Technical Efficiency and Productivity of Ethiopian Commercial Banks: Data Envelopment Analysis (DEA) Approach

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Abstract- Ethiopia has no capital market, thus, the majority of investment and saving are through the banking system, hence, it is more important for the public as a whole to find out Relative Technical Efficiency of banks. This study aims to evaluate the relative technical efficiency and productivity change of Ethiopian commercial banks during the period 2007 to 2011. Using Intermediation approach two input variables - fixed asset and labor, and two output variables- total deposits and net loans & advances, - were selected. The study adopts DEA to measure effici3ency of banks and MPI to measure the productivity gains of banks over time. A panel data of ten commercial banks operating in Ethiopia from 2007 – 2011 were collected. The results show that, on average, Ethiopian commercial banks were relatively technically inefficient. Scale inefficiency takes the leading contribution for source of inefficiency. The study also reveals that the average TFP change is 0.965 during the study period. In this case, technical efficiency regress takes the most contributions to the loss of TFP.

Index Terms- Data Envelopment Analysis, Malmquist productivity index, technical efficiency, commercial banks in Ethiopia

I. INTRODUCTION

The banking sector is the only important formal system through which firms can obtain access to external financing in Ethiopia. In light of these, the performance of Ethiopian commercial banks remains to be a compelling agenda of concern for several stakeholders including government, investors, business enterprises, and so on

The Performance of banks is often stated in terms of efficiency. The measured efficiency is interpreted as a difference between observed input and output levels and the corresponding optimal values *(Wheelock and Wilson, 1995).* The efficiency of the banking system is the most important issues in the financial market because it affects the stability of the banking industry and then, the effectiveness of the nation's monetary policy *(yilmaz, 2013).* Therefore, efficiency scores of banks are indicators of success of individual banks and banking industry as a whole and also help to check the potential impact of government policies on efficiency (*Wheelock and Wilson, 1995).* However, most traditional evaluators used ratios analysis. Ratios analysis can be misleading as it measure partial efficiency of banks *(Rao and Tekeste, 2012).* To overcome this problem in the few past decades, researchers are using frontier analysis methods.

In Ethiopia, by the end of June 30, 2011 the number of banks raised to 17 (three public owned and 14 private banks) with 970 (483 public and 487 private) branches *(National Bank of Ethiopia annual report, 2010/11).* In addition, banks will surely be challenged by very rapidly growing microfinance institutions in all regions of the country, and by the proliferation of share company formations. In this competitive sector only efficient bank is getting benefited from. Few researchers *(Muluneh, 2008 and Rao and Tekeste 2012)* tried to examine bank level efficiency using frontier analysis methods in Ethiopia.

Muluneh (2008) examined the cost efficiency and its determinant of private commercial banks under parametric stochastic Frontier Analysis (SFA) method. However, this method requires a prior knowledge of weights or prices of inputs and outputs, specification of their functional relationships, and also has no ability to identify the potential improvement for the inefficient banks like DEA. *Rao and Tekeste (2012)* examined the cost efficiency and ownership structure of commercial banks in Ethiopia using non-parametric DEA and Tobit method. But cost efficiency by itself cannot reveal the source of inefficiency that helps the bank managers to take corrective action to improve efficiency gain. Therefore, conducting a study on the issue of technical efficiency of Ethiopian commercial banks using DEA is vital for having an insight regarding technical efficiency of each bank and banking sector as a whole, to know the inefficient bank and to determine the source of inefficiency, and also helpful to identify the potential improvement for the inefficient banks to reach efficiency frontier. The purpose of the study is to investigate the relative technical efficiency and productivity change of the commercial banks during the study period.

II. MATERIAL AND METHOD

1.1. Research Design

This study is descriptive in nature. It describes the relative technical efficiency and productivity growth of Ethiopian commercial banks during the period 2007 up to 2011. Since there is no accurate data on input prices, both allocate and economic efficiencies are out of the research scope.

1.2. Data

Five years panel data of bank level variables were collected. That is, audited financial statements of 10 commercial banks were gathered from National Bank of Ethiopia. The ten commercial banks were purposively selected based on their time establishment. This is to collect the balanced panel data because

all banks must be observed in each year in order to measure their productivity change using MPI (Coelli, 1996).

1.3. Method of Data Analysis

To measure banks' efficiencies Charnes, Cooper and Rhodes (CCR) and Banker, Charnes and Cooper (BCC) input-oriented DEA models are utilized. In addition, Output-orientated Malmquist productivity index (MPI) is adopted to measure the productivity of the banks over the study period. Data Envelopment analysis program (DEAP) version2.1 software is used to measure both technical efficiency and productivity growth of the bank

1.4. Selection of Variables And Modeling

Measuring bank efficiency requires selection of appropriate input and output variables. For defining these variables, prior studies has mostly followed two main approaches - intermediate and production approaches (Berger & Humphrey, 1997; Sharma *et al*., 2012; Farrell, 1957).

- *Intermediate approach* defines a bank as an intermediary that transfers assets from the surplus units to deficit units. This approach was widely used by previous studies using various conceptualizations in defining banks' inputs and output (Berger and Humphrey, 1997). *Production approach* considers the bank as producer, and hence the inputs are the physical elements such as labor and capital and all other assets and liabilities are outputs.

Thus, by using intermediate approach, four variables - two input variables and two output variables were selected. The Input variables are Labor – total expenditures on employees and Fixed assets - book value of physical capital and premises while Output Variables are Total deposits - total demand, saving and fixed deposits and Net Loan and advances - total customer loans and advances less provision for doubtful debts. Deposits are considered as output, because, in Ethiopia deposit mobilization is one of the major performance indicators of commercial banks and they incur costs to mobilize deposits *(Rao and Tekeste 2012).*

The study applied CCR and BCC models to estimate the relative efficiency and Malmquist productivity index in order to measure total factor productivity change.

$$\text{Efficiency} = \frac{\text{weighted sum of outputs}}{\text{Weighted sum of inputs}} \quad \ldots\ldots (2.1)$$

- The Malmquist productivity index used to measure the productivity trends of the banks over the given period of time and decomposed it to technical efficiency change and technological changes, according to the following equation (for detail see, Fare et al., 1989)

- $$Mt+1(x_{t+1}, y_{t+1}, x_t, y_t) = \sqrt{\frac{Dt(x_{t+1}, y_{t+1})}{Dt(x_t, y_t)} \frac{Dt+1(x_{t+1}, y_{t+1})}{Dt+1(x_t, y_t)}} \quad \ldots\ldots (2.2)$$

- This decomposed into:

- $$\mathbf{M_{t+1}}(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{\mathbf{Dt+1}\,(x_{t+1}, y_{t+1})}{\mathbf{Dt}\,(x_t, y_t)} \sqrt{\left[\frac{\mathbf{Dt}\,(x_{t+1}, y_{t+1})}{\mathbf{Dt+1}\,(x_{t+1}, y_{t+1})} * \frac{\mathbf{Dt}\,(x_t, y_t)}{\mathbf{Dt+1}\,(x_t, y_t)}\right]} \quad \ldots\ldots (2.3)$$

= Technical efficiency change (Tech)* Technological change (Techch)

III. RESULTS AND DISCUSSION

1.5. DEA Models Results

Here the major findings of the two DEA models - CCR & BCC models and the necessary movement by each variable to reach target level under BCC model were summarized. Technical efficiency and pure technical efficiency are calculated directly by the CCR and BCC models respectively. Scale efficiency on the other hand, computed by ratio of TE/PTE. The basic rules followed for evaluation of efficiency is that Technical Efficiency equal to one shows relatively technically efficient, but less than one denotes inefficient

Table1 and 2 describe efficiency scores of Ethiopian commercial banks based on CCR model and BCC model. Under CCR model, it is found that the average technical efficiency between 2007 and 2011 ranges from the least 0.710 to the highest 0.876. This indicates that the overall level of technical inefficiency ranges from a minimum12.4% to a maximum 29%. Under the BCC model it is found that the average pure technical efficiency ranges between 0.829% and 0.974%. When efficiency scores of the two DEA models are different, the variable return to scale scores are better than in the constant return to scale model because in the VRS model the banks are benchmarked against the bank of similar size. So, it shows better performances of the sector as compared to the CRS. For scale efficiency, it ranges between 0.859 and 0.925. This implies that deviation of actual scale of production from the most productive scale size range between 14.1% and 7.5% during the study period.

Table1. Technical efficiency of banks based on CCR model

No.	Bank Name	Abbr.	Technical Efficiency (TE)					
			2007	**2008**	**2009**	**2010**	**2011**	Average
1	Construction & Business Bank	CBB	0.819	0.761	0.943	0.870	0.622	**0.803**
2	Commercial Bank of Ethiopia	CBE	0.637	1.000	1.000	1.000	1.000	**0.927**
3	Dashen Bank	DB	1.000	1.000	1.000	1.000	0.794	**0.959**
4	Awash International Bank	AIB	0.893	0.957	0.906	0.740	0.600	**0.819**
5	Bank of Abyssinia	BA	1.000	0.973	0.833	0.895	0.773	**0.895**
6	Wegagen Bank	WB	1.000	1.000	0.756	0.626	0.503	**0.777**
7	United Bank	UB	0.897	1.000	1.000	1.000	1.000	**0.979**
8	Lion International Bank	LIB	0.443	0.445	0.616	0.751	0.674	**0.586**
9	Cooperative Bank of Oromia	CBO	0.602	0.646	0.680	0.646	0.450	**0.605**

10	Nib International Bank	NIB	0.989	0.974	0.846	0.764	0.680	**0.851**
		Mean	**0.828**	**0.876**	**0.858**	**0.829**	**0.710**	**0.820**

Source: Own computation 2013

The overall mean TE of sample banks over the entire period of the study was 0.820 which indicates the banks could have reduced their input on average by 18% in order to produce the same level of output. This implies that on average banks are relatively technically inefficient. Further, the overall mean PTE and SE were 0.925 and 0.888 respectively. When the PTE is greater than SE, then inefficiency is caused by scale inefficiency. Hence, the source of technical inefficiency among commercial banks operating in Ethiopia on average is due to scale inefficiency. The study is in line with Darwin (2012), Soetanto and Ricky (2011), Usman *et al.,* (2010) those argued that the source of inefficiency is scale inefficiency rather than pure technical efficiency.

Table2: Average Annual Technical Efficiency and Its Components, PTE and SE

	2007	**2008**	**2009**	**2010**	**2011**	**Average**
TE	0.828	0.876	0.858	0.829	0.710	**0.820**
PTE	0.974	0.973	0.949	0.898	0.829	**0.925**
SE	0.853	0.896	0.908	0.925	0.859	**0.888**

Source: Own computation 2013

On the other hand, it contradicts the findings of Drake and Hall (2003) and Miller and Noulas (1996). According to Drake and Hall (2003), the bulk of inefficiency of the Japanese banks is attributable to pure technical inefficiency rather than scale inefficiency. Meanwhile, Miller and Noulas (1996) found that pure technical inefficiency of large US banks is twice as great as scale inefficiency.

Table3 describes the possible improvements by inefficient banks. To produce the targeted outputs by using the targeted inputs and to be technically efficient, commercial banks operating in Ethiopia during the period 2007 to 2011, had to increase further their output variables; total deposits (TD) and net loan & advance (NLOA) on average by 5,095.015(1.6%) & 1080.719(0.4%) respectively and they had to reduce their input variables; fixed asset (FA) and labor (LAB) on average by 789.885(14.3%) & 301.18(7%) respectively.

Table3. Potential Improvements Summary of Ethiopian Commercial Banks 2007-2011

Variable	**Original value (in million birr)**	**Potential Improvement**	
		Amount (in million birr)	**Percentage**
Total Deposits	319,768	5,095.015	1.6
Net Loan & Advance	302,488	1,080.719	0.4
Fixed Assets	5,525	-789.885	14.3
Labor	4,307.3	-301.18	7.0

Source: Own computation 2013

Note: The negative sign shows that the potential improvement is reduction in amount.

1.6. Malmquist Productivity Index Results

The Malmquist productivity index evaluates the productivity changes over time which is measured as the product of technical efficiency change and technological change. The basic rule that is followed for evaluation is if the total factor of productivity index is more than one, it means banks are working efficiently. But if the value of TFP is less than one that means efficiency is declining during the study period.

Table 4. Average TFP and its components' change of commercial banks from 2007 to 2011

No	**Bank**	**Effch**	**Techch**	**Pech**	**Sech**	**Tfpch**
1	CBB	0.933	0.943	0.973	0.959	0.881
2	CBE	1.119	1.006	1.000	1.119	1.126
3	DB	0.944	1.024	0.958	0.985	0.966
4	AIB	0.905	1.013	0.919	0.985	0.918
5	BA	0.938	0.997	0.946	0.991	0.935
6	WB	0.842	1.024	0.845	0.991	0.862
7	UB	1.028	1.027	1.019	1.009	1.056
8	LIB	1.110	0.990	1.000	1.110	1.100

9	CBO	0.930	1.038	0.927	1.003	0.966
10	NIB	0.911	1.038	0.910	1.001	0.884
Mean		**0.962**	**1.003**	**0.948**	**1.015**	**0.965**

Source: Own computation 2013

Table 4 reveals that, according to technical efficiency change, 3(30%) banks increased their average annual technical efficiency, whereas 7(70%) banks decline in technical efficiency observed. It also revealed that in 7(70%) banks technological progress has been observed. In contrast, 3(30%) banks demonstrate deterioration in technology during the relevant period. In addition, the results show, on average, the TFP change is 0.965 which is less than unity; it indicates a 3.5% regress over the five years (2007-2011). The loss in TFP has been mostly due to technical efficiency regress in banks.

Table 5 describe of average changes in total factor productivity and its components by year. The results reveal that the average annual technical efficiency is equal to 0.962. This is the result of decline in pure technical efficiency averagely by 5.2% and proceeding in scale efficiency averagely by 1.5%. Technical efficiency change reaches the peak stage in the year 2008 and the bottom stage in 2011. Nevertheless, the average technological change of Ethiopian commercial banks is 1.003. This implies that technological progress of 0.3% during the period 2007 to 2011. In 2011, technological change reaches its highest stage and in 2008, it reaches the lowest stage. The results also reveal that technical efficiency change is continuously declining, while technological change is continuously increasing. This indicates that banks are focusing on technological improvement than management quality in allocation of resources into input-output mix. This support idea of Sturm and Williams (2004) which states that the main source of efficiency improvement was technological change rather than technical efficiency change

Table 5. Average Changes in Total Factor Productivity and Its Components by Year

Year	Effch	Techch	Pech	Sech	Tfpch
2008	1.060	0.905	0.966	1.098	0.960
2009	0.996	0.978	1.011	0.986	0.975
2010	0.965	0.984	0.926	1.043	0.949
2011	0.841	1.161	0.895	0.940	0.977
Mean	**0.962**	**1.003**	**0.948**	**1.015**	**0.965**

Source: Own computation 2013

IV. CONCLUSION

The present study evaluates technical efficiency and productivity of banking sector in Ethiopia during the year 2007 – 2011 using DEA and MPI and the balanced dataset of 50 observations from 10 banks. The input and output variables are selected according to intermediation approach of banks – bank is intermediary that transfers assets from the surplus units to deficit units. Thus, we select Fixed Assets and Labor as input and Total Deposits and Net Loans and Advances as output variables.

The results indicate that commercial banks are on average relatively technically inefficient. It shows the overall mean average technical efficiency is 0.820, pure technical efficiency of 0.925 and scale efficiency of 0.888. This demonstrates that major source of inefficiency among sample banks is scale inefficiency. That is, these banks are averagely efficient in allocation of resources in to input and output mix than scale of operation. The necessary Radial and Slack movements in each variable for each inefficient bank in order to improve the technical efficiency and to reach the efficiency frontier found that, the output variables are under produced: total deposits and net loan & advance by 1.6% and 0.4% respectively and the input variables are over utilized; fixed asset and labor by 14.3% and 7% respectively. This indicates that the inefficient banks use excess inputs and under produced output which reveals management and scale inefficiency of the banks.

The TFP change during the average five years study period is 0.956 which shows deterioration in TFP. This is the results of average annual technical efficiency change of 0.629 and technological change of 1.003. This indicates that technical efficiency regression the reason for TFP loss. In addition, the results reveal that the average pure technical efficiency change is 0.948, whereas scale efficiency change is 1.015. This shows technical efficiency regress is due to management inefficiency rather than scale of operation.

Finally, we concludes that the study is in line with Darwin (2012), Soetanto and Ricky (2011), Usman *et al.*, (2010) those argued that the source of inefficiency is scale inefficiency rather than pure technical efficiency, and Sturm and Williams (2004) which states that the main source of efficiency improvement was technological change rather than technical efficiency change.

V. RECOMMENDATIONS

Ethiopian commercial banks are, on average, technically inefficient during the study period and averagely scale inefficiency takes the leading contribution. Thus, the inefficient banks management should take care about the improvement of scale efficiency while allocating their inputs. To reach the efficiency frontier, the managers of inefficient banks should focus on the excess used inputs and reduce the excess utilized amount.

Lastly, the trends of productivity growth during the study period show deterioration, and this is due to management inefficiency. In the scarce resource economy, and competitive world, the need of management quality is incontestable to provide service at a minimum cost and to dominate the competitors. The study suggests that the banks should reduce, if possible illuminate, this by giving training to the existing managers, assign competitive skilled human resources, etc. This means banks have to arrange education and training program intended to improve managerial ability, and/or extension programs designed to speed-up the adoption of new technologies.

2. Directions to Future Studies

The variables selected for the study are not the only indicator of efficiency; there are multiple inputs and outputs

variables which are used as an indicator of efficiency. Thus, future study may consider the additional variables. Moreover, in the absence of accurate measure of input prices, the study focused on technical efficiency rather than allocate and economic efficiencies. While acknowledging these limitations, then we hope that they do not significantly reduce the relevance of comprehensive analysis of technical efficiency and productivity change.

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