Measuring Total Factor Productivity of Kenana Sugar Company Plant, (2000-2007)

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Abstract

This paper reports the measurement of Total Factor Productivity Change (TFPCH) for Kenana sugar company plant: An empirical analysis with reference to Kenana Sugar Company, based on Data Envelopment Analysis Program (DEAP) using model of input–oriented Malmquist indices Total Factor Productivity(TFP) was carried out. This model could give meaningful results regarding technological and economic behavior relationship over time using time series data of Kenana sugar company plant. Relevant annual data were collected and analyzed to meet the stated objectives. This paper was aimed to measure 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 Kenana sugarcane plant, the innovation was improving up and down of TECH over time. Scale efficiency operating in Kenana is remained constant return to scale, and total factor productivity was improving at an average of (6.3%) due to improvement in technical change at (6.3%), and improvement in efficiency change, while the average of total factor productivity is deteriorate at (-1.2%) due to deterioration of technical change at an average of (-1.2%) and improvement in efficiency change. The scale efficiency for Kenana Sugar Company is constant return to scale. The study recommended that the policy maker in the Kenana Sugar Company should make effort to benefit from added value of Sugar industry through downstream processes of Sugarcane by product such as molasses bagasse and filter cake, which could be utilized usefully for animal feed, energy for production and ethanol.

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قياس الكفاءة الإنتاجية لمصنع سكر كنانة في الفترة (2000-2007)

الخلاصة

هذه الورقة تتحدث عن قياس التغير في الإنتاجية الكلية لمصنع سكر كنانة : تحليل تطبيقي بالرجوع إلى شركة سكر كنانة في السودان لهذا الغرض استخدم التحليل المحيط بالبيانات والذي يحتوي على نموذج (المامكويست) وأساسه مؤشر مساهمة معدل الإنتاجية الكلي للمدخلات. تم جمع بيانات ثانوية من مصنع شركة سكر كنانة استخدمت السلاسل الزمنية وجداول البيانات لتقدير الإنتاجية والكفاءة الفنية. وقد أكدت النتائج بأن المدخلات الحديثة في مناطق الدراسة حسنت من التغير التقني على مر الزمن ولاحظت الدراسة أن الإنتاجية الكلية كانت موجبة عند 6.3% نتيجة إيجابية التغير التقني عند (6.3%) وايجابية الكفاءة المتغيرة بينما كان متوسط عامل الإنتاجية الكلية سالباً بسبب التغير التقني السالب عند (1.2-%) والكفاءة المتغيرة الموجبة. كما توصلت الدراسة إلى أن مستوي الكفاءة التشغيلية لمصنع كنانة قد وصل لأقصي مستوياتها (ثابتة). وقد أوصت هذه الدراسة على أنه ينبغي لصانعي السياسة في شركة سكر كنانة ومديري مصنع السكر ن بذل جهود مقدرة للاستفادة من القيمة المضافة لهذه الصناعة من خلال للاستفادة من تفعيل العمليات التصنيعة لمخلفات قصب السكر مثل المولاص والبقاس والتي يمكن استخدامها كعلف للحيوان وإنتاج الطاقة الإيثانول.

Introduction:

Kenana Sugar Company is private sector, the most important of Kenana sugar factory considered as one of the biggest factories of sugar in the Africa and Arab countries. The sugar commodity plays a significant role in national economy of Sudan. It produced sugar cane locally to fill the gap of sugar consumption, saving hard currency, and improving the trade balance. Increasing export of sugar could also save hard currency and then refresh national economy.

Sugar production had increased from 290,000 tons in 1990 to 756,000 tons in 2007. Yield per feddan was only 2 tons of cane sugar, but now and after continuous efforts, it reached 48 tons of cane sugar in Kenana factory.

Problem statement:

Productivity is of interest to economists and policy makers, because productivity growth is a major source of economic growth and welfare improvement. Technical advance and technical efficiency change are two key factors to productivity growth, which are associated with different sources, and so different policies may be required to address them. Therefore, it is important to decompose productivity growth into these two components: technical change and efficiency change.

Despite problems associated with any industry, the sugarcane industry has performed well as it surpassed the target of the Industrial Master Plan (IMP) in terms of total production and export revenue. In 2007 the total output of Sudanese sugarcane raw 756.000 tones.

Through the above performance gave case for satisfaction, there was reasonable apprehension that the industry would grind itself to stagnation, as it was unable to break away from its present narrow range of basic sugarcane raw production (table 1). Given the industrial development, together with the technological change and availability of raw material, there was a vast potential for the industry to break off from its nutshell and go beyond basic sugarcane to immediate and end use products. But to take full advantage of this potential, there was a need for the industry to be more proactive and to address fundamental issues that were still causes for concern to the industry.

Table (1) Raw sugar production in the Arab region in the thousand tons (99-2003,-2007)

Country	Average 99-03	2004	2005	2006	2007
Sudan	655.02	755.021	711.534	728.108	756.00
Syria	90.70	105.96	95.5	117.6	115.52
Somalia	22.14	22.00F	23.00F	23.00A	23.00
Iraq A	1.98	2.00	2.00	2.00	2.00
Lebanon	15.62	1.90A	3.75	3.75A	3.75
Egypt	1467.00	1524.05	1689.05	1689.05A	1689.05A
Morocco	510.00	508.00	500.00	409.00	450
Total	2762.46	2956.91	3034.21	2995.40	3034.32

Source: Arab Organization of Agriculture Development (AOAD). 2008, A = Aggregate (may include official, semi-official or estimates), F = FAO estimate.

One of critical issues that could heavily impact on the future direction of the local sugarcane Company plant, was the rising intense of local regional and global competition, and the world

production of sugarcane compared with the Sudan. world sugar production and consumption/million tons and World Sugar Balance as shown in tables (2) and (3).The Sudanese Sugarcane Company plants and Kenana private Company had been able to develop rapidly due to its relative low costs of production and availability of cheap local raw material. is important to answer a basic question whether this industry is competitive enough to face these local, Regional and global challenges. The competitiveness of this industry over time could be measured by efficiency and productivity analysis.

Table (2): World production and consumption of sugar in million tons (2003/2006)

Item	2003/2004	2004/2005	2005/2006
World Sugar production	143.711	144.048	134.711
World Sugar import	49.006	50.291	49.006
World Sugar stock	67.105	65.152	67.105
World available consumption	259.822	259.444	259.822
World consumption	142.185	145.276	52.532
Export	52.532	54.667	52.532
End of Stock	65.105	59.501	65.105

Source: ISO 2009

Table (3) World Sugar Balance (2007\2008):

Item	2007/08 raw value Million tone	2008/09 raw value Million tone	Change in million tone	in %
Production	168.611	161.527	-7.084	-4.20
Consumption	162.241	165.801	3.560	2.19
Surplus / Deficit	6.370	-4.274		
Import demand	45.948	49.621	3.673	7.99
Export availability	46.245	49.608	3.363	7.27
End Stocks	70.533	66.272	-4.261	-6.04
Stocks/Consumption ratio in%	43.47	39.97		

Source: ISO 2009

From an applied perspective, measuring efficiency is important because this is the first step in a process that might lead to substantial resources saving. These resource savings would have important implications for both policy formulation and factories management. In an economy where resources are scare and opportunities for new technologies are limited, efficiency studies would be able to show that it was possible to raise productivity by improving efficiency. Estimates on the extent of the inefficiency could help
to decide whether to improve efficiency or to develop new technologies to increase industrial productivity.

In policy arena, there is a continual controversy regarding the connection between factories size, efficiency and the structure of production. Efficient plant is more likely to generate higher income and thus have a better chance of surviving and prospering. Therefore, it is pertinent to review the existing production structure and identify some critical parameters of the sugarcane

plant of Kenana Company with a view to sustaining the competitive edge of the industry to face regional and global competition.
Sugar industry is one of the competent agricultural development projects in Sudan, which aims to bridge the country's needs and access to self-sufficiency. Based on the findings the study aimed to provide policy recommendations that would help the Sudanese sugarcane industry administration to stabilize the price level and reduce cost of production and thereby increase owners, income and their welfare.

Objective of the study:
The general objective is to measuring total factor productivity changes of Kenana sugarcane Company plant in the Sudan sugar Industries. To work out technical efficiency Index for each of Kenana Sugarcane factory and determination on the efficiency levels for eight interval period starting from 2000 and ending in year 2007.
Measurement of how performance changes over time in Kenana Sugar cane factory. This meant that the study would have little to say about property rights, principals and agents, incentive mechanisms competition versus monopoly, and private versus public provision

The specific objectives of the study are:
- To provide current information on technical change and efficiency of the sugarcane industry;
- To identify some critical parameters to improve the total factor productivity and competitiveness of the sugarcane industry.

Methodology and Data

This study is concerned with the measurement of changes in economic performance of Kenana Sugar company Plant over time. The emphasis was to measure change in productivity over time. The particular measurement of productivity used was based on distance function namely input oriented Malmquist index, using Data Envelopment Analysis computer program DEAP Version 2.1. Input-oriented measure look for a minimal proportional of an input vector, given an output vectors. The particular measurement of productivity used was based on distance function namely input oriented Malmquist index, using data envelopment analysis computer program DEAP Version 2.1. Input-oriented measure looking for a minimal proportional of an input vector, given an output vector (Fare etal.,1994;Fare and Grosskopf,1996; Bushara,2001)

Total factor productivity model:
Nonparametric linear programming techniques were employed to decompose the plant 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:

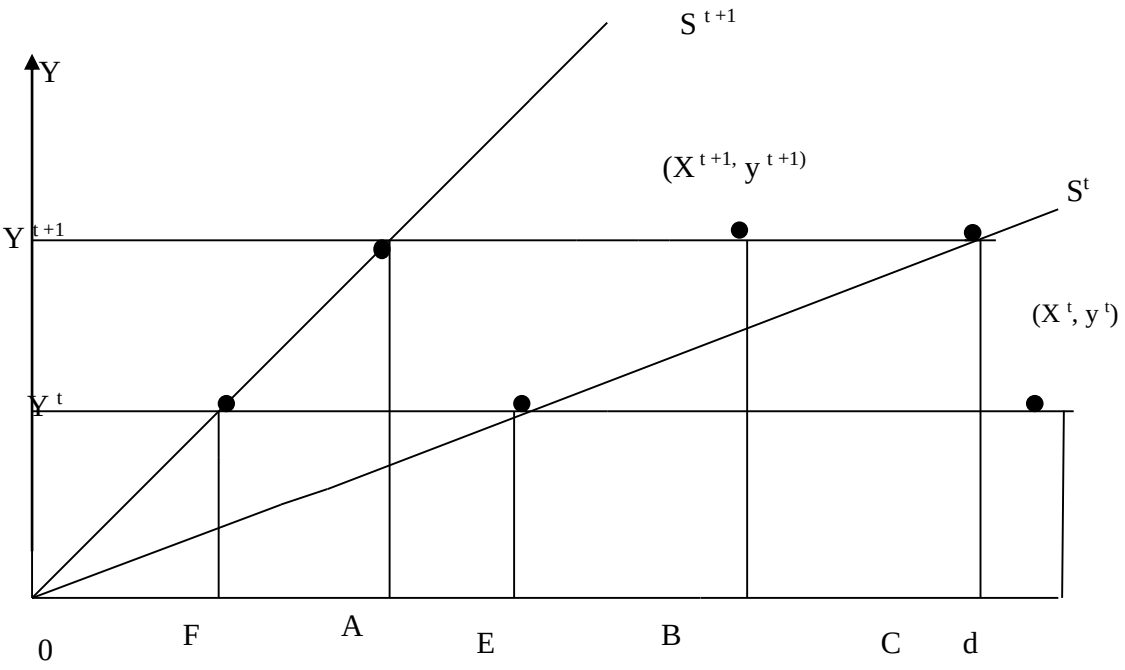
$$M_i^{t+1}(y^{t+1},x^{t+1},y^t,x^t)=\frac{D_i^{t+1}(y^{t+1},x^{t+1})}{D_i^t(y^t,x^t)}*\left[\frac{D_i^t(y_i^{t+1},x^{t+1})}{D_i^{t+1}(y^{t+1},x^{t+1})}*\frac{D_i^t(y^t,x^t)}{D_i^{t+1}(y^t,x^t)}\right]\ldots\ldots\ldots\ldots(1)$$

Quotient outside the brackets measures the change in technical efficiency and the ratios inside the brackets measured the shift in the frontier between period's t and t +1.
If the value of Malmquist index or any component is less than 1 denotes improvement in the performance where value is greater than 1 denotes deterioration in its performance.
The technical efficiency could be further; decomposed to become:

$$M_i^{t+1}(y^{t+1},x^{t+1},y^t,x^t)=PECH*SECH*TECHCH\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

In which TECHCH representes technical change, PECH representes pure efficiency change, and SECH representes scale change. The technical efficiency (TECHCH) can be decomposed the scale efficiency (SECH) pure technical efficiency (PECH) components. EFFCH referred to efficiency change calculated under constant returns to scale, and PECH is the efficiency change calculated under variable returns to scale (Coelli, 1996) The productivity index may be expressed in terms of the following distances along the x-axis in Figure (1) as:

$$M_i^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = \frac{\left(\frac{ob}{oa}\right)}{\left(\frac{od}{oe}\right)}\left[\left(\frac{oa}{oc}\right)\left(\frac{of}{oe}\right)\right]^{\frac{1}{2}} \quad \text{.....(3)}$$



Source Fare, (1992).
Fig (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 (yt and yt+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.

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

$$\min_{\lambda,\hat{\theta}_i} \hat{\theta}_i \quad \text{.....} \quad (4)$$

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 DMUs, bounded by 0 and 1, with a value of 1 indicating a technically efficient DMUs.

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) (Gorton and Davidova, 2004).

Type of data:

The data used were a complete time series annual observation on Kenana Sugar Company of 8 years (2000-2007). The data were normalized by the Gross Domestic Product (GDP) deflator, and calculating the natural log so as to avoid variations in data.

The method used input cost for all according to the production function is: $Y = f(x_1, x_2, x_3, x_4)$

Y = output of sugar tone in SDG.

X_1= sugar cane cost in SDG for ton/feddan.

X_2= labour cost in SDG.

X_3= material cost in SDG.

X_4= other expenses in SDG.

The information needed include the following:

1. Detailed cost of sugarcane industry (input total cost).
2. Value of output.

Results and Discussion

The results of this analysis were documented in (Tables 4,5 and Figures 2 and 3) in the same period (2000-2007). Table 4, shows average annual growth rate of TECH, EFFCH, and TFPCH over the whole period of (2000-2007), there was improvement average annual productivity at the beginning (i.e., the TFPCH value was less than one) at seasons (2000/2001and 2001\ 2002 and 2002/2003) and deterioration change (i.e., the TFPCH value was greater than one) from season (2003/2004), it improvement again in season (2004/2005) and deterioration again from seasons (2005/2006 and 2006/2007) it improvement again in season (2007/2008).

TFPCH growths recorded by this sugarcane plant was estimated to range from low of -8.2 % in (2006/2007) to a high of 6.3% in (2000/2001). TECH in average means range from 6.3 % in season (2000/2001) to -8.2 % in (2006/2007). EFFCH was improving in the whole period. The separate rates of growth, TECH and EFFCH have to be combined in order to identify the source of TFPCH growth and hence. Furthermore, the TFPCH growth in the whole period (2000-2007) was -1.2%, all of the change in TFPCH was mainly

due to EFFCH. In fact in the same period was improvement, while the average contribution of TECH for the whole period was –1.2% and this was mainly due to scale inefficiency (Table 4 and Figure 1).

Table (4): Malmquist Index Components: Summary of Annual Means of Kenana Sugar Company (2000/01- 2006/07)

year	Effch	Techch	Pech	Sech	Tfpch
2000/01	1.000	0.937	1.000	1.000	0.937
2001/02	1.000	0.977	1.000	1.000	0.977
2002/03	1.000	0.993	1.000	1.000	0.993
2003/04	1.000	1.037	1.000	1.000	1.037
2004/05	1.000	0.966	1.000	1.000	0.966
2005/06	1.000	1.002	1.000	1.000	1.002
2006/07	1.000	1.082	1.000	1.000	1.082
G. mean	1.000	1.012	1.000	1.000	1.012

Effch =Efficiency change; Techch = Technical change; Pech = Pure efficiency change; Sech =Scale efficiency change; Tfpch = Total factor productivity change Tfpch =Effch x Techch and Effch= Pech*Sech

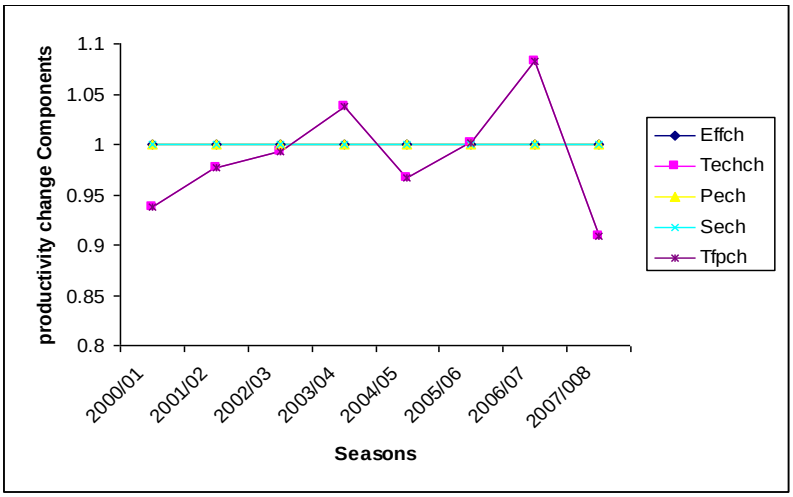


Fig. (2): Malmquist Index Component; Summary of Annual Means of Kenana Sugar Company (2000/01- 2006/07)

Table (5): Efficiency Summary and scale returns of Kenana Sugar Company (2000/01-2006/07)

Plant (Factory)	Crste	Vrste	Scale	Scale Return
Kenana	1.000	1.000	1.000	Crs

Note: Crste = Technical efficiency from CRS DEA, vrste = Technical efficiency from VRS DEA, Scale = Scale efficiency = Crste/Vrste

Table (5): shows that the scale efficiency is operating constant returns to scale in Kenana Sugar Company because it reached maximum production (stagnant).

Conclusion of the study

In this study improvements in productivity occur when the value of Malmquist index or any component is less than unity.

In the analysis of Kenana Sugarcane Plant (2000-2007), the innovation was improving through the gradual and slow decline of negative productivity change over time.

Furthermore, all of the change in TFP was mainly due to EFFCH. In fact in the same period was positive, while the average contribution of TECH for the whole period was –1.2% and this was mainly due to scale inefficiency.

The estimate of Kenana Sugarcane Plants TFPCH was -1.2% for the whole period. The major contributor to this negative TECH was -1.2% contributions at an average annual rate of -1.2 % over the period of this study

Out of 8 years Kenana scale inefficiency was due to constant return to scale (CRS). In this paper the substantial contribution is the improvement in knowledge of productivity, efficiency and innovation in technology is explained to increase the productivity of sugar factories. No one has done such efforts in Kenana sugar factory

Recommendations

1. Technical package should be put in consideration.
2. In depth and oriented training will lead to good productivity.
3. Highly consideration should be taken towards sugarcane research center by training expansion in Kenana sugarcane company plant.
4. To policy maker in the Kenana Sugar Company and managers of other Sugar factories should make efforts to benefit form added value of Sugar industry through downstream processes of sugarcane by product such as molasses and Bagasse, which could be utilized usefully for animal feed, and production ofenergy and ethanol.

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