MEASURING THE SUDANESE ISLAMIC BANKS' SCALE EFFICIENCY, TECHNOLOGICAL CHANGE AND TFP GROWTH USING TRANSLOG COST FUNCTION

Maziruddin Abdullah(*) & Abd elrhman Elzahi Saaid (**)

1. Introduction

With few exceptions, studies on the performance of Islamic Banks that operate in either Muslim-ruled or non-Muslim-ruled countries are still scanty. Hitherto, Darrat (1988), Yousefi et. al. (1997), Samad (1999), Ebrahim and Tan (2001) and Bashir (1999) are, among the few, actively engaged in measuring the performance of Islamic banks in countries like Tunisia, Iran, Malaysia, Brunei and Sudan. The methods used to measure them are confined to the standard measurements such as financial ratios, data envelopment analysis and linear programming. Recently, however, there are attempts being made to use other recently developed methods to measure the Islamic banks performance. El-Zahi (2002), for example, used translog cost function to investigate the efficiency of the Sudanese Islamic Banks for the period 1989-98. Darrat (1988) and Yousefi *et. al.* (1997), on the other hand, employed money demand function to study the impact of the presence of Islamic banks on monetary stability in Tunisia and Iran, respectively. Although the above-mentioned studies have explicitly unraveled many untold stories and secrets about the Islamic banks' strengths and weaknesses in terms of their efficiencies, contribution to a country's monetary stability and managing the portfolios, and the efforts they made are indeed commendable, none have measured the banks' scale and technological change effects, let alone its productivity growth.

(*) Assoc. Professor Dr., Department of Economics, Kulliyyah of Economics and Management Sciences, International Islamic University, Malaysia
(**) Assist. Prof. Dr., Department of Banking and export, College of Business Studies Sudan University of Science and Technology, Sudan

Since a study that is specifically undertaken to investigate the Islamic banks scale and technological change effects is virtually none, the present paper can be considered as the first to measure and analyze them. Specifically, our study distinct itself from the previous studies in that: (i) it employs the index number procedure to compute the total factor productivity (TFP), from which the two effects are derived, of the twelve but disaggregated Sudanese Islamic banks over a 10-year period. To the best of our knowledge, there had been no study conducted so far to investigate the performance of Islamic banks in any single Muslim country that is so extensive like ours in terms of both number of banks and years covered. We note in passing that to measure the TFP growth we will utilize time-series of cross-section data or pooled data, for brevity; (ii) it also incorporates the widely used method to decompose the TFP growth of the Sudanese Islamic banks into its two major sources, namely the scale and technological change effects. To this end, the translog cost function or parametric approach will be engaged. It is wise mentioning at this juncture that the translog cost function is preferred to the Cobb-Douglas function because its assumptions are less restrictive (Binswanger, 1974); (iii) in the process of measuring (i) and (ii) we will show mathematically as well as empirically how TFP growth, which is measured using the index number procedure, is linked to the parametric approach, which is estimated using the translog cost function. In other words, we offer a procedure that links the analysis of TFP to that of the production theory.

The plan of the paper is as follows. In Section 2, the measurement of scale effect, technological change effect and TFP based on the index number procedure and parametric approach is specified. It further discusses how the two procedures are linked. Section 3 looks at the econometric specification and the sources of data, while in Section 4 the results of the quantity indexes of output, total input and the sources of TFP growth are presented. Section 5 is a concluding summary.

2. The Measurement and Decomposition of TFP and Its Source Components

2.1. Index Number Procedure

To begin with a model that has multi-output, we denote the index of output as Y, and the rate of growth as[1],

$$\frac{\dot{Y}}{Y} = \sum_{i=1}^{n} N_i \frac{\dot{Y}_i}{Y} \qquad (1)$$

where $N_i = P_i Y_i \Big/ \sum_{i=1}^{n} P_i Y_i = P_i Y_i \big/ R$, and P_i and Y_i are respectively the price and quantity of output ***i***; R = $\sum_{i=1}^{n} P_i Y_i$, the total revenue; and $\dot{Y}/Y$ the rates of growth of output ***i***. An analogous index of the quantity of total input, *X*, is expressed as,

$$\frac{\dot{X}}{X} = \sum_{j=1}^{m} S_j \frac{\dot{X}_j}{X} \qquad (2)$$

where $S_j = W_j X_j \Big/ \sum_{j=1}^{m} W_j X_j = W_j X_j \big/ C$, and W_j and X_j are respectively the price and quantity of input ***j***; $C = \sum_{j=1}^{m} W_j X_j$, the total cost; and $\dot{X}_j / X_j$, the rates of growth of input ***j***. These two quantity indexes may be regarded as a family of Divisia quantity indexes.

Next, we define total factor productivity, TFP, as the ratio of output to the quantity of total input:

[1] Despite we discussed the model of multi-out put; in this paper we used only one output and three inputs.

$$TFP = \frac{Y}{X} \tag{3}$$

The rate of growth of TFP $(T\dot{F}P)$ is defined as

$$T\dot{F}P = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} \tag{4}$$

While formulas (1) - (4) are in terms of instantaneous changes, the data to be used in this study are gathered at yearly intervals. The most commonly used discrete approximation to the continuous formulas (1) - (4) is given by the Törnqvist approximations,

$$\Delta \ln Y = \ln(Y_T / Y_{T-1}) = 1/2 \sum_i^n (N_{i,T} + N_{i,T-1}) \ln(Y_{i,T} + Y_{i,T-1}) \tag{5}$$

$$\Delta \ln X = \ln(X_T / X_{T-1}) = 1/2 \sum_j^m (S_{i,T} + S_{i,T-1}) \ln(X_{i,T} + X_{i,T-1}) \tag{6}$$

where N_i and S_j are as defined before and T is time. The corresponding discrete approximation to equation (4) is given by

$$\Delta \ln P = \Delta \ln Y - \Delta \ln X \tag{7}$$

2.2 Parametric Procedure

The characteristics of production that we intend to analyse are related to scale economies and technological change. We assume that the Sudanese banking sector is characterized by a production function satisfying the usual regularity conditions,

$$Y = f(X, T) \tag{8}$$

where X is a vector of ***m*** inputs, T is time, which indicates the effect of technological change, and Y denotes output. We note that output (Y) is produced utilizing labor (L), capital or fixed assets

(*M*), and deposits (*U*) as factor inputs. Assuming that technically efficient bankers act to minimize production costs at any given level of output, the dual cost function can be written as,

$$C = C(W, Y, T) \tag{9}$$

where *C (.)* is the cost function that defines *C* as the minimum cost of producing any output *Y*, given the vector of input prices $W = (W_L, W_M, W_U)$ and the state of technology, *T*.

Now, log-differentiating Equation (9) w.r.t. (T) will decompose the rate of growth of total cost into its source components:

$$\frac{\dot{C}}{C} = \left(\sum_{j=1}^{3} \frac{\partial \ln C}{\partial \ln W_j} \frac{\dot{W}_j}{W_j}\right) + \left(\frac{\partial \ln C}{\partial \ln Y} \frac{\dot{Y}}{Y}\right) + \left(\frac{\partial \ln C}{\partial T}\right) \tag{10}$$

The variables with a dot on top denote a differentiation w.r.t. time, *T*. In words, the rate of growth of total cost ($\dot{C}/C$) can be expressed as the cost elasticity weighted average of rates of growth of input prices, plus the scale weighted rate of growth of output, plus the rate of cost diminution due to technological change.

Applying Shephard's lemma to the logarithmic partial derivative appearing in (10), we obtain the following relations:

$$\sum_{j=1}^{3} \frac{\partial \ln C}{\partial \ln W_j} = \sum_{j}^{3} \frac{X_j W_j}{C} = \sum_{j}^{3} S_j = 1 \tag{11}$$

where $S_j = X_j W_j / C$ denotes the cost share of the j[th] input.

Next, we define the elasticity of cost w.r.t. output (Y), ε_{CY}, as,

$$\frac{\partial \ln C}{\partial \ln Y} = \frac{\partial C}{\partial Y}\frac{Y}{C} = \varepsilon_{CY} \qquad (12)$$

Equation (12) is used in this study as an indicator to measure the returns to scale. The ε_{cy} indicates increasing returns to scale, constant returns to scale, or decreasing returns to scale according as $\varepsilon_{cy} < 1$, $\varepsilon_{cy} = 1$, or $\varepsilon_{cy} > 1$.

We define λ as the rate of growth of cost diminution,

$$\frac{\partial \ln C}{\partial T} = -\lambda \qquad (13)$$

By collecting (11), (12) and (13), and then substituting them into (10), we obtain

$$\frac{\dot{C}}{C} = (\sum_{j=1}^{3} S_j \frac{\dot{W}_j}{W_j}) + (\varepsilon_{CY})\frac{\dot{Y}}{Y} - (\lambda) \qquad (14)$$

Finally, by differentiating total costs, $C = \sum_{j=1}^{4} W_j X_j$, w.r.t. time (*T*), and dividing by *C* and rearranging, we obtain,

$$\sum_{j}^{3} S_j \frac{\dot{W}_j}{W_j} = \frac{\dot{C}}{C} - \sum_{j}^{3} S_j \frac{\dot{X}_j}{X_j} \qquad (15)$$

2.3. The Linkage

Having equations (1) - (4) and (9) - (15) at our disposal, we can now establish a "link" between the index number and parametric procedures. This is done to cross check the consistency of TFP measurement between the two procedures. By substituting (14) into (15) and rearranging, we obtain,

$$\varepsilon_{CY}\frac{\dot{Y}}{Y}-\lambda-\sum_{j=1}^{3}S_j\frac{\dot{X}_j}{X_j}=0 \qquad (16)$$

Subsequently, substituting (2) into (16) yields,

$$\varepsilon_{CY}\frac{\dot{Y}}{Y}-\lambda-\frac{\dot{X}_j}{X_j}=0$$

or

$$\lambda=\varepsilon_{CY}\frac{\dot{Y}}{Y}-\frac{\dot{X}_j}{X_j} \qquad (17)$$

A comparison between equations (4) and (17) reveals that, under the assumptions of constant returns to scale (i.e., $\varepsilon_{cy}=1$), efficient and optimizing producers, Hick's-neutral type technical change and no measurement errors, the rate of change in TFP(i.e., $\dot{TFP}$) equals the rate of technological change or shift of the production function (i.e., λ) . That is:

$$\dot{TFP}=\frac{\dot{Y}}{Y}-\frac{\dot{X}}{X}=\lambda \qquad (18)$$

However, if we assume that one of the conditions above does not exist, that is, the technology does not exhibit constant returns to scale (i.e., $\varepsilon_{cy}\neq 1$), then the index number procedure cannot be used to estimate the rate of technological change. This is because the methodology cannot account for the measurement of rate of returns to scale. On the contrary, the parametric procedure can still serve the purpose as before. Nevertheless, it can be explicitly shown that if the two procedures are linked, a validation concerning the consistency of measuring the TFP growth between them is possible. That is to say, in the presence of the scale effects, the two procedures will come-up with the same TFP value. This can be done by substituting $\dot{TFP} = \dot{Y}/Y - \dot{X}/X$ [(i.e., equation (4)] into equation (17) and rearranging:

$$\dot{TFP} = (1 - \varepsilon_{CY})\frac{\dot{Y}}{Y} + \lambda \qquad (19)$$

where λ is as defined in equation (17). This equation suggests that if the scale effects are present (i.e., $\varepsilon_{cy} \neq 1$), then $\dot{TFP}$ (estimated by index number procedure) equals $\dot{Y}/Y$ (estimated by index number procedure) weighted by $(1 - \varepsilon_{cy})$ i.e., estimated by parametric procedure, plus λ [estimated by parametric procedure via equation (17) or can be computed using the standard residual method (Abdullah, 1997). Henceforth, equation (19) will be used as the basis to measure the TFP growth and its two major components, namely, the scale and technological change effects, of the Sudanese Islamic banking sector.

3. Econometric Specification and Data Sources

3.1 Translog Cost Function

The translog specification of the generalized cost function as given in equation (9) is,

$$\begin{aligned}\ln C = {} & \alpha_0 + \sum_{j=1}^{3} \alpha_j \ln W_j + \alpha_Y \ln Y + \alpha_T T \\ & + \tfrac{1}{2}\sum_{j=1}^{3}\sum_{k=1}^{3} \gamma_{jk} \ln W_j \ln W_k + \tfrac{1}{2}\gamma_{YY} (\ln Y)^2 \\ & + \sum_{j=1}^{3} \gamma_{jT} \ln W_j T + \sum_{j=1}^{3} \delta_{YT} \ln W_j \ln Y \\ & + \delta_{YT} \ln Y\, T + \tfrac{1}{2}\gamma_{TT} (T)^2 \end{aligned} \qquad (20)$$

where all the subscripts remaining as they were before.

The cost-share S_j is derived through Shephard's lemma as,

$$S_j = \alpha_j + \sum_{k=1}^{3} \gamma_{jk} \ln W_k + \delta_{jY} \ln Y + \gamma_{jT} T \qquad (21)$$

For any cost function to be sensible, it must satisfy the linear homogeneity in input prices which requires:

$$\sum_{j=1}^{3} \alpha_j = 1, \ \sum_{j=1}^{3} \gamma_{jt} = 0 \ , \ \sum_{j=1}^{3} \gamma_{kj} = \sum_{k=1}^{3} \gamma_{jk} = 0 \ , \ \sum_{j=1}^{3} \delta_{Yj} = 0 \qquad (22)$$

Additional regularity conditions that the cost function must satisfy in order to correspond to well-behaved production technology are monotonicity and concavity in factor prices. Sufficient conditions for these to hold are positive fitted cost shares (α_j) and negative semi-definiteness of the bordered Hessian of the cost function.

For econometric estimation, the cross-equations equality and the linear homogeneity restrictions defined in (22) are imposed *a priori* on the translog cost function (20), and on the cost-share equations (21). This allows us to drop arbitrarily any one of the three (3) cost-share equations. In this study, the cost-share equation of deposits was omitted. The estimates of the coefficients of this equation are obtainable by using the parameter relationships of the linear homogeneity restrictions, once the system of the remaining cost-share equations has been estimated. Given this set of conditions, we chose as the estimation method the Iterative Seemingly Unrelated Regression (ISUR).

The cost elasticity is defined as $\varepsilon_{cy} = \partial \ln C / \partial \ln Y$, and if it is applied to equation (20), it will give,

$$\varepsilon_{CY} = \partial \ln C / \partial \ln Y = \alpha_Y + \gamma_{YY} \ln Y + \sum_{j=1}^{3} \delta_{Yj} \ln W_j + \delta_{YT} \mathrm{T} \qquad (23)$$

(23)

From equation (23), we can obtain information on returns to scale. If $\alpha_Y = 1$ $\gamma_{YY} = 0$, δ_{YT} T = 0, and $\delta_{Yj} = 0$ *(j = L, M, U,)*, then $\varepsilon_{cy} = 1$, which signifies constant returns to scale. If, however, $\alpha_Y > 1$ or $\alpha_Y < 1$ then $\varepsilon_{cy} > 1$ or $\varepsilon_{cy} < 1$, signifying decreasing returns to scale or increasing returns to scale, respectively.

Finally, the growth rate of cost diminution can be obtained as

$$\frac{\partial \ln C}{\partial T} = \lambda = \alpha_T + \sum_{j=1}^{3} \gamma_{jT} \ln W_j + \delta_{yT} \ln Y + \gamma_{TT} (T \ \ ) \qquad (24)$$

This method of estimating λ is used, among others, by Denny *et. al*. (1981), Kuroda (1995), Glass and McKillop (1990), and Abdullah (2000).

3.2. Data Sources and Variables Specifications

The data used to estimate the cost function were gathered from 12 Sudanese banks' annual reports for the years 1989-1998. The years 1989-1998 were chosen because they represent the transformation of the conventional Sudanese banks into full-fledged Islamic banks. The definitions of the cost, prices, and output variables were made based on how and what banks produce(1). There

(1) Karlyn Mitchell and Nur M. Onvural, 1996, Economies of Scale and Scope at Large Commercial Banks: Evidence from the Fourier Flexible Functional Form, Journal of Money, Credit and Banking, Vol. 28, No. 2.pp.178-199.

are two different views on the determination of input and output variables. They are the intermediate approach and the production approach.

The intermediate approach views banks as using deposits together with physical inputs to produce various types of bank assets as measured by their currency value. Berger and Humphrey (1997) suggest that the intermediate approach is best suited for evaluating firm level efficiency as in our case. The reason is that the intermediate ap[illegible]g the importance of frontier efficiency to the profitability of the financial institution since the minimization of total costs, not just production costs, is needed to maximize profit[1]. The production approach on other hand, views bank as is using only physical inputs such as labor and capital to produce deposits and other types of bank assets. The production approach is appropriate for evaluating the efficiency of the branches of financial institutions. This is because branches initially process customers' services for the whole institution and branch managers have little influence over the bank's funding and investment decisions.

From the above discussions**,** the bank outputs are both investments and various banks loans if we following the intermediate approach or loans, investments and various types of bank's deposits if we follow the production approach. Since we used bank's level data, the intermediate approach is best suited our study. Hence in this study, one output variable and three variable inputs are used to measure 12 Sudanese banks' TFP[1]. Since during the period of investigation loans that were given on the basis of interest bearing f[illegible]mic banking system, all Sudanese banks practiced only equity financing. As a result, the only output available was

[1] Allen N. Berger and David B. Humphrey, Efficiency of financial institutions: International survey and directions for future research, European Journal of Operational Research 98 (1997).

[1] For more details see the appendix.

investments (*Y*). While labor (X_1), fixed assets (X_2) and core deposits (X_3) are treated as factor inputs, salaries and wages divided by number of employees (W_1), total expenses on furniture, equipment and premises divided by their book value (W_2), and rate of return on deposits divided by the total deposits (W_3) are the prices of X_1, X_2 and X_3 respectively.

4. Empirical Results

4.1. Sample Statistics for the Variables and Group

In Table 1 we present summary statistics for output (investment), inputs (labor, capital or fixed assets, and deposits) and their respective prices of the average 12 Sudanese Islamic banks and each group, namely Group A, Group B and Group C.

Table 1

Sample Statistics of Variables: Output, [illegible] lions Sudan Pound, SP) [a], 1989-98

Variables	Mean	Std. Dev.	Minimum	Maximum	
Panel A[b]					
					Output
Investment (Y)	9644909	20674338	1791.5	13700000	
					Inputs
Fixed Assets (X_1)	2682402	4132545	1769.7	16140186	
Labor (X_2)	1006	1279	17.0	7099.0	
Deposits (X_3)	24893232	85561647	2154.4	89100000	
					Input Prices
Fixed Assets (W_1)	0.929	0.056	0.665	0.995	
Labor (W_2)	0.948	5.500	0.018	60.461	
Deposits (W_3)	1.04098	0.7933	0.3539	9.6145	
					Share of each Input in Total Cost
Fixed Assets (S_1)	0.155	0.138	0.012	0.707	
Labor (S_2)	0.055	0.095	0.004	0.944	
Deposits (S_3)	0.790	0.170	0.041	0.980	

Total Cost (TC)	28726032	88852153	18079.35	0900000
Panel B[c]				
1. Group A				
Output				
Investment (Y)	19173501	30712558	1791.5	13700000
Inputs				
Fixed Assets (X_1)	5067513	5480157	3020.25	6140186
Labor (X_2)	1932.6	1846.9	164	7099
Deposits (X_3)	58303946	14200000	2154.4	9100000
Input Prices				
Fixed Assets (W_1)	0.938	0.034	0.841	0.955
Labor (W_2)	1.944	9.493	0.034	60.46
Deposits (W_3)	1.183	1.37	0.3539	9.616
2. Group B				
Output				
Investment (Y)	6532271	13354650	6852.22	65343601
Inputs				
Fixed Assets (X_1)	2284306	3354001	19733.10	13984541
Labor (X_2)	795.03	270.97	259	1527
Deposits (X_3)	11910392	15848081	194861.20	7397124
Input Prices				
Fixed Assets (W_1)	0.927	0.072	0.665	0.992
Labor (W_2)	0.526	0.752	0.018	.581
Deposits (W_3)	0.964	0.067	0.732	0.999
3. Group C				
Output				
Investment (Y)	3228954	6108778	16000	23697647
Inputs				
Fixed Assets (X_1)	695387.3	884031.1	1769.72	4216487
Labor (X_2)	290.4	235.60	17	840
Deposits (X_3)	4465359	6703973	86567.2	4700248
Input Prices				
Fixed Assets (W_1)	0.923	0.054	0.733	0.990
Labor (W_2)	0.374	.233	0.037	0.991

Deposits (W_3)	0.9750	0.0714	0.6936	1.1733

Note: [a] labor is measured in terms of number of employees by the end of the respective financial year.

[b] Panel A summarizes output, inputs, input prices and other relevant variables of the Sudanese Islamic banks for aggregate data, i.e., 12 sample banks and 10 observation years or 120 observations.

[c] Panel B summarizes output, inputs and input prices of the Sudanese Islamic banks for the specified groups, namely Group A, Group B and Group C. There are 40 observations in each group, i.e., four sample banks and 10 observation years.

Panel A reports the average output, inputs, input prices, share of each factor inputs in the total cost and the total cost itself along with their standard deviations, minimum and maximum values. On the other hand, with the aim to provide a clear picture on the production structure of each group of the surveyed banks, we also report the average output, inputs and input prices of each factor inputs along with their standard deviations, minimum and maximum values. To conserve space, we will, however, highlight the variables that are extensively used in the study. First, as evident from Panel A, deposits took the lion share of the total cost of the Sudanese Islamic banks during the 1989-98 period. Second, the large-size banks (Group A), on average, held approximately 63.0% of the total fixed assets. This is shown in the Panel B of Table 1. Third, in terms of investment (Y) Group A banks invested the largest amount of investment worth SP19173501 million during the 1989-98 period. It seems from observations (i) and (ii) that there is a positive relationship between the size of fixed assets and the amount of investment made. A tentative conclusion that can be made from this observation is that the larger the bank the bigger the size of its fixed assets and investment.

4.2. Quantity Indexes of Output, Total Input and Productivity

For reference purposes, we present in Table 2 a complete set of quantity indexes of output (Y), total input (X) and productivity (Y/X) for all banks. There are few interesting observations that can be gleaned from the table. This is particularly true if the focus is given to the trends of productivity index (i.e., the division of output index by input index or Y/X) of the specified groups of banks. First, with the exceptions of El Neillien Industrial Development Bank and few observation years, the productivity index of other banks in Group A showed an increasing trend over the 1993-97 period. Second, in the case of Group B banks it seems 1995 and 1996 were the years where the productivity index reached its peak. Specifically, the index registered was larger than unity. In fact, in two banks the index was 7.27 and 6.84, which is quite an extraordinary achievement. Third, to some extent, the Group B banks' productivity index shared the same trend as that of Group A.

For readers with high interest to know in greater details about the trends of the indexes, we also provide Figures 1-9. They are attached to the paper as Appendix A. One question that remains unanswered is, what were the factors behind the several trends showed by the three groups of banks? We will, in due course of the paper, answer the question.

Table 2
Quantity Indexes of Output (Y), Total Input (X) and Productivity (Y/X) for Sudanese Islamic Banks, 1989-98

Sample No.	Year	Y	X	Y/X	Sample No.	Year	Y	X	Y/X
1	1989	0.116	0.190	0.16	61	1989	0.443	0.656	0.68
2	1990	0.183	0.889	0.21	62	1990	0.514	0.763	0.67
3	1991	0.805	0.110	7.32	63	1991	0.107	0.909	0.12
4	1992	0.271	0.137	1.98	64	1992	0.175	0.104	1.68
5	1993	0.708	0.196	3.61	65	1993	0.465	0.119	3.91
6	1994	0.151	0.204	0.74	66	1994	0.147	0.136	1.08
7	1995	0.265	0.101	2.62	67	1995	0.110	0.155	0.71
8	1996	0.410	0.969	0.42	68	1996	0.345	0.177	1.95
9	1997	0.463	0.869	0.53	69	1997	0.141	0.201	0.70
10	1998	0.799	0.862	0.93	70	1998	0.156	0.212	0.74
11	1989	0.783	0.157	4.99	71	1989	0.134	0.478	0.28

12	1990	0.103	0.190	0.54	72	1990	0.261	0.588	0.44
13	1991	0.158	0.246	0.64	73	1991	0.179	0.747	0.24
14	1992	0.161	0.304	0.53	74	1992	0.199	0.835	0.24
15	1993	0.171	0.376	0.45	75	1993	0.399	0.837	0.48
16	1994	0.232	0.464	0.50	76	1994	0.474	0.747	0.63
17	1995	0.401	0.571	0.70	77	1995	0.763	0.105	7.27
18	1996	0.795	0.913	0.87	78	1996	0.175	0.124	1.41
19	1997	0.907	0.534	1.70	79	1997	0.154	0.115	1.34
20	1998	0.616	0.635	0.97	80	1998	0.233	0.126	1.85
21	1989	0.285	0.392	0.73	81	1989	0.324	0.234	1.38
22	1990	0.420	0.230	1.83	82	1990	0.427	0.357	1.20
23	1991	0.107	0.206	0.52	83	1991	0.673	0.476	1.41
24	1992	0.309	0.100	3.09	84	1992	0.239	0.490	0.49
25	1993	0.880	0.109	8.07	85	1993	0.459	0.611	0.75
26	1994	0.163	0.140	1.16	86	1994	0.670	0.707	0.95
27	1995	0.150	0.220	0.68	87	1995	0.745	0.702	1.06
28	1996	0.281	0.219	1.28	88	1996	0.123	0.605	0.20
29	1997	0.249	0.225	1.11	89	1997	0.528	0.634	0.83
30	1998	0.748	0.139	5.38	90	1998	0.680	0.585	1.16
31	1989	0.832	0.142	5.86	91	1989	0.104	0.462	0.23
32	1990	0.102	0.224	0.46	92	1990	0.144	0.500	0.29
33	1991	0.144	0.352	0.41	93	1991	0.184	0.657	0.28
34	1992	0.241	0.573	0.42	94	1992	0.351	0.935	0.38
35	1993	0.460	0.661	0.70	95	1993	0.347	0.120	2.89
36	1994	0.147	0.867	0.17	96	1994	0.681	0.119	5.72
37	1995	0.214	0.953	0.22	97	1995	0.800	0.104	7.69
38	1996	0.488	0.961	0.51	98	1996	0.170	0.100	1.70
39	1997	0.677	0.726	0.93	99	1997	0.476	0.527	0.90
40	1998	0.798	0.873	0.91	100	1998	0.264	0.536	0.49
41	1989	0.114	0.701	0.16	101	1989	0.631	0.644	0.98
42	1990	0.260	0.827	0.31	102	1990	0.137	0.101	1.36
43	1991	0.367	0.961	0.38	103	1991	0.326	0.161	2.02
44	1992	0.659	0.133	4.95	104	1992	0.522	0.236	2.21
45	1993	0.164	0.144	1.14	105	1993	0.104	0.300	0.35
46	1994	0.150	0.153	0.98	106	1994	0.267	0.413	0.65
47	1995	0.998	0.146	6.84	107	1995	0.607	0.374	1.62
48	1996	0.504	0.144	3.50	108	1996	0.116	0.379	0.31
49	1997	0.183	0.144	1.27	109	1997	0.137	0.366	0.37
50	1998	0.106	0.995	0.11	110	1998	0.148	0.351	0.42
51	1989	0.266	0.350	0.76	111	1989	0.152	0.218	0.70
52	1990	0.751	0.557	1.35	112	1990	0.358	0.245	1.46
53	1991	0.868	0.693	1.25	113	1991	0.546	0.270	2.02
54	1992	0.245	0.769	0.32	114	1992	0.153	0.331	0.46
55	1993	0.111	0.963	0.12	115	1993	0.374	0.353	1.06

56	1994	0.101	0.102	1.00	116	1994	0.592	0.373	1.59
57	1995	0.101	0.973	0.10	117	1995	0.773	0.424	1.82
58	1996	0.611	0.960	0.64	118	1996	0.636	0.342	1.86
59	1997	0.644	0.959	0.67	119	1997	0.166	0.351	0.47
60	1998	0.411	0.958	0.43	120	1998	0.166	0.625	0.27

Note: The overall sample size is 120 which consisted of 10 observation years and 12 banks. The benchmark for the initial and terminal year was 1989 and 1998, respectively. We arrange the data sets in the following order:

Group **Bank** **Sample No.** **Year**

1-10	‘89-98	Faisal Islamic Bank Of Sudan	A/Large
11-20	‘89-98	Bank Of Khartoum	A/ Large
21-30	‘89-98	El Neillien Industrial Development Bank	A/ Large
31-40	‘89-98	Sudanese French Bank	A/Large
41-50	‘89-98	Tadamon Islamic Bank	B/Medium
51-60	‘89-98	Islamic Co-operative Development Bank	B/Medium
61-70	‘89-98	Sudanese Islamic Bank	B/ Medium
71-80	‘89-98	Sudanese Saving Bank	B/ Medium
81-90	‘89-98	Al Baraka Bank of Sudan	C/Small
91-100	‘89-98	Islamic Bank for Western Sudan	C/ Small
101-110	’89-98	Workers’ National Bank	C/ Small
111-120	’89-98	Mashreq Bank PSC	C/ Small

4.3. TFP Growth

Table 3 exhibits output, total input and TFP growth rates of all Sudanese Islamic banks and the three groups, Group A (the Large-size banks), Group B (the Medium-size banks) and Group C (the Small-size banks) for the 1989-98 period. As can be seen from the table, irrespective of the groups, the average annual TFP growth rate for all Sudanese Islamic banks over the 1989-98 period was 1.61%. More or less the same rate was recorded by the Large-size banks with TFP of 1.45% over the same period. In the case of Medium-size banks, the TFP growth rate registered by them over the surveyed period was an exceptionally high of 14.43%. It is fairly obvious from the table that the reason for such a high achievement can be attributed to the negative rate of input growth rate, which points to the fact that the banks were undergoing a "down-sizing" or "cost-saving" strategy. In other words, given the fact that the output growth rate was negative, banks were obliged or compelled to minimize their input costs. Indeed, judging from the input growth rate of -14.93%, the Medium-size banks succeeded to that effect.

Next, we turn our attention to the performance of the Small-size banks. In stark constrast to the case of Medium-size banks, the Small-size banks, despite experiencing a negative output growth rate during the 1989-98 period, have failed to minimize the input costs. This had resulted in a negative TFP growth rate for the small-size banks.

The actual reason(s) for variation in TFP growth rates registered by the Sudanese Islamic banks as a whole and the ones registered by the groups can only be empirically verified when the TFP growth is decomposed into scale and technological change effects.

Table 3

Output, Total Input and TFP Growth Rates for Sudanese Islamic Banks, 1989-98

Bank Classifications	$\dot{TFP}$	$\frac{\dot{X}}{X}$	$\frac{\dot{Y}}{Y}$
Group A (Large-size)	***10.18***	***8.73***	***1.45***
Group B (Medium-size)	***- 0.50***	***-14.93***	***14.43***
Group C (Small-size)	**-1.83**	**6.69**	**-8.52**
Average (Aggregate Data)	***3.14***	***1.53***	***1.61***

$\dot{Y}/Y$ is the growth rate of output which is computed by fitting lnY=k+qT, where Y is the Tornqvist index of output (as shown in Table 2), T is time and k and q are parameters to be estimated. The same procedure is used to compute the growth rate of total input ($\dot{X}/X$). As defined before, Total Factor Productivity growth rate ($\dot{TFP}$) is a substraction of total input growth rate from output growth rate or

$\dot{TFP} = \dot{Y}/Y - \dot{X}/X$ (Equation 4)

4.4. Decomposition of TFP into its Source Components

The advantage of decomposing the sources of TFP into scale and technological change effects is that it provides certain insights as to what lies behind this pattern of TFP growth. For example, it is interesting to note that if scale effect shows up as a negative value it reflects the diseconomies of scale associated with the relatively small average bank size in Sudan. Before we proceed to discuss the findings of the study, we present the result of parameter estimates of the specified translog cost function. They are displayed in Table 4. The adjusted R^2 was 0.82, indicating a fairly good measurement of goodness of fit for the model. The test statistics for the three hypotheses concerning the production technology of the Sudanese Islamic banking sector were conducted and they were rejected at the 10% significance level. Just to give but one example, the first condition [refer to equation (22)] is satisfied by the model as indicated in Table 4 by $\sum_{j}^{3} \alpha_j$ =1.

Next, the two methods of measuring TFP growth, which is based on equation (19), are shown in Table 5. To reiterate, while the left-hand side term of equation (19) is derived from the index number procedure, the right-hand side terms, which consist of scale and technological change effects, are derived from the parametric procedure. More specifically, the scale effect is estimated using equation (23) while the technological change effect is computed using equation (17). It is very interesting to note that irrespective of the measurement used; be it index number procedure or parametric procedure, the results are the same. This points to the fact that the two procedures are equivalent and one is complementary to the other. However, the parametric procedure has an edge over the index number procedure because it can be used to decompose as well to distinguish the actual contribution of each component to TFP. For example, using the parametric procedure, we know that the Group A banks' TFP growth is 1.45% of which 8.65% is contributed by scale effect and the remaining –7.20% is contributed by technological change effect. Whereas using the index number procedure the TFP growth can easily be computed, and in the case of the Group A banks it is 1.45%, but the sources are not explicitly known.

4.4.1. Scale Effects

The scale economies, defined as **(1-ε_{CY})**, is positive (Table 5, column 1, row 4) for the Average Sudanese Islamic banks for the 1989-98 period. This implies that the underlying production technology of the banking sector in Sudan exhibits increasing returns to scale. To be more precise, the ε_{CY} of 0.28 for the Average bank means, on average, a 1% increase in output resulted in only 0.28% increase in total cost. Thus, the positive value of **(1-ε_{CY})** of the Average and other Groups of banks also suggest that they could further exploit the scale economies through expansion of the size of their operations.

The scale effect of the three groups of banks together with the Average is shown in column 2 of Table 5. As can be seen from the table, the effect has changed from negative to positive in accordance with the size of the banks. A closer scrutiny reveals that as the Sudanese Islamic banks' size gets larger the scale effect changes from one that of negative to positive. Since the magnitude of scale effect of the Sudanese Islamic banks is intimately related to the bulkiness of the banks, we can confidently conclude therefore that in order for the Medium- and Small-size banks to be more vibrant they have to expand their size of operations.

4.4.2. Technological Change Effect

With Group B banks being the only exception, the other groups of banks experienced negative technological growth rate over the surveyed period. While the positive growth rate indicates that the adoption of new technology by the Group B banks had taken place during the 1989-98 period, the opposite is true in the case of other two groups of banks when the technological change effect registered negative sign. From this finding, we can conclusively argue that the reason behind the high TFP growth achieved by Group B banks (i.e., 14.43%) was that the adopted technique had enabled them to minimize cost. In other words, the technology adopted, judging from the relatively low index of total input growth rate ($\dot{X}/X$ -Table 3), could have been factor-input saving in nature. This is perhaps consistent with the Central Bank of Sudan directive to all Sudanese banks to adhere to the Basle Commission capital sufficiency standard in which banks are required to undergo a restructuring program. The objective of the program, popularly known in Arabic as *Tawfiq Awda' Al-Bunok* (Banking Conformity Program), was to create strong locally, and financially sound banking institution that can compete both internally and internationally (Bank of Sudan, the Thirty Eight Annual Report, p. 42). This is in fact consistent with the reality on the ground. According to the data published by the Sudanese Banking Union (1997, pp.53-55), in 1996 alone the group B banks had reduced, on average, 7.5% of their labor input.

4.4.3. Relative Contributions of Scale and Technological Change Effects

Table 5 (in parentheses) also exhibits information on the relative contributions of each effect to TFP growth. They are expressed in terms of percentage (%). As can be seen from the table, in the case of Groups B and C banks, the effect of technological change seems to exert more influence on the TFP growth compared with the scale effect. Taking the former group of banks as an example, while the contribution of scale effect to TFP growth was –2.6%, the contribution of technological change effect was 102.6%. However, the overall picture shows that the scale effect is the major contributor to the TFP growth of the Sudanese Islamic banks over the surveyed period with 140.4% as compared to the technological change effect with –40.4%. In other words, the negative effect of the technological change has on the TFP growth had been compensated for by the positive scale effect. The negative contribution of the technological change to productivity gains may be in part a consequence of an ill-judged or imprudent use of the available factor inputs.

Table 4
Parameter Estimates of the Translog Cost Function
For the Sudanese Islamic Banks, 1989-98

Coefficients	Estimate	t-value	Coefficients	Estimate	t-value
α_0	**19.780**	**29.37**	γ_{LT}	**1.359**	**10.67**
α_Y	**0.280**	**52.37**	γ_{KT}	**-0.050**	**-7.23**
α_T	**0.040**	**23.49**	γ_{DT}	**-0.471**	**-7.63**
α_L	**0.361**	**6.85**	γ_{TT}	**0.004**	**0.95**
α_K	**0.226**	**9.52**	γ_{YY}	**0.164**	**19.43**
α_D	**0.413**	**9.35**	δ_{LY}	**-1.964**	**-10.01**
γ_{LK}	**-0.346**	**-1.80**	δ_{KY}	**0.061**	**6.83**

γ_{LD}	**5.810**	**9.48**	δ_{DY}	**-0.419**	**-4.15**
γ_{KD}	**-6.817**	**-19.13**	δ_{YT}	**-0.070**	**-14.04**
				Adjusted R^2=0.824	

Table 5

TFP and Its Source Components for the Sudanese Islamic Banks, 1989-98

	[1]	**[2]**	**[3]**	**[4]**
Bank Group	**(1-** ε_{CY} **)**	**(1-** ε_{CY} **)** $\frac{\dot{Y}}{Y}$ **(via Equation 17)**	λ	$\dot{TFP}$
Group A	**0.85** (596.6%)*	**8.65** (-496.6%)	**-7.20** (100.0%)	**1.45**
Group B	**0.76** (-2.6%)	**-0.38** (102.6%)	**14.81** (100.0%)	**14.43**
Group C	**0.77** (16.6%)	**-1.41** (83.4%)	**-7.11** (100.0%)	**-8.52**
Average	**0.72** (140.4%)	**2.26** (-40.4%)	**-0.65** (100.0%)	**1.61**

* Figures in the parentheses are the sources of TFP growth rate; the scale effect and technological change effect, measured in percentage (%). The former effect was computed by dividing (2) by (4), and the latter effect was computed by dividing (3) by (4).

5. Concluding Summary

Our objective in undertaking this empirical study was to measure the TFP growth and its source components for the Sudanese Islamic banks for the 1989-98 period. To serve this objective we employed two different procedures to measure the TFP growth. They are; the index number and parametric procedures.

The major findings of this study may be summarized as follows:

(i) The average productivity growth for the Sudanese Islamic banks was 1.61% of which 2.26% was contributed by the scale effect and –0.65% by the technological change effect.

(ii) The result of the empirical study points to the fact that, on average, the production technology of the Sudanese Islamic banks for the 1989-98 period was bound by increasing returns to scale. This suggests that an expansion of the bank size operation is still possible. Judging from this point of view, it seems plausible for the government of Sudan to confidently proceed with its policy, if any, to allow banks to actively open their branches in the states where no or few banks are in operation. By so doing, the rural and remote areas may benefit from their existence. This is particularly true in the case of small retailers and farmers who were previously, although unintentionally, denied from enjoying the Islamic banking products and services.

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Appendix A

Abbreviations: Note that for every **KEY** with initials **Y**, **X** and **Y/X**, it denotes Output, Total Input and Productivity indexes, respectively.

Key	Full Name	Bank Group
FSB	**Faisal Islamic Bank of Sudan**	**A**
BKH	**Bank of Khartoum**	**A**
ENB	**El Neillien Industrial Development Bank**	**A**
SFB	**Sudanese French Bank**	**A**
TSB	**Tadamon Islamic Bank**	**B**
ISCB	**Islamic Co-operative Development Bank**	**B**
SIB	**Sudanese Islamic Bank**	**B**
SSB	**Sudanese Saving Bank**	**B**
BBS	**Al Baraka Bank of Sudan**	**C**
IBWS	**Islamic Bank for Western Sudan**	**C**
WNB	**Workers' National Bank**	**C**

MBP	**Mashreq Bank PSC**	**C**