529	1.000	0.965	0.965	1.100	1.061	19	1.008	1.024	1.032	1.093	1.128	161
2	Kuwait	Asia	111	0.870	1.000	0.975	0.975	1.088	1.060	20	1.026	1.112	1.141	1.028	1.173	64
2	Mauritania	Africa	351	0.582	1.000	0.975	0.975	1.087	1.060	21	1.000	0.910	0.910	1.097	0.998	129
2	Réunion	Africa	145	0.530	1.000	0.966	0.966	1.096	1.060	22	1.007	0.991	0.997	1.090	1.087	156
2	Swaziland	Africa	257	0.440	1.000	0.973	0.973	1.087	1.057	23	1.000	0.950	0.950	1.211	1.151	87
2	Timor-Leste	Asia	108	0.468	1.000	0.970	0.970	1.087	1.055	24	1.000	0.955	0.955	1.207	1.153	84
2	Puerto Rico	A. Carrabin	386	0.513	1.000	0.964	0.964	1.092	1.053	25	1.007	0.987	0.994	1.098	1.091	128
3	Albania	Europe	809	1.000	1.000	1.000	1.000	1.229	1.229	1	1.067	0.967	1.032	1.133	1.169	71
3	Burundi	Africa	959	0.955	1.000	0.999	0.999	1.209	1.208	2	1.067	0.996	1.063	1.066	1.133	98
3	Central Africaican Republic	Africa	631	0.922	1.000	0.998	0.998	1.197	1.194	3	1.068	1.101	1.176	1.109	1.304	8
3	El Salvador	C. America	925	0.855	1.000	1.004	1.004	1.174	1.178	4	1.041	0.994	1.035	1.219	1.262	13
3	Haiti	A. Carrabin	942	0.909	1.000	0.995	0.995	1.156	1.150	5	1.026	1.077	1.105	0.921	1.017	148
3	Jamaica	A. Carrabin	504	0.912	1.000	0.996	0.996	1.150	1.145	6	1.026	1.105	1.134	0.994	1.128	104
3	Jordan	Asia	638	0.904	1.000	0.997	0.997	1.143	1.140	7	1.026	1.108	1.136	0.990	1.125	110
3	Lao People's Democratic Republic	Asia	850	0.873	1.000	0.992	0.992	1.136	1.127	8	1.026	1.128	1.157	1.044	1.208	36
3	Zambia	Africa	794	0.679	1.000	0.992	0.992	1.086	1.077	9	1.000	0.922	0.922	1.163	1.073	134
3	Mongolia	Asia	820	0.821	1.000	0.996	0.996	1.079	1.075	10	1.000	0.903	0.903	1.111	1.002	154
3	Libya	Africa	893	0.925	1.000	0.992	0.992	1.082	1.073	11	1.000	0.942	0.942	1.005	0.947	162
3	Nicaragua	C. America	848	0.843	1.000	0.995	0.995	1.072	1.067	12	1.004	0.903	0.906	1.129	1.023	142
3	Panama	C. America	797	1.000	1.000	0.984	0.984	1.075	1.057	13	1.006	0.979	0.985	1.171	1.154	81
3	Yemen	Asia	929	0.738	1.000	0.990	0.990	1.054	1.044	14	1.000	0.924	0.924	1.182	1.092	127
3	Togo	Africa	548	0.794	1.000	0.989	0.989	1.014	1.002	15	1.000	0.952	0.952	1.225	1.166	72
3	Senegal	Africa	947	0.901	1.000	0.986	0.986	0.965	0.952	16	1.007	0.995	1.002	1.174	1.176	60
4	Cambodia	Asia	1507	0.964	1.000	1.001	1.001	1.225	1.226	1	1.067	0.996	1.063	1.062	1.129	102
4	Angola	Africa	1203	1.000	1.000	1.000	1.000	1.200	1.200	2	1.067	0.983	1.049	1.073	1.125	111
4	Benin	Africa	1188	1.000	1.000	1.000	1.000	1.163	1.162	3	1.067	0.993	1.060	1.162	1.231	29
4	Chad	Africa	1005	0.953	1.000	0.996	0.996	1.164	1.159	4	1.068	1.086	1.160	1.114	1.292	9
4	Bolivia (Plurinational State of)	S. America	1970	0.984	1.000	0.999	0.999	1.145	1.143	5	1.067	0.994	1.061	1.164	1.235	25
4	Costa Rica	C. America	1815	0.918	1.000	0.995	0.995	1.136	1.130	6	1.041	0.985	1.025	1.221	1.252	17
4	Burkina Faso	Africa	1329	0.975	1.000	0.997	0.997	1.127	1.124	7	1.067	0.996	1.063	1.089	1.158	77
4	Dominican Republic	A. Carrabin	1858	0.911	1.000	0.998	0.998	1.125	1.122	8	1.041	0.993	1.034	1.215	1.256	15
4	Guinea	Africa	1239	0.909	1.000	0.991	0.991	1.121	1.111	9	1.026	1.063	1.090	0.977	1.065	136
4	Honduras	C. America	1311	0.913	1.000	0.989	0.989	1.112	1.100	10	1.026	1.081	1.109	0.924	1.024	140
4	Lebanon	Asia	1084	0.915	1.000	0.988	0.988	1.108	1.094	11	1.026	1.101	1.130	1.058	1.195	46
4	Malawi	Africa	1349	0.878	1.000	0.989	0.989	1.104	1.091	12	1.000	0.931	0.931	0.994	0.926	165
4	Zimbabwe	Africa	1571	0.649	1.000	1.005	1.005	1.070	1.076	13	1.000	0.922	0.922	1.161	1.069	135
4	Norway	Europe	1461	0.761	1.000	0.997	0.997	1.049	1.047	14	1.006	0.903	0.908	1.086	0.986	160
4	Somalia	Africa	1430	0.621	1.000	1.007	1.007	1.038	1.045	15	1.007	0.996	1.003	1.199	1.203	38
4	Niger	Africa	1478	0.740	1.000	0.999	0.999	1.027	1.026	16	1.004	0.902	0.906	1.101	0.997	158
4	Rwanda	Africa	1140	0.711	1.000	1.004	1.004	1.005	1.008	17	1.007	0.992	0.999	1.097	1.096	126
4	Mozambique	Africa	1417	0.830	1.000	0.987	0.987	1.001	0.988	18	1.000	0.901	0.901	1.122	1.011	150
4	Papua New Guinea	Oceania	1877	0.715	1.000	0.998	0.998	0.978	0.975	19	1.007	0.950	0.957	1.211	1.159	76
4	Mali	Africa	1739	0.835	1.000	0.987	0.987	0.960	0.948	20	1.000	0.920	0.920	1.100	1.012	149
5	Afghanistan	Asia	2471	1.000	1.000	1.000	1.000	1.334	1.334	1	1.067	0.950	1.014	1.162	1.178	56
5	Algeria	Africa	3485	0.972	1.000	0.997	0.997	1.277	1.273	2	1.067	0.975	1.041	1.126	1.172	65
5	Cameroon	Africa	2584	0.954	1.000	0.995	0.995	1.236	1.230	3	1.067	0.996	1.063	1.057	1.124	113
5	Cuba	A. Carrabin	3694	0.943	1.000	0.998	0.998	1.209	1.207	4	1.041	0.988	1.028	1.209	1.243	23
5	Democratic People's Republic of	Asia	3562	0.942	1.000	0.998	0.998	1.188	1.187	5	1.041	0.990	1.031	1.270	1.309	7
5	Democratic Republic of the Congo	Africa	3973	0.964	1.000	0.995	0.995	1.175	1.170	6	1.041	0.991	1.031	1.252	1.291	10
5	Ghana	Africa	3296	0.972	1.000	0.992	0.992	1.172	1.162	7	1.042	1.130	1.177	1.114	1.311	6
5	Finland	Europe	2245	1.000	1.000	0.994	0.994	1.161	1.155	8	1.041	0.995	1.036	1.163	1.205	37

Table 14. Cont

G	Countries	Regions	Q	Estimation for countries in each groups						O1	Estimation for countries as one groups					O2
			IS million	Teff.	PTeff.ch	Seff.ch.	Teff.ch	Tch.	TFPch		PTeff.ch	Seff.ch	Teff.ch	Tch.	TFPch.	
5	Guatemala	C. America	2374	0.984	1.000	0.991	0.991	1.155	1.145	9	1.026	1.056	1.084	0.991	1.074	133
5	Iraq	Asia	2632	0.992	1.000	0.987	0.987	1.145	1.131	10	1.026	1.097	1.125	1.005	1.131	99
5	Israel	Asia	2071	0.925	1.000	0.987	0.987	1.142	1.127	11	1.026	1.101	1.130	0.998	1.128	105
5	Madagascar	Africa	2569	0.903	1.000	0.989	0.989	1.131	1.118	12	1.000	0.937	0.937	1.008	0.944	163
5	Paraguay	S. America	2684	0.866	1.000	0.991	0.991	1.122	1.112	13	1.007	0.967	0.974	1.209	1.177	58
5	Nepal	Asia	3189	0.931	1.000	0.987	0.987	1.126	1.111	14	1.001	0.898	0.899	1.134	1.019	145
5	Uruguay	S. America	2537	0.755	1.000	0.989	0.989	1.092	1.080	15	1.000	0.927	0.927	1.244	1.154	82
5	Tunisia	Africa	2536	0.633	1.000	0.994	0.994	1.074	1.067	16	1.000	0.940	0.940	1.189	1.118	118
5	Switzerland	Europe	2886	0.627	1.000	0.996	0.996	1.050	1.047	17	1.000	0.961	0.961	1.222	1.175	62
5	Sweden	Europe	3376	0.669	1.000	0.997	0.997	1.023	1.020	18	1.000	0.958	0.958	1.202	1.152	85
5	Sri Lanka	Asia	2201	0.722	1.000	1.000	1.000	0.985	0.985	19	1.007	1.128	1.136	1.247	1.416	1
5	Saudi Arabia	Asia	2362	0.773	1.000	1.000	1.000	0.942	0.942	20	1.007	0.995	1.001	1.177	1.178	57
5	Portugal	Europe	3929	0.809	1.000	0.999	0.999	0.894	0.894	21	1.007	0.986	0.992	1.110	1.101	125
6	Austria	Europe	4501	1.000	1.000	1.000	1.000	1.235	1.235	1	1.067	0.990	1.056	1.127	1.190	48
6	Bulgaria	Europe	4463	1.000	1.000	0.999	0.999	1.210	1.208	2	1.067	0.995	1.062	1.079	1.146	90
6	Chile	S. America	5199	0.891	1.000	1.003	1.003	1.189	1.193	3	1.041	0.950	0.989	1.123	1.110	121
6	Côte d'Ivoire	Africa	4310	0.950	1.000	1.001	1.001	1.171	1.173	4	1.041	0.987	1.027	1.219	1.252	18
6	Denmark	Europe	6347	0.919	1.000	1.000	1.000	1.131	1.131	5	1.041	0.992	1.032	1.228	1.267	12
6	Ecuador	S. America	4198	0.954	1.000	0.997	0.997	1.123	1.120	6	1.041	0.994	1.034	1.214	1.255	16
6	Hungary	Europe	7413	0.943	1.000	0.997	0.997	1.118	1.115	7	1.026	1.084	1.112	0.976	1.086	130
6	Ireland	Europe	4412	0.960	1.000	0.995	0.995	1.107	1.101	8	1.026	1.099	1.128	1.001	1.128	106
6	Kenya	Africa	4214	0.915	1.000	0.995	0.995	1.086	1.080	9	1.026	1.110	1.138	1.021	1.162	74
6	Sudan (former)	Africa	5890	0.948	1.000	0.995	0.995	1.082	1.076	10	1.007	1.101	1.109	1.246	1.381	2
6	Morocco	Africa	5134	0.958	1.000	0.992	0.992	1.080	1.071	11	1.000	0.902	0.902	1.116	1.007	34
6	Peru	S. America	4579	0.948	1.000	0.993	0.993	1.079	1.071	12	1.007	0.975	0.982	1.237	1.214	88
6	Venezuela (Bolivarian Republic of)	S. America	4694	0.961	1.000	0.987	0.987	1.086	1.071	13	1.000	0.925	0.925	1.242	1.149	152
6	United Republic of Tanzania	Africa	4353	0.929	1.000	0.991	0.991	1.049	1.039	14	1.000	0.938	0.938	1.225	1.148	89
6	Uganda	Africa	4197	0.968	1.000	0.992	0.992	1.019	1.010	15	1.000	0.937	0.937	1.187	1.113	120
6	Syrian Arab Republic	Asia	4699	0.963	1.000	0.995	0.995	0.967	0.962	16	1.000	0.958	0.958	1.221	1.170	68
7	Viet Nam	Asia	14381	0.776	1.000	0.989	0.989	1.150	1.137	1	1.000	0.925	0.925	1.245	1.152	86
7	South Africaica	Africa	9459	0.785	1.000	0.990	0.990	1.118	1.106	2	1.007	0.996	1.003	1.220	1.224	30
7	Romania	Europe	10648	0.803	1.000	0.990	0.990	1.101	1.090	3	1.007	0.992	0.998	1.126	1.124	114
7	Republic of Korea	Asia	8612	0.812	1.000	0.991	0.991	1.086	1.077	4	1.007	0.990	0.997	1.089	1.085	131
7	Philippines	Asia	13914	0.886	1.000	0.990	0.990	1.079	1.067	5	1.007	0.980	0.986	1.213	1.196	44
7	New Zealand	Oceania	8004	0.891	1.000	0.991	0.991	1.071	1.061	6	1.003	0.902	0.905	1.133	1.025	139
7	Netherlands	Europe	12206	0.884	1.000	0.993	0.993	1.058	1.051	7	1.004	0.908	0.912	1.129	1.030	138
7	Myanmar	Asia	9101	0.897	1.000	0.994	0.994	1.051	1.045	8	1.000	0.900	0.900	1.132	1.018	147
7	Malaysia	Asia	8501	0.938	1.000	0.994	0.994	1.049	1.043	9	1.000	0.926	0.926	1.010	0.935	164
7	Greece	Europe	8382	0.942	1.000	0.996	0.996	1.037	1.033	10	1.026	0.998	1.024	1.105	1.131	100
7	Egypt	Africa	13243	0.965	1.000	0.997	0.997	1.012	1.009	11	1.041	0.994	1.034	1.209	1.251	20
7	Colombia	S. America	10087	1.000	1.000	0.998	0.998	0.996	0.994	12	1.041	0.975	1.014	1.180	1.197	43
7	Bangladesh	Asia	12494	1.000	1.000	1.000	1.000	0.978	0.978	13	1.067	0.992	1.058	1.165	1.233	27
8	Argentina	S. America	28183	1.000	1.000	1.000	1.000	1.204	1.204	1	1.067	0.987	1.054	1.122	1.182	51
8	Australia	Oceania	20818	0.933	1.000	1.003	1.003	1.154	1.157	2	1.067	0.989	1.055	1.120	1.182	52
8	Brazil	S. America	76130	0.910	1.000	1.000	1.000	1.117	1.117	3	1.067	0.994	1.061	1.147	1.217	33
8	Canada	N. America	21937	0.936	1.000	0.998	0.998	1.100	1.098	4	1.067	0.996	1.063	1.049	1.115	119
8	United States of America	N. America	191174	0.649	1.000	1.002	1.002	1.095	1.097	5	1.000	0.932	0.932	1.224	1.140	95
8	China	Asia	292930	0.905	1.000	0.999	0.999	1.089	1.088	6	1.041	0.967	1.006	1.135	1.142	93
8	United Kingdom	Europe	18516	0.644	1.000	1.003	1.003	1.076	1.079	7	1.000	0.939	0.939	1.215	1.141	94
8	France	Europe	42525	0.895	1.000	0.997	0.997	1.079	1.075	8	1.041	0.995	1.036	1.160	1.201	39
8	Germany	Europe	35616	0.881	1.000	1.000	1.000	1.072	1.073	9	1.042	1.129	1.176	1.127	1.325	5
8	Turkey	Asia	27639	0.672	1.000	1.002	1.002	1.061	1.062	10	1.000	0.939	0.939	1.211	1.137	97

Table 14. Cont

G	Countries	Regions	Q	Estimation for countries in each groups						O 1	Estimation for countries as one groups					O2
			IS million	Teff.	PTeff.ch	Seff.ch.	Teff.ch	Tch.	TFPch		PTeff.ch	Seff.ch	Teff.ch	Tch.	TFPch.	
8	Indonesia	Asia	33829	0.889	1.000	0.998	0.998	1.057	1.055	11	1.026	1.092	1.120	1.004	1.125	112
8	Mexico	C. America	25934	0.840	1.000	0.996	0.996	1.060	1.055	12	1.000	0.905	0.905	1.112	1.006	153
8	Nigeria	Africa	21555	0.846	1.000	0.994	0.994	1.060	1.055	13	1.006	0.905	0.910	1.095	0.997	159
8	Japan	Asia	20019	0.847	1.000	0.996	0.996	1.057	1.053	14	1.026	1.106	1.134	0.991	1.124	115
8	Italy	Europe	32429	0.857	1.000	0.996	0.996	1.055	1.050	15	1.026	1.103	1.132	0.996	1.127	108
8	Iran (Islamic Republic of)	Asia	16100	0.967	1.000	0.992	0.992	1.051	1.043	16	1.026	1.095	1.123	0.999	1.122	116
8	Thailand	Asia	21093	0.720	1.000	0.998	0.998	1.043	1.042	17	1.000	0.954	0.954	1.195	1.139	96
8	India	Asia	143688	0.920	1.000	0.994	0.994	1.047	1.040	18	1.026	1.090	1.118	1.012	1.131	101
8	Spain	Europe	27696	0.740	1.000	1.000	1.000	1.013	1.013	19	1.007	0.996	1.003	1.232	1.235	26
8	Poland	Europe	21608	0.754	1.000	1.000	1.000	0.981	0.980	20	1.007	0.983	0.990	1.118	1.107	123
8	Pakistan	Asia	23896	0.789	1.000	0.998	0.998	0.930	0.928	21	1.007	0.997	1.004	1.172	1.176	61
All overall mean				0.817	1.001	0.991	0.992	1.100	1.091		1.024	0.991	1.014	1.127	1.143	

Teff.: technical efficiency, Teff.ch.: technical efficiency change, Tch.:, technical change,PTeff.ch. pure technical efficiency change, Seff.ch. scale efficiency change, TFPch.: total factor productivity change, column (o1) of table (14) shows the rank of countries in each group in descending order of the magnitude of the total factor productivity changes. column (o2) of table (14) shows the rank of countries in descending order of the magnitude of the total factor productivity changes depend on Estimation for countries as one group

Source: results of Data Envelopment Analysis (DEA)

Table (14) shows that the means technical efficiency change, technical change, pure technical efficiency change scale efficiency change, and TFP change for each country in each group during 1980-2007. For instance, Sao Tome, Seychelles, and Samoa posted the highest TFP change on group (1) of 18.3, 18 and 17.6%, due to technical change which posted of 16.1, 16.2 and 15.2%, respectively. While, the technical efficiency change for those countries are posted of 1.8, 1.5 and 2.1 %, respectively during the same period 1980-2007.

Table (14) also shows Botswana, Congo, and Bhutan posted the highest TFP change on group (2) of 12.1, 11.7 and 11.2 % due to technical change 12, 11.9 and 11.2%, respectively. For countries on group (3), Albania, Burundi, and Central African Republic posted the highest TFP change of 22.9, 20.8 and 19.4%, due to technical change 22.9, 20.9 and 19.7%, respectively. Cambodia, Angola, and Benin achieved the highest TFP change on group (4). Those countries posted of 22.6, 20 and 16.2% due to technical change 22.5, 20 and 16.3% respectively. Also, Afghanistan, Algeria, and Cameroon posted the highest TFP change on group (5) of 33.4, 27.3 and 23 %due to technical change 33.4,27.7and 23.6%, respectively. While, Austria, Bulgaria, and Chile posted the highest TFP change on group (6) of 23.5, 20.8 and 19.3%due to technical change 23.5, 21and 18.9%respectively. Vietnam, South Africa, and Romania are posted the highest TFP change on group (7) of 13.7, 10.6 and 9% due to technical change 15, 11.8 and 10.1%, respectively. Finally, Argentina, Australia, and Brazil posted the highest TFP change on group (8) of 20.4, 15.7 and 11.7%due to technical change 20.4, 15.4 and 11.7%, respectively.

2- Results for all countries based on estimation for countries as one group.

Table (14) shows that there are 154 countries that had positive TFP growth from 1980 to 2007, while 11 countries had TFP decline from 1980 to 2007. Also, there are 149 countries that had positive technical change and 16 countries that had decline technical change from 1980 to 2007. According to **Table (14),** there are 98 countries that had positive technical efficiency change and 65 countries that had a decline in technical efficiency. Also, there are only 2 countries that showed no change from 1980 to 2007. Also, **Table (14)** shows the means technical efficiency change, technical change, pure technical efficiency change, scale efficiency change, and TFP change for each country 1980-2007. For instance, Sri Lanka, Sudan, and Suriname posted the highest TFP change for all countries 41.6, 38.1 and 35.3%due to technical change 24.7, 24.6 and 23.7% respectively. While, the technical efficiency change for those countries are posted of 13.6, 10.9 and 9.4%, respectively.

The results which depend on estimation for countries in each group are different from the results which depends on estimation for all countries as one group. For instance, the overall groups means of TFP annually growth posted of 9.1% due to 10% annually growth of technical change which depends on estimation for countries in each group **(Table 6).** This finding contrust with **Roa et al (2005).**

Which depends on estimation for countries as one group during 1980-2007 **(Table 10).** The overall groups means of TFP annually growth posted of 14.3% due to 12.7% annually growth of technical change On the other hand, **Table (7)** show that the overall means of Asia TFP annual growth posted of 7.6 % due to 8.6% annually growth of technical change, depends on estimation for countries in each group. While **Table (11)** show that the overall mean for Asia TFP annually growth posted of 14.1% due to 11.6% annually growth of technical change which depends on estimation for countries as one group. **Table (8)** shows that the overall annual means for groups of TFP growth with the estimation depends on for countries in each group posted of 16.9% during 1980-1990,7.2 % during 1991-2000,12 % during 2001-2007, 0.4 % during 1980-2000 and 8.8% during 1980-2007. **Table (12)** shows that the overall annual means for groups of TFP growth with the estimation for all countries as one group posted of 32.3% during 1980-1990, 3.7% during 1991-2000, 6.6% during 2001-2007,17.1% during 1980-2000and 14.3% during 1980-2007.

The results of the estimation of Malmquist productivity indices for countries obtained from the base of dividing these countries to consistent groups were different than the results obtained based on considering all countries as one group. The difference in these results may be due to:

1- Dividing countries based on agriculture gross production value to consistent groups in their labor and gross capital stock is different than treating these countries as one group.
2- The consistency of the countries in the labor and gross capital stock within the same group means that these countries have almost the same level of technology. However the technology levels are different when gathering all of these countries in one group.

On the other hand, the results of Malmquist productivity indices in this study are higher than in other studies, this difference maybe due to the following reasons:

1- This study estimated Malmquist productivity indices based on inputs of the capital stock and labor at aggregate level of agricultural production, while most studies used other inputs such as land, labor, fertilizers, machines and livestock **(Fulginiti and Perrin, 1997; Fulginiti & Perrin, 1998; Fulginiti & Perrin, 1999; Fulginiti et al 2004; Galanopoulos et al 2004; Lusigi & Thirtle, 1997; Nin-Pratt & Yu, 2008; Nin-Pratt & Yu, 2010; Nkamleu et al 2006; Nkamleu et al 2008; Pfeiffer, 2003; Rao et al 2005; Rao & Coelli, 2011; Suhariyanto & Thirtle, 2001; Suhariyanto et al 2001a; Suhariyanto et al 2001b; Thirtle et al 1995; Yu et al 2003 and. Mugera & Ojede, 2011 and Arnade, 1998),** use land, labor and Irrigation. On the other hand, **Arnade (1994)** used land, Fertilizers.
2- The time period of this study is 1980-2007, while most studies estimated Malmquist productivity indices covered the periods (1960-1980), (1960-1999), (1961-1985), (1961-1993), (1970-2000),(1984-2003).
3- This study estimated Malmquist productivity indices for 165 countries while other studies estimated TFP change for countries between 5 and 111 countries.

For previous reasons, some result of this study is different than those of other studies. For instance, The Malmquist TFP change is less than one in many studies over 1965-2003 such as **(Fulginiti & Perrin, 1997; Fulginiti & Perrin, 1998; Fulginiti & Perrin, 1999; Nin-Pratt & Yu, 2008; Nin-Pratt & Yu, 2010; Suhariyanto & Thirtle, 2001; Suhariyanto et al 2001a; Suhariyanto et al 2001b; Thirtle et al 1995 and Yu et al 2003).** Meanwhile, the TFP change posted of 1.002, 1.02, 1.027 in the studies of **Nkamleu et al (2008), Galanopoulos et al (2004) and Roa & Coelli (2011),** respectively. On the other hand, TFP change posted highest value in some studies such as **Roa et al (2005)** who posted TFP change of 1.117 for 111 countries, **Lusigi and Thirtle (1997)** posted TFP change of 1.274 for 47 countries, **Nin-Pratt and Yu' (2008)** who posted TFP change of 1.6 for 72 countries, and **Pfeiffer (2003)** who posted of 1.3

SUMMARY AND CONCLUSION

In this study we use aggregate level data on agricultural sector during 1980-2007 based on used Data Envelopment Analysis DEA, inputs data (labor and gross capital stock) drawn from the Food and Agriculture organization of the United Nations. This study is conducted to estimate the Malmquist productivity indices for 165 countries, which are distributed over 8 regions. Also those countries divided into 8 groups based on annual average of agricultural gross value. This paper attempts to estimate the Malmquist productivity indices for countries in each group separately, and for all 165 countries as a one group. The results of

the estimation of Malmquist productivity indices for countries obtained from the base of dividing these countries to groups were different than the results obtained based on considering all countries as a one group.

The overall mean of the TFP change in this study during posted of 1.091 due to1.10 technical change based on estimation for countries in each group, while the TFP change posted 1.143 due to technical change posted of 1.127 based on estimation for all countries as one group.

The overall groups means of TFP annually growth posted of 9.1% due to 10% annually growth of technical change which depends on estimation for countries in each group, while the overall groups means of TFP annually growth posted of 14.3% due to 12.7% annually growth of technical change which depends on estimation for countries as one group. On the other hand, this study show that the overall means of Asia TFP annual growth posted of 7.6 % due to 8.6% annually growth of technical change, depends on estimation for countries in each group. The overall mean for Asia TFP annually growth posted of 14.1% due to 11.6% annually growth of technical change which depends on estimation for countries as one group.

The results of the estimation of Malmquist productivity indices for countries obtained from the base of dividing these countries to consistent groups were different than the results obtained based on conceding all countries as one group. The difference in these results may be due to dividing countries to eight groups based on agriculture gross production value, and their labor and gross capital stock. The results are deferent when we take these countries as one group. The consistency of the countries in the labor and gross capital stock within the same group means that these countries have almost the same level of technology, the technology levels are different when gathering all of these countries in one group. On the other hand, the results of Malmquist productivity indices in this study are higher than in other studies. This difference between the results in this study and other studies maybe due to the following reasons: This study estimated Malmquist productivity indices based on inputs of the capital stock and labor at aggregate level of agricultural production, while most studies used other inputs such as land, labor, Fertilizers, Machines and Livestock.also,The time period of this study is 1980-2007, while most studies estimated Malmquist productivity indices covered the periods (1960-1980), (1960-1999), (1961-1985), (1961-1993), (1970-2000) or (1984-2003). Finally, this study estimated Malmquist productivity indices for 165 countries while other studies estimated TFP change for countries between 5 and 111 countries.

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