<u>Decomposing Total Factor Productivity Change of Cotton Cultivars **(** Barakat-90 and Barac (67)B**)** in the Gezira Scheme (1991 – 2007) Sudan</u>

By

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Decomposing Total Factor Productivity Change of Cotton Cultivars (Barakat-90 and Barac (67)B) in the Gezira Scheme (1991 – 2007) Sudan

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ABSTRACT

The main objective of this paper was to decompose Total Factor Productivity Change (TFPCH) of cotton cultivars Barakat-90 and Barac(67)B in the Gezira scheme in 1991-2007, based on Data Envelopment Analysis Program (DEAP) Software Version 2.1, using model of input–oriented Malmquist indices Total Factor Productivity (TFP). This model could give meaningful results regarding technological and economic behavior relationship over time using balance panel data on Barac(67)B and Barakat-90 cultivars, Relevant secondary data were collected and analyzed to meet the stated objectives. This paper was aimed to decompose TFPCH into two components Technological Change (TECH) and Technical Efficiency Change (EFCH) and the latter was further divided into Scale Efficiency Change (SEFCH) and Pure Efficiency Change (PEFCH). The methodology allowed the recovery of various efficiency and productivity measures. The paper was mainly to answer the questions related to technical efficiency, scale efficiency and productivity changes. In the study on cotton cultivars, the innovation was improving up and down of TECH over time. Scale inefficiency was the main problem in efficiency analysis and mainly due to production operating at increasing returns to scale in Barac(67)B and Barakat-90 operating at constant return to scale. TFPCH was -1.3%, the contribution of EFCH was -1.6% and TECH was 0.30%, the main problem was efficiency change and this was mainly due to scale inefficiency, Barac(67)B contributed to this negative at an average annual rate -3.3%. This implying that the Barac(67)B was ailing due to efficiency change. The study has recommended, substantial improvement in knowledge about productivity and efficiency using scientific approaches, the scheme administration should take full advantage of Barac(67)B cultivar to be extensively

grown, Barakat-90 requires further investigation benefiting from technological innovation, additional, improvement in agricultural processing to increase the value added, and the benefit of scientific breakthrough in agricultural science are also recommended**.**

INTRODUCTION

Sudan was traditionally one of the world largest producers of long-staple cotton and medium-staple cotton, In the Sudan cotton has been the most important cash crop and foreign-currency earner for the past 50 years (Sudan Cotton Company SCC: 1, 1993). During the seventies and up to late eighties cotton alone contributed between 45% and 65% of the total foreign-currency earnings, in addition, cotton is considered as a main source of income for about 13 % of the total labor- force (SCC: 2, 1993). In spite of the economic importance of cotton for the Sudan economy, big fluctuations in cotton area, production and yield occurred. During the period from 1987 to 2002 cotton area, production and yield dropped, on average, by 38%, 48% and 18 %, respectively (Ahmed *et al.*, 2004).

On the other hand, cotton productivity is low compared to other cotton producing countries, best practice productivity and the productivity achievable in the research station. Cotton productivity in the Sudan is only 53%, 47%, 35%, and 61% of the cotton productivity in Egypt, China, Australia and Pakistan respectively.

This paper deal with measurement of how performance changes over time in Gezira scheme cotton cultivars, The emphasis was to measure change in productivity over time, the particular measure of productivity used was based on distance functions, namely a Malmquist (input-based) productivity index Fare, et al., (1992). Productivity was estimated and decomposed into two separate effects using the mathematical programming procedures Fare, etal. (1990) and Hjalmarsson and Veiderpass (1992). These effects represent: the catching up of separate firms with the benchmark production frontier and the shift of frontier over time, (Figure.1) Price and Thomas, (1996).

The basic used here was what is typically called productivity or productivity growth; in fact, they were the natural building blocks for measuring Total Factor Productivity (TFP).

It was noted that improvements in productivity would result in values of input based Malmquist index (M_i) to be less than one. Values of greater than one signified deterioration in productivity. The same interpretation applied to the efficiency change and technical change component. Note, however, that improvement in productivity could be accompanied by deterioration in one of component. Value of one reflected no change in performance.

Linear programming techniques were employed to construct the Malmquist productivity index for two cotton cultivars. The advance of this approach was that the index allowed the decomposition of change in total factor productivity into change in technical efficiency, change in pure efficiency, change in scale efficiency and technological change.

Therefore, improvement in total factor productivity could occur as result of either improvement in technical efficiency (moving closer to the production frontier) or improvements in technology (outward shift of the production frontier).

One issue that must be stressed was that the returns to scale properties of the technology were very important in (TFP) measurement (Coelli, 1996), Coelli and Rao (2005), Bushara and Mohayidin, (2007) proved that a Malmquist TFP index might not correctly measure TFP change when Variable Return to Scale (VRS) was assumed for technology. Hence it was important that Constant Return to Scale (CRS) be imposed upon any technology that might used to estimate distance function for the calculation of a Malmquist TFP index.

MATERIALS AND METHODS

Following (Fare *et al.*, 1994a), the product-specific directional Malmquist TFP index measures the TFP change between two data points by calculating the ratio of the distances to the frontier for a particular period of each data point. (Fare and primont, 1997), (Nin *et al.*, 2003) (Mahadevan, 2004), take advantage of information on input allocation by introducing specific input constraints for allocated inputs, modifying the directional distance function measure

Measures of Cotton cultivars and productivity change were constructed by examining the production technology of individual cultivars over time. Nonparametric linear programming techniques were employed to decompose each cultivar productivity index into two components, one measuring change in efficiency and the other measuring technical change or equivalently change in the frontier technology. The equation could be written as:

$$M_i^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = \frac{D_i^{t+1}(y^{t+1}, x^{t+1})}{D_i^t(y^t, x^t)} * \left[\frac{D_i^t(y^{t+1}, x^{t+1})}{D_i^{t+1}(y^{t+1}, x^{t+1})} * \frac{D_i^t(y^t, x^t)}{D_i^{t+1}(y^t, x^t)} \right]^{\frac{1}{2}} \text{.............(3)}$$

Where the quotient outside the brackets measured the change in technical efficiency and the ratios inside the brackets measured the shift in the frontier between period's t and t +1 as illustrated in Figure1.

The technical efficiency could be further; decomposed to become:

$$M_i^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = PEFCH \ * SEFCH \ .* TECH \text{ ....(4)}$$

In which TECH represent technical change, PEFCH represent pure efficiency change, and SEFCH represent scale efficiency change. The scale change and pure efficiency change components were decompositions of efficiency change calculated relative to constant returns to scale: EFCH=PEFCH* SEFCH. EFCH referred to efficiency change calculated under constant returns to scale, and PEFCH is efficiency change calculated under variable returns to scale. To derive the full decomposition, including the scale-change component, calculation of two additional programming problems are required, these are D^t_i (y^t, x^t) and D_i^{t+1} (y^{t+1}, x^{t+1}) relative to the technology of variable return to scale (Fare *et al.*, 1994b), and (Coelli, 1996) (Bushara and Mohayidin, 2007).

The linear programming method has two advantages over parametric stochastic techniques in measuring productivity change in productivity change (Fare and Primont, 1997). When parametric techniques were used, the choice of functional form for specifying the technology and the choice of the error structure both influenced the degree of efficiency (Coelli, 1995). Linear programming techniques enveloped the data without the specification of a restrictive functional form and were free from distribution bias. The methodology allowed the recovery of various efficiency and productivity measures in a commendable calculable manner. Specifically it was able to answer questions related to technical efficiency, scale efficiency and productivity changes.

The input distance function (Fare *et al.*, 1989, 1992 and 1994a) (Bushara and Mohayidin, 2007) was employed to construct the various measures of cotton cultivars of Gezira scheme, efficiency and productivity.

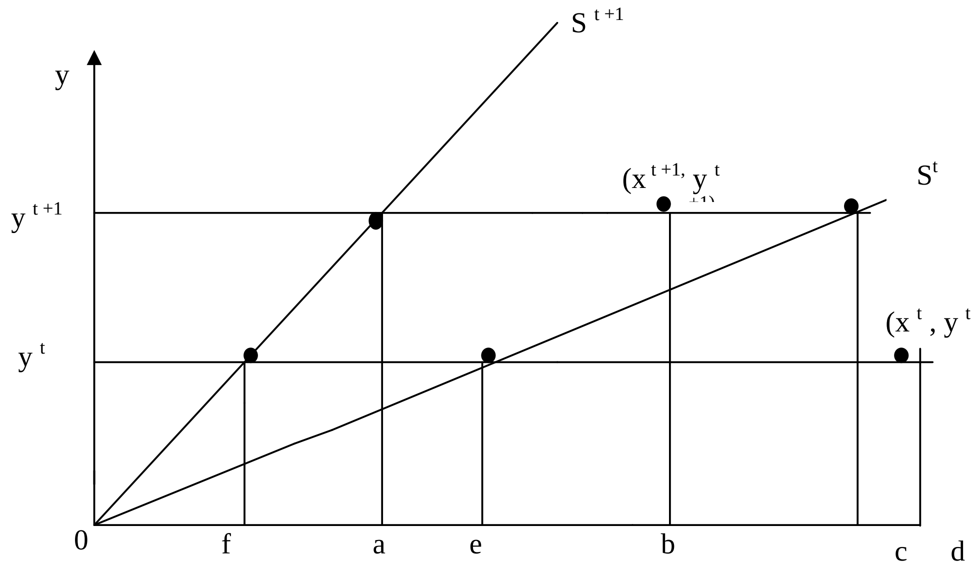
Productivity growth was estimated and decomposed into separate effects using the mathematical programming procedures of (Fare *et al.*, 1990), (Hjalmarsson and Veiderpass, 1992). These effects represented:

1. The catching-up of separate firms with the industry production frontier and
2. The shift of the frontier over time and panel time (Figure 1) (Price and Thomas, 1996).

To estimate the distance function defined by equation (3), a non-parametric linear programming technique was employed (Fare *et al.*, 1994b). This technique was automated in DEAP software Version 2.1 described in Coelli, (1996).

Equation (4) was estimated to decompose technical efficiency into pure technical efficiency and scale efficiency. Note that efficiency scores in this study were estimated using the same technique. The technique served to envelop the data and define the best-practice reference technology, without imposing a restrictive functional form. The productivity index may be expressed in terms of the following distances along the x-axis as:

$$M_i^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = \frac{\left(\frac{ob}{oa}\right)}{\left(\frac{od}{oe}\right)}\left[\left(\frac{oa}{0c}\right)\left(\frac{of}{oe}\right)\right]^{\frac{1}{2}} \quad \text{...(5)}$$



Source: Fare, *et al.* (1992).

Figure (1): The input based Malmquist productivity index.

where (0b/0a)/ (od/oe) denotes the ratio of the Farrell measures of technical efficiency and the last part is the geometric mean of the shifts in technology at y^t and y^{t+1}. It is to be noted that the shifts in technology are to be measured locally for the observation at t and t+1. This implies that: the whole technology need not behave uniformly and the technological regress is possible.

The observed values of inputs of cotton cultivars in Gezira scheme were land, water, capital input, material, labour, and output, as defined by (Bushara, 2001) and all value that were used to construct the reference technology. The assumptions were constant returns to scale, variable returns to scale and strong disposability. This disposability of input meant that an increase in input could not decrease, i.e., 'congest' output, which meant' too much' input (Bushara and Moheyidin, 2007).

Scale inefficiency change would not indicate whether the change was due to operation of the decision making unit (DMUs) at increasing returns to scale (IRS) or at decreasing returns to scale (DRS) or at constant return to scale (CRS) To know this technical efficiency for the ith DMU, the estimated input-orientated efficiency score under constant returns to scale is given by solving the following linear programming model:

$$\min_{\lambda,\hat{\theta}_i} \hat{\theta}_i \quad \ldots\ldots \quad (6)$$

Subject to $-y_i + Y\lambda \geq 0$

$$\hat{\theta}_i x_i - X\lambda \geq 0$$

$$\lambda \geq 0$$

where X and Y are matrices of the inputs and outputs, respectively, of all observed (N) DMUs; x_i and y_i are, respectively, the input and output vectors of the ith DMU; λ is a N x 1 vector of constants; $\hat{\theta}_i$ is the technical efficiency of the ith DMU, bounded by 0 and 1, with a value of 1 indicating a technically efficient DMU.

The VRS DEA model is obtained by adding the constraint $N_1'\lambda = 1$, where N1 is an N x 1 vector of ones. This is a convexity constraint ensuring that a firm is benchmarked against firms of a similar size. Scale efficiency is obtained as the ratio of the CRS efficiency measure (technical efficiency) to the VRS measure (pure technical efficiency). DEA under decreasing returns to scale (DRS) is obtained by adding the constraint $N_1'\lambda = 1$. If the two scores are different, then the ith DMU operates under increasing returns to scale (IRS), (Simar and Welson, 2000).

% during the seventies, to 22% in 1995 and in 2000 and 2001 it dropped below 3%.

Descriptive Statistic Package for Social Sciences (SPSS)

SPSS software was used to analyze the results of this study using back word regression to test the relationship between TFP growth, EFCH, TECH, and different input variable in the two cotton cultivars according to the following model:

Where:

$\hat{Y}$ = total factor productivity growth (dependant variable).

$$\hat{Y} = B_0 + B_1x_1 + B_2x_2 + B_3x_3 + B_4x_4 + B_5x_5 \quad \ldots\ldots (7)$$

B_0 = the intercept.

B_1, B_2, B_3, B_4, B_5 = regression coefficients.

x_1, x_2, x_3, x_4, x_5 = land, water, capital input, material, and labour, respectively (independent variable).

Data sources and variables

Basically the purpose of this paper was to look in to the TFP of two cotton cultivars in the Gezira scheme.

In general the paper needs the input data (Land x_1 water x_2, capital input x_3, Material x_4, labour x_5, and value of output y). However, the following institutions were the main sources of information and data: Gezira Board planning Unit and socio-economic Research Administration. The time frame of this study was (1991-2007). The data used were a complete panel of annual observation on two cultivars of cotton Barac(67)B, and Barakat-90 decision making units DMUs of 16 years (1991-2007). These data were derived from cotton cultivars in Gezira scheme. Information needed include the following:

1. Detailed cost of cotton cultivars (SDG/ fed) (input total cost)
2. Value of output.

And the data were normalized by the Gross Domestic Product (GDP) Deflator to avoid variations in data. SPSS was used to test the effect of input on TFP, EFCH and TECH in four cotton cultivars.

The method used input cost for all (DMUs) according to the production function is:

y = f (x_1, x_2, x_3, x_4, x_5) cotton cultivars

y = output of cotton cultivars in (SDG / fed).

x_1= Land cost in (SDG / fed).

x_2 = Water cost in (SDG / fed).

x_3 = capital input cost in (SDG / fed) included: ploughing, ridging, splite ridging, green ridging, disk harrowing, cross ridging, opening field channels, fertilizer,

herbicide, pesticides and seeds.

x_4 = Material cost in (SDG / fed) included: sacks, transport.

x_5 = labour cost in (SDG / fed) included: prewatering, sowing, thinning, fertilizer broadcast, raising field channel, irrigation, cleaning field channels, weeding, picking, preparation, picking, sacking, stalks pulling and burning, services.

RESULTS AND DISCUSSION

The input-oriented Malmquist index using Data Envelopment Analysis computer program DEAP Version 2.1 and multi-stage DEA Procedure (Coelli, 1996) to compute the index of total factor productivity (TFP) growth that decomposed into index of technological change (TECH) and technical efficiency change (EFCH). Index of (EFCH) has been further decomposed into pure technical efficiency change (PEFCH) and scale efficiency change (SEFCH). Note TFP, as measure by input-oriented Malmquist index. If the value of Malmquist index or any component is less than 1 denotes improvement in the performance, whereas value is greater than 1 denote deterioration in its performance. The performance relative to best practice or frontier.

The results of this analysis were documented in (Tables 1, 2, and 3 and Figures 2, and 3) to compare Barakat-90 and Barac(67)B in the same period (1991-2007). The Malmquist productivity index and its decomposition are given in (Table 1), per year per cultivar Barakat-90 and Barac(67)B**.** High rates of productivity growth recorded by Barakat-90, 41.2% in season (1992-1993), while low rates of productivity recorded -54% in (2001-2002). For Barac(67)B high rates of productivity growth was 35.7% in (2003-2004), while low rates of productivity growth was -84% in (2000-2001).

Table (1): Total factor productivity growth component of Barakat-90 and Barac(67)B cotton cultivars (1991-2007).

Season	Cultivar	EFCH	TECH	PEFCH	SEFCH	TFPCH
1992-1993						
	Barakat-90	1.000	0.588	1.000	1.000	0.588
	Barac(67)B	1.095	0.603	1.000	1.095	0.660
	Mean	1.046	0.595	1.000	1.046	0.623
1993-1994						
	Barakat-90	1.000	1.102	1.000	1.000	1.102
	Barac(67)B	1.072	1.032	1.000	1.078	1.107
	Mean	1.035	1.066	1.000	1.035	1,104
1994-1995						
	Barakat-90	1.000	0.645	1.000	1.000	0.645
	Barac(67)B	1.090	0.693	1.000	1.090	0.755
	Mean	1.044	0.668	1.000	1.044	0.698
1995-1996						
	Barakat-90	0.956	1.096	1.000	0.956	1.048
	Barac(67)B	1.277	1.096	1.000	1.277	1.400
	Mean	1.105	1.096	1.000	1.105	1.211
1996-1997						
	Barakat-90	1.046	1.134	1.000	1.049	1.187
	Barac(67)B	1.000	0.969	1.000	1.000	0.969
	Mean	1.023	1.049	1.000	1.023	1.073
1997-1998						
	Barakat-90	1.000	0.729	1.000	1.000	0.729
	Barac(67)B	0.902	0.840	1.000	0.902	0.757
	Mean	0.950	0.783	1.000	0.950	0.743
1998-1999						
	Barakat-90	1.000	0.811	1.000	1.000	0.811
	Barac(67)B	0.926	0.849	1.000	0.926	0.786
	Mean	0.962	0.830	1.000	0.962	0.798
1999-2000						
	Barakat-90	1.000	1.335	1.000	1.000	1.335
	Barac(67)B	0.852	1.259	1.000	0.856	1.073
	Mean	0.923	1.296	1.000	0.923	1.197
2000-2001						
	Barakat-90	1.000	1.496	1.000	1.000	1.496
	Barac(67)B	1.405	1.310	1.000	1.405	1.840
	Mean	1.185	1.400	1.000	1.185	1.652
2001-2002						
	Barakat-90	1.000	1.541	1.000	1.000	1.541
	Barac(67)B	0.875	1.439	1.000	0.875	1.260
	Mean	0.936	1.489	1.000	0.936	1.393
2002-2003						
	Barakat-90	1.000	0.713	1.000	1.000	0.713
	Barac(67)B	1.143	1.205	1.000	1.143	1.377
	Mean	1.069	0.927	1.000	1.069	0.991

Table 1 continued						
2003-2004						
	Barakat-90	0.897	0.778	1.000	0.897	0.698
	Barac(67)B	1.000	0.643	1.000	1.000	0.643
	Mean	0.947	0.707	1.000	0.946	0.670
2004-2005						
	Barakat-90	1.114	1.234	1.000	1.114	1.375
	Barac(67)B	0.905	1.143	1.000	0.905	1.034
	Mean	1.004	1.188	1.000	1.004	1.192
2005-2006						
	Barakat-90	1.000	1.368	1.000	1.000	1.368
	Barac(67)B	0.812	1.317	1.000	0.812	1.069
	Mean	0.901	1.342	1.000	0.901	1.209
2006-2007						
	Barakat-90	1.000	1.080	1.000	1.000	1.080
	Barac(67)B	1.362	1.065	1.000	1.362	1.437
	Mean	1.167	1.068	1.000	1.167	1.249

Source: Authors own table

EFCH=Efficiency change; TECH = Technical change; PEFCH = Pure efficiency change; SEFCH =Scale efficiency change; TFPCH = Total factor productivity change

TFPCH =EFCH x TECH and EFCH= PEFCH*SEFCH

The average annual growth rate TECH, EFCH, and TFPCH over the whole period of (1991-2007) are shown in (Table 2 and Figure 2). There was positive average annual productivity growth at the beginning (i.e., the TFP value was less than one) at season (1992-1993) and gave negative change relevant to benchmark year (1992) from season (1999-2000) up to (2001-2002) and increase again from season (2002-2003) and (2003-2004), it gave negative again in (2004-2005) up to (2006-2007) but with a decreasing rates.

TFP growth recorded by these cultivars ranged from low (-65.2%) in 2000-2001 to a high (37.7%) in 1992-1993, TECH in average mean ranged from (40.5%) in season 1992-1993 to (-48.9%) in season 2001-2002, and EFCH range from (9.9%) in season 2005-2006 to (-18.5) in 2000-2001.

Table (2): Total factor productivity component: Summary of annual means of cotton cultivars Barakat-90 and Barac(67)B (1991-2007).

Season	EFCH	TECH	PEFCH	SEFCH	TFPCH
1992/1993	1.046	0.595	1.000	1.046	0.623
1993/1994	1.035	1.066	1.000	1.035	1.104
1994/1995	1.044	0.668	1.000	1.044	0.698
1995/1996	1.105	1.096	1.000	1.105	1.211
1996/1997	1.023	1.049	1.000	1.023	1.073
1997/1998	0.950	0.783	1.000	0.950	0.743
1998/1999	0.962	0.830	1.000	0.962	0.798
1999/2000	0.923	1.296	1.000	0.923	1.197
2000/2001	1.185	1.400	1.000	1.185	1.652
2001/2002	0.936	1.489	1.000	0.936	1.393
2002/2003	1.069	0.927	1.000	1.069	0.991
2003/2004	0.947	0.707	1.000	0.947	0.670
2004/2005	1.004	1.188	1.000	1.004	1.192
2005/2006	0.901	1.342	1.000	0.901	1.209
2006/2007	1.167	1.068	1.000	1.167	1.246
G. Mean	1.016	0.997	1.000	1.016	1.013

Source: Authors own table

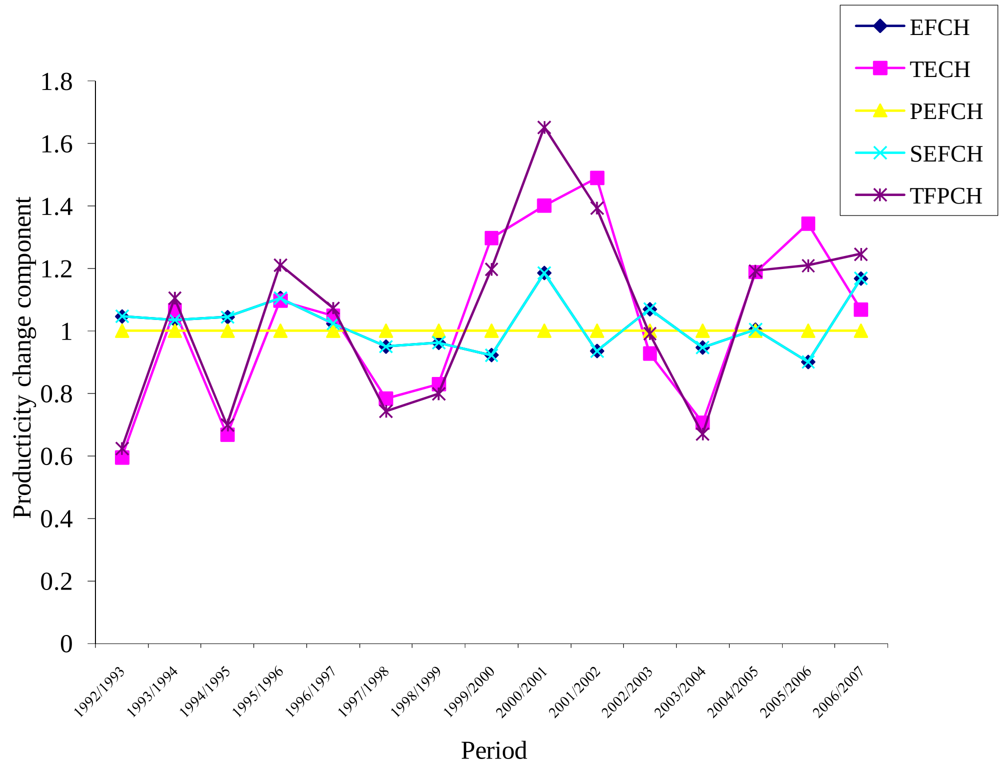


Figure (2): Total factor productivity component: Summary of annual means of cotton cultivars Barakat-90 and Barac(67)B (1991-2007)

The separate rates of growth of TECH and EFCH have to be combined in order to identify the source of TFP growth. Furthermore, in (Table 2), the TFP growth in the whole period (1991-2007) was -1.3% all of the change in TFP was mainly due to EFCH. In fact TECH in the same period was 0.30%. While the average contribution of EFCH for the whole period was –1.6% and this was mainly due to scale inefficiency.

The interpretation of the result for two cultivars experienced inward shift in their production frontiers over the whole period due to productivity growth. For the Barac(67)B cultivar, TFPCH was -3%, SEFCH as a component of TFP, as measured by input-oriented Malmquist index, was the main problem facing the Barac(67)B by -3. 3%, while the EFCH contributed -3.3%, TECH 0.3% and the PEFCH has positive values (Table 3 and Figure 3).

Table (3): Malmquist index total factor productivity component: Summary mean of cotton cultivars Barakat-90 and Barac(67)B (1991-2007).

Cultivar	EFCH	TECH	PECH	SECH	TFPCH
Barakat-90	1.000	0.997	1.000	1.000	0.997
Barac(67)B	1.033	0.997	1.000	1.033	1.030
G. Mean	1.016	0.997	1.000	1.016	1.013

Source: Authors own table

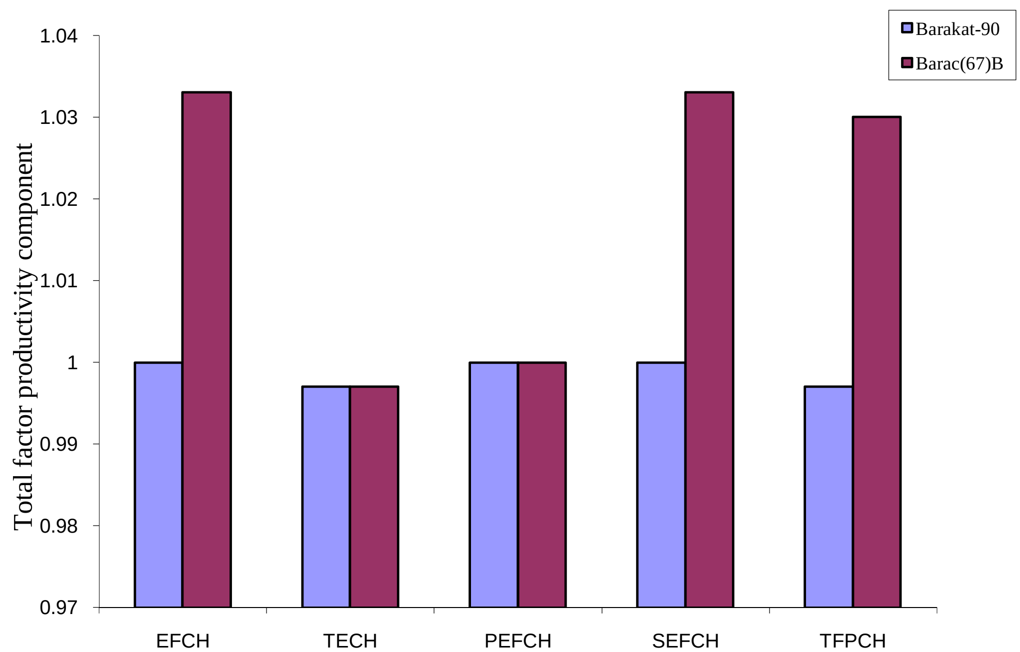


Figure (3): Malmquist index total factor productivity component: Summary mean of cotton cultivars Barakat-90 and Barac-67 B (1991-2007)

Malmquist productivity indices might be calculated relative to any type of technology (i.e. satisfying any type of return to scale). Here the Malmquist index relative to the constant-return to scale (CRS) technology was chosen for calculation and the efficiency changes component calculated relative to the CRS technology and decomposed into PEFCH component calculated relative to the variable return to scale

(VRS) and SEFCH component which capture change in the deviation between the VRS and CRS technology.

Table (4) shows that in the 16-years Barac(67)B scale inefficiency was mainly due to operating at increasing return to scale (IRS), While Barakat-90 operating at CRS.

Table (4): Barakat-90 and Barac(67)B efficiency level and scale return (1991-2007).

Cultivar	CRS	VRS	Scale	Scale Return
Barakat-90	1.000	1.000	1.000	CRS
Barac(67)B	0.612	1.000	0.612	IRS

Source: Authors own table

CRS: technical efficiency from CRS DEA

VRS: technical efficiency from VRS DEA

Scale: Scale efficiency = CRS/VRS

The descriptive analysis SPSS reflect that when the independent variables regressed to Total Factor Productivity change (TFPCH) and Technical change (TECH) it seemed that the material had negative effective on both TFPCH and TECH by 0.506 and 0.790 respectively, and the effect was significant. Land has positive result on TECH by 0.413 and it was statistical significant (Table 5).

Table (5): Barakat-90 and Barac(67)B variable coefficients (1991-2007)

Model	**Coefficients**			
	Variable	Beta	T- value	Sig.
TFPCH	(Constant)		13.484	0.000
	Material	-0.506	-3.126	0.004
EFFCH	(Constant)	1.026	42.123	0.000
TECH	(Constant)	1.128	11.873	0.000
	Land	0.413	2.745	0.011
	Material	-0.790	-5.253	0.000

Source: Authors own table

Dependent variable: TFPCH, EFFCH, TEC

SUMMARY AND CONCLUSIONS

The paper was intended to investigate and measure cotton cultivars productivity change by examining TFP of these cultivars over time. Input-based Malmquist TFP index was employed to decompose this cultivars productivity index into two components: measuring change in efficiency and the other measuring technical change in the frontier technology and the efficiency change decomposed into: scale efficiency change and pure efficiency change.

Secondary data were collected included detailed cost of cotton cultivars SDG / fed. Those costs were deflated by GPD deflator based year. DEAP software Version 2.1 was used to calculate input-based Malmquist productivity index and its components of Barakat-90 and Barac(67)B cultivars for the period 1991 to 2007, The theoretical background of this analysis is based on the work of (Fare *et al*., 1994a and 1994b). The particular measure of productivity used is based on distance functions, namely Malmguist input-based TFP index (Fare, *et al*., 1992). This decomposition thus provided away of testing for convergence of productivity growth as well as allowing the identification of innovation (Fare *et al*., 1994a).

In the analysis of Barakat-90 and Barac(67)B (1991-2007), the innovation was improving through the gradual and slow decline of negative productivity change over time Further more, all the change in TFP were mainly due to EFCH; in fact, TECH in a whole period 1991 to 2007 was only 0.30%, while the contribution of EFCH was -1.6%. The estimate of Barakat-90 and Barac(67)B TFPCH was -1.3% for the period 1991 to 2007. The major contributor to this negative EFCH was the Barac(67)B contribution at an average annual rate of -3.3% over the period of this study, and the other cultivar Barakat-90 was at an average rate annual rate of 1.00%.

(Table 4) shows out of 16-years Barac(67)B scale inefficiency was mainly due to operating at increasing return to scale (IRS) and in Barakat-90 scale inefficiency was due to constant return to scale (CRS).

Second soft was used (SPSS) descriptive statistic to analyze the different input variable technology or innovation over output finding, it was found that material had negative effective on both TFPCH and TECH by 0.506 and 0.790 respectively, and the effect was significant. Land has positive result on TECH by 0.413 and it was statistical significant.

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