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Measurement of Commercial Bank Efficiency in Ethiopia: an Application to Data Envelopment Analysis (DEA)

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Abstract
This research was conducted to measure the relative technical, cost, revenue and profit efficiency of the Ethiopian Commercial Banks, using banks level data of 18 commercial banks for the period covered 2005 to 2016. The study used financial data of the banks extracted from the audited annual financial reports and data from the international banking data base (Orbis Data Base). Data Envelopment Analysis (DEA) have been used, with the inputs and outputs of the banks selected following the intermediation approach. The result shows that among four banks namely Commercial bank of Ethiopia, Adis International bank, Zemen bank & Enat bank are the most efficient banks in terms of Technical Efficiency, and are found to be on the DEA frontier under both input & output orientations. Under Cost Efficiency, the giant Commercial Bank of Ethiopia, Adis International Bank and Debub Global Bank are found to be the most efficient ones, and on the DEA frontier. Finally, the research finding shows that Commercial Bank of Ethiopia and Adis International Bank are 100% efficient compared to other participants under both revenue & profit efficiency, followed by Zemen Bank.
Keywords: Cost Efficiency, Data Envelopment Analysis, Ethiopia Banking, Measurement of Efficiency, Profit efficiency, Technical Efficiency

1. Introduction

Banks play a fundamental role in the financing of economic activities in given nation. Djalilov and Piesse (2014) indicated that the development of the banking sector greatly affects the sustainable growth of the economy of a country due to the fact that the sector impacts the efficiency to mobilize and allocate funds through the improvement of saving and investment. The improvement in the performance of the banking industry has positive influence for the sector to play the intermediary role better.

In addition to profitability, efficiency is a measure of bank performance by showing the resource utilization performance of a bank relative to other competitors in the industry (Adusei, 2016). The measurement of efficiency of different forms has been considered as main area of research in the sector. The most efficient and best performing bank can be identified through the measurement of efficiency of the players, and taken as a benchmark for others to improve theirs. Moreover, measuring the relative efficiency of the banks in a given country has great importance for the general public in general and government and investors in particular to design policy interventions in the sector.

There are various studies conducted in the measurment of technical, pure technical and scale efficiencies at country level and regional level including (Peng, Jeng, Wang, & Chen, 2017), (Adusei, 2016), (Gwahula, 2013), (Djalilov & Piesse, 2014), (Andries, 2011), (Garza-García, 2012), (Al-Attafi, 2014) & (Dharmendra & Bashir, 2015). Various studies were also conducted in the measurement and analysis of cost and scale efficiency of banks including (Tan, 2016a), (Nguyen, Nguyen, Nghiem, & Nghiem, 2016) and Tan et al. (2017). Moreover examining the productivity of banks in generating revenues and profits from the bundle of resources relative to other banks operating in the same industry is another area of research (Berger & Mester, 1997), (Tan, 2016a), (Casu & Molyneux, 2003), (Nguyen et al., 2016) and (Tecles & Tabak, 2010). Revenue Efficiency and Profit Efficiency are of great interest for managers as the two are more inclusive.

However, Studies conducted in the measurement of the various types of efficiency of banks operating in developing countries like Ethiopia, where the financial system is at its enfant stage and closed for foreign investment, is very limited. And hence, the purpose of this paper is to measure the relative Technical, Cost, Revenue and Profit efficiency of the Ethiopian Commercial Banks.

2. Review of literatures

As explained in the previous chapter, efficiency of a bank refers to the ability of the bank to provide its service with the minimum possible resources, or producing maximum possible products and services using limited amount of inputs. The explanation of a bank's performance through the measurement of efficiency, by indicating how a unit is close to its possibility frontier (Zawadi & Patel, 2014) is a more sounding approach as it

can show that a bank with higher efficient will end up with having higher profits due to its ability to convert the inputs to outputs at a lesser price Jacob A. Bikker and Bos (2008) and (Molyneux & Thornton, 1992). Efficiency is a key concept for financial institutions in general, and banking sector in specific terms. Therefore, it is essential to analyze the efficiency of banks from its technical, cost, revenue and profit perspectives.

(Farrell, 1957) was the first to explain technical efficiency as the ability of a firm to get maximum possible outputs from a given set of inputs, assuming that a firm uses two inputs for the production of one output, under constant returns to scale assumption. Later, his work was extended by (Charnes, Cooper, & Rhodes, 1978) with the application of more than one output. Moreover, Haiyan, Jiawen, and Jamshid (2013) and (Adusei, 2016) explained it as the rsource utilization performance of a firm relative to the best performing competitors in the industry. The value of technical efficiency ranges rom 0 to 1, a value of 1 indicating the bank is the most effcicient, and as it approaches to 0 means inefficiency is increasing relative to the competitors.

In this regard, (Farrell, 1957) proposed Technical efficiency (TE) and allocative efficiency (AE) as the two scalars of measures of efficiency for input oriented problems. The product of TE and AE gives us the total economic efficiency of the bank (Uri, 2001).

There are various studies conducted in the measurment of technical efficiency and examination of the determining factors affecting the same at country level, regional level, and also in comparison of the scores in different categories of banks. These research publications reviewed in the previous chapter include (Peng et al., 2017), (Adusei, 2016), (Gwahula, 2013), (Djalilov & Piesse, 2014), (Tesfaye, 2016), (Seelanatha, 2012), (Andries, 2011), (Garza-García, 2012), (Al-Attafi, 2014). (Xiaofeng & Sun, 2013), (Moh'd, Mohammad, & Waleed, 2011), (Zawadi & Patel, 2014), (Ally, 2013) & (Dharmendra & Bashir, 2015) and (San, Theng, & Heng, 2011).

Through the manipulation of inputs and outputs, managers and regulatory authorities give emphasis on the minimization of operating costs (Cost Efficiency). There are various empirical studies conducted in the measurement and analysis of cost efficiency of banks operating in different economic setups, including (Tan, 2016a), (Nguyen et al., 2016) and Tan et al. (2017). Other researchers like (Karim, Chan, & Hassan, 2010), (Musonde, 2008), (Kaur & Kaur, 2013), (Tecles & Tabak, 2010), (Girardone, Molyneux, & Gardener, 2000).

There are also empirical studies conducted to examine the productivity of banks in generating revenues and profits from the bundle of resources relative to other banks operating in the same industry, technically referred as Revenue Efficiency (RE) and Profit Efficiency (PE), including (Berger & Mester, 1997), (Tan, 2016a), (Casu & Molyneux, 2003), (Nguyen et al., 2016) and (Tecles & Tabak, 2010). RE and PE are of great interest for managers and other governing organs of banks due to the fact that the two are more inclusive, to know their performance status in relation to other players in the market.

The prominent researchers in the banking area have indicated the difficulty of measuring efficiency of a banking business due to the absence of consensus on the outputs of banking business (Vittas, 1991) and (Berger & Humphrey, 1992). Despite these controversies regarding the appropriateness of measuring efficiency of commercial banks, various country level empirical research publications have been produced. To indicate some, Tan et al. (2017), (Zawadi & Patel, 2014), (Ally, 2013), (Musonde, 2008), Xiaofeng and Sun (2013), (Ngoc Nguyen & Stewart, 2013), (Peng et al., 2017), (Mester, 1997), (Xiaotian & Yong, 2014), (Berger, Hasan, & Zhou, 2009) & (Tung-Hao & Shu-Hwa, 2013) are country level studies. Others like Karim et al. (2010), (Nguyen et al., 2016; Triki, Kouki, Dhaou, & Calice, 2017) & (San et al., 2011) are regional level studies; and Jacob A Bikker and Bos (2005), (Jacob A Bikker, 2010) & (Grigorian & Manole, 2006) are some of the studies conducted at international level for comparison purpose.

Based on the assumptions and methods used, efficiency scores can be estimated using parametric approaches or nonparametric approaches. The parametric approaches estimates the frontiers using statistical modeling techniques, requiring a pre-specified functional form of the best practice frontier Tan (2016a) and Fiorentino, Karmann, and Koetter (2006). Under this econometrics approach, efficiency scores can be estimated using Stochastic Frontier Approach, Distribution Free Approach or the Thick Frontier Approach depending on the nature of the data, Tan (2016a), Aigner, Lovell, and Schmidt (1977), Berger and Humphrey (1992), Coelli, Rao, O'Donnell, and Battese (2005) and Coelli et al. (2005).

The nonparametric technique is a mathematical linear programming technique, as opposed to the above, have no assumptions on the functional form of the distribution of the population and inefficiency Fiorentino et al. (2006) and Zhu (2014). One can use either the Data Envelopment (DEA) or Free Disposal Hull (FDH) technique under the nonparametric approach (Charnes et al., 1978), (Banker, Charnes, & Cooper, 1984), (Kočišová, 2014), (Tulkens, 1993), (Fiorentino et al., 2006), (Charnes, Cooper, Lewin, & Seiford, 2013), (Coelli et al., 2005) and (Tan, 2016a).

As indicated in the literatures, the nonparametric approach is preferred due to the reasons that there is absence of the functional form requirement; handles multiple inputs and outputs of different measurement units; and also it works well with small samples Tan (2016b) & Charnes et al. (1978). And hence robust efficiency estimates can be found with this approach.

Under the nonparametric approach of estimating efficiency scores, one need to identify the indicators to be used as inputs and outputs Noulas, Glaveli, and Kiriakopoulos (2008). In various studies, these inputs and outputs have been identified in light of consideration of the banks applying theories of the firm in explaining behavior of banks, as the primary role of the banks is intermediating the borrowers and lenders in the financial system (Ahn & Le, 2014), (Titko, Stankevičienė, & Lāce, 2014), (Tan, 2016a) and (Kamau, 2011). There are four main approaches of identifying inputs and outputs in the estimation of efficiency scores under the nonparametric technique, (intermediation, production, user cost and value added) among which researchers can choose depending on the nature of their research (Ahn & Le, 2014), (Muvingi & Hotera, 2015), (Titko et al., 2014) and (Martin & Zimková, 2015).

3. Methodology

In this section, the type and source of the data used, the input and output variables and the related prices used in the measurement of the different efficiency scores have been discussed. Moreover, Details related to the measurement approach adopted in the estimation of different types of efficiencies, and the rationale behind using the technique have also been included.

3.1 Data Type and Source

Currently, there are 18 banks including the development bank of Ethiopia operating the banking business in the country. Previously, there was a government owned, Commercial and Business bank of Ethiopia, which is now merger with another giant government owned commercial bank of Ethiopia. The Development Bank of Ethiopia is the one financing long term development projects of the government, doesn't engage in commercial activities, and hence it has been excluded from this study. To get the true picture of the efficiency of the banking sector in the country, the researcher have included as many commercial banks as possible. And hence, all the banks engaged in the commercial banking business, including from the most recently established ones to those having long time experience in the sector have been included in the study.

The duration of the banks in the commercial banking sector differs due to the fact that the year of establishment varies since the change in the financial policy of the country. As a result, the study have used an unbalanced data set of the 18 commercial banks for the period covering 2005 to 2016, ranging from 3 to 12 years.

The research employed the financial data extracted from the income statement and balance sheet of the commercial banks in Ethiopia. As per the company law of the country, the commercial banks are required to publicly issue audited annual financial statements. These audited financial statements are the main sources of the data for this research. Moreover. Due to the high interest of the researcher to include most recent data, the international banking data base, Orbis data base, have used to get some financial data of the recent years which are not found from the website of the banks.

There are 154 observations in total with maximum of 18 banks in 2014 and minimum of 8 banks in the years 2005 and 2006. Due to the fact that the study includes all the commercial banks operating in the country, the study is not constrained by problems related to sampling.

3.2 Variable Definition and Measurement

The reliability of the efficiency scores estimated depend on the appropriateness of the variable definition and their respective input & out price for whatever the estimation approach is to be used. Therefore, for the estimation of the efficiency, determination of constitutes inputs and out puts of the banks is the first task that needs to be done. As per the literatures consulted, there exists no consensus on the regarding the appropriate definition and measurement of the outputs of banks.

There are four approaches of identifying inputs and outputs in the estimation of efficiency scores in the banking literature, including the intermediation, production, user cost and value added) (Ahn & Le, 2014), (Muvingi & Hotera, 2015), (Titko et al., 2014) and (Martin & Zimková, 2015). The intermediation and production approaches are the two most competing approaches. The controversy is mainly on how to treat ***deposits of banks*** (as input or output). In most of the previous studies, the choice of the input output identification depends on availability of data and choice of the author. And hence, regardless of the controversies on the two approaches, this research used the ***intermediation approach*** in the identification of inputs and outputs of the banks. Moreover the data based used for this research lacks data necessary to implement the production approach. Because, under this approach to measure outputs, it requires the number of transactions and deposits processed during each of the years covered in this study.

Following previous studies, there are three input variables used in this study including Total Deposits (Arrawatia, Misra, & Dawar, 2015), (Alhassan & Ohene-Asare, 2016), (Ab Rahim, 2016) & (Tan, 2017); Salary & Benefits expense, (Arrawatia et al., 2015), (Louati & Boujelbene, 2015), (Alhassan & Ohene-Asare, 2016), (Ab Rahim, 2016) & (Adjei-Frimpong, Gan, & Hu, 2013); and Other Operating Expenses incurred by the banks (Tan, 2017). The total deposits of the banks include Demand Deposits, Saving Deposits and Fixed

Deposits of the banks (Řepková & Stavárek, 2013). Salary & Befits expense includes all the salary payments made to the employees and other benefits of the employees paid during each of the years under study. Other Operating expense includes all operating expenses of the banks excluding interest & employee salary related expenses of the banks.

There are also two Output Variables used including Total Loans & Advances (Casu & Girardone, 2009), (Tan, 2017); and Non-Interest Income (Tan, 2017). Loans are the ones considered as the main outputs of commercial banks, serving the intermediary role by collecting money from those who want to deposit (customers) to lend it to the investors (borrowers). The Total Loan and advances include all kinds of loans forwarded by the commercial banks be it for service sector, manufacturing sector, or local & international trade. Non-Interest income includes Fees, Commission and Other Operating Income.

In the estimation of cost, revenue and profit efficiencies, prices of the inputs and outputs identified needs to be given. Based on the previous studies consulted, the prices for all the variables are identified, and summarized in the following table.

S No.	Input/Output Variable	Prices of the variable	Description	Sources
1	ToDep (X_1)	Price of Deposits (W_1)	Ratio of Interest Expense to Total Deposits	(Louati & Boujelbene, 2015), (Řepková & Stavárek, 2013)
2	SalBen (X_2)	Price of Labor (W_2)	Ratio of Salary & Other Benefits Expense to Total Assets	(Řepková & Stavárek, 2013)
3	OOpEx (X_3)	Price of Other Operating Expenses (W_3)	Ratio of Other Operating Expense to Total Assets	(Řepková & Stavárek, 2013)
4	GLoAd (Y_1)	Price of Loans and & advances (P_1)	Ratio of Interest income to Loans and Advances	(Casu & Girardone, 2009), (Tan, 2017)
5	NoInIn (Y_2)	Prices of Non-interest Income (P_2)	Ratio of Non-interest Income to Total Assets	(Tan, 2017)

Table 1: Summary of the input and output variables used to estimate efficiency

3.2 The Measurement Approach used

It is indicated in the literature review that there are two estimation approaches for the measurement of efficiency scores of banks, the parametric and nonparametric estimation techniques. Though it is an extreme technique and can be affected by outliers (Coelli, 2005), in various literatures, it has been explained that the non-parametric, DEA model of estimating efficiency scores is advantageous than the other parametric technique due to *(Noulas et al., 2008)*: it can handle multiple inputs and outputs; it assumes no functional form to relate inputs and outputs; it directly compares a Decision Making Unit (DMU) against another peer or set of peers; and it can handle inputs and outputs with different unit of measurement. Therefore, the nonparametric DEA model has been used in this research for the estimation and analysis of the efficiency of the commercial banks in the country.

3.2.1 Input Output Orientations and Returns to Scale

Under the DEA, the input oriented and output oriented models are available to estimate technical efficiencies. Under the input oriented model, the objective is to minimize the amount of input usage to produce a certain level of output, whereas under the output oriented model, maximization of level of output is the aim given same amount of inputs. The choice of the model is up to the managers on which one they have more control. In order to make the study more comprehensive and full-fledged, we used both the input orientation and output orientations have been examined. Moreover, the efficiency scores of banks can be estimated under the constant returns to scale or under the variable returns to scale. As indicated, this is a comprehensive study of the efficiency of the commercial banks in Ethiopia, and hence efficiency have been estimated under both the constant returns to scale and variable returns to scale assumption. As indicated above, it is DEA study and we used the Data Envelopment Analysis Program (DEAP) (Coelli et al., 2005) and Stata (12) for the estimation of technical and Cost Efficiency scores, and the DEAFrontier software developed by (Zhu, 2014) for the estimation of Revenue and Profit efficiency scores.

3.3 Descriptive Statistics of the Variables and price of the variables

Summary statistics on the inputs and output quantities and price variables from the data set used for the study period covering June 30, 2005 to June 30, 2016 have been given in the following table. It needs to be noted that, input and output prices are proxies based on previous studies consulted, are not perfectly accurate approximations.

	Variables (in Millions of ETB)	Obs	Mean	Std. Dev.	Min	Max
Y_1	Total Loans and Advances (GLoAd)	154	6,816.21	18,260.68	154.49	147,046.00
Y_2	Non-Interest Income (NoInIn)	154	461.11	976.67	5.4	6,416.00
X_1	Total Deposits (ToDep)	154	12,947.72	37,322.24	211.4	288,609.00
X_2	Personnel Expenses (SalBen)	154	190.7	501.38	4.67	4,418.00
X_3	Other Operating Expenses (OOpEx)	154	158.82	302.72	9	2,371.00
P_1	Prices of Loans and Advances	154	0.11	0.02	0.05	0.15
P_2	Price of Noninterest Income	154	0.04	0.01	0.01	0.1
W_1	Interest Expenses/Total Deposits	154	0.03	0.01	0.01	0.04
W_2	Personnel Expense/Total Assets	154	0.01	0.01	0	0.03
W_3	Other Operating Expense/Total Assets	154	0.02	0.01	0	0.04

Table 2: Descriptive Statistics of variables utilized in the estimation of efficiencies

3.4 Model Specification

Following the previous scholars including (Banker et al., 1984), (Adusei, 2016), (Kočišová, 2014), and (Coelli et al., 2005), the DEA models used in the estimation of the different efficiency scores of the commercial banks have been summarized in the table given below.

Efficiency	DEA Model used
Technical, Pure Technical and Scale Efficiency	$\min \theta_q^*$ $s.t. \quad \sum_{j=1}^{n} x_{ij}\lambda_j \leq \theta_q x_{iq} \qquad i = 1,2,\dots,m,$ $\sum_{j=1}^{n} y_{rj}\lambda_j \geq y_{rq} \qquad r = 1,2,\dots,s,$ $\sum_{j=1}^{n} \lambda_j = 1$ $\lambda_j \geq 0 \qquad j = 1,2,\dots,n.$
Cost and Allocative Efficiency	$min \sum_{i=1}^{m} w_{iq} x_{iq}^*$ $s.t. \quad \sum_{i=1}^{n} x_{ij}\lambda_j \leq x_{iq}^* \qquad i = 1,2,\dots,m,$ $\sum_{i=1}^{n} y_{rj}\lambda_j \geq y_{rq}^* \qquad r = 1,2,\dots,s,$ $\sum_{i=1}^{n} \lambda_j = 1$ $\lambda_j \geq 1 \qquad j = 1,2,\dots,n.$
Revenue Efficiency	$max \sum_{r=1}^{s} p_{rq} y_{rq}^*$ $s.t. \quad \sum_{j=1}^{n} x_{ij}\lambda_j \leq x_i \qquad i = 1,2,\dots,m$ $\sum_{j=1}^{n} y_{rj}\lambda_j \geq y_{rq}^* \qquad r = 1,2,\dots,s.$ $\sum_{j=1}^{n} \lambda_j = 1$ $\lambda_j \geq 1 \qquad j = 1,2,\dots,s.$
Profit Efficiency	$max \sum_{r=1}^{s} p_{rq} y_{rq}^* - \sum_{i=1}^{m} w_{iq} x_{rq}^*$

	$s.t. \quad \sum_{j=1}^{n} y_{rj}\,\lambda_j \geq y_{rq}^{*} \qquad r = 1, 2, \dots, s$ $\sum_{j=1}^{n} x_{ij}\,\lambda_j \leq x_{iq}^{*} \qquad i = 1, 2, \dots, m,$ $\sum_{j=1}^{n} \lambda_j = 1$ $\lambda_j \geq 0 \qquad j = 1, 2, \dots, n$

Note: Θ_q^* indicates the TE_q, PTE_q & SE_q of $DMUq$; y_{rq} is produced amounts of r^{th} output ($r = 1,2,\dots,s$) for DMU_q; x_{iq} is consumed amounts of i^{th} input ($i = 1,2,\dots,m$) for $DMUq$; y_{rj} is produced amounts of r^{th} output ($r = 1,2,\dots,s$) for DMU_j ($j = 1,2,\dots,n$), x_{ij} is consumed amounts of i^{th} input ($i = 1,2,\dots,m$) for DMU_j ($j = 1,2,\dots,n$); λ_j is weight assigned to the DMU_j ($j = 1,2,\dots,n$); w_{iq} is a vector of input prices of $DMUq$; x_{iq}^* is the cost minimizing vector of input quantities for $DMUq$, given the input prices w_{iq} and the output levels y_{rq} ; p_{rq} is a vector of output prices of $DMUq$, and y_{rq}^* is the revenue maximizing vector of output quantities for $DMUq$, given the output prices p_{rq} and the input levels x_{iq}.

Table 3: Summary of the DEA models used in Estimating Efficiency

4. Empirical Results

In this section, details of the DEA estimation results have been reported and analyzed with the help of graphs and tables.

4.1 Technical, Pure Technical and Scale Efficiency of the Commercial Banks

The table below (Table….) presents the descriptive statistics of the technical efficiency, pure technical and scale efficiency scores of all the banks for the period covered (2005-2016) under both the input oriented approach and output oriented approach.

Orientation	Efficiency under	Eff.	Obs	Mean	Std. Dev.	Min	Max
Input Oriented	Constant Returns to scale	TE	154	0.926948	0.094789	0.637	1.00
	Variable Returns to scale	PTE	154	0.954968	0.078684	0.642	1.00
	Scale Efficiency	SE	154	0.970714	0.057544	0.692	1.00
Output Oriented	Constant Returns to scale	TE	154	0.926948	0.094789	0.637	1.00
	Variable Returns to scale	PTE	154	0.953805	0.079258	0.639	1.00
	Scale Efficiency	SE	154	0.971656	0.053514	0.705	1.00

Table 4: Descriptive statistics of the efficiency scores for all the years

As show in the table, the mean efficiency scores ranges from a 92.69% under the constant returns to scale to 97.17% of scale efficiency under the output oriented approach. Under the Input oriented approach, it has been recorded that the minimum efficiency scores are 63.7% technical efficiency, 64.2% Pure Technical Efficiency & 69.2% efficiency by Co-operative Bank of Oromia for Technical Efficiency & Pure Technical Efficiency during the year2011, and Oromia International Bank for the Scale efficiency during the year 2010. Under the output oriented approach, the Co-operative Bank of Oromia recorded the minimum Technical Efficiency (63.7%) & Pure Technical Efficiency (63.9%) during the year 2011, Scale Efficiency (70.5%) for the year 2008.

The DEA result that there are four commercial banks including Commercial bank of Ethiopia, Adis International Bank, Zemen bank and Enat bank with 100% in terms of Technical, Pure technical & Scale efficiency for all the periods covered. This is an indication that the four banks are on the frontier under both the input and output oriented approaches. These banks are found to be the most efficient ones relative to others, in producing the maximum possible output from a given amount of input, and also most efficient ones in using the minimum amount of inputs for the production of a given level of output. The four banks are technically efficient relative to their peers during the period. Dashen bank is also found to be on the Frontier in terms of Pure Technical Efficiency during all the years, but not less efficient in terms of technical efficiency & scale efficiency than the four mentioned banks.

The mean efficiency scores of all the banks have also been summarized as follows:

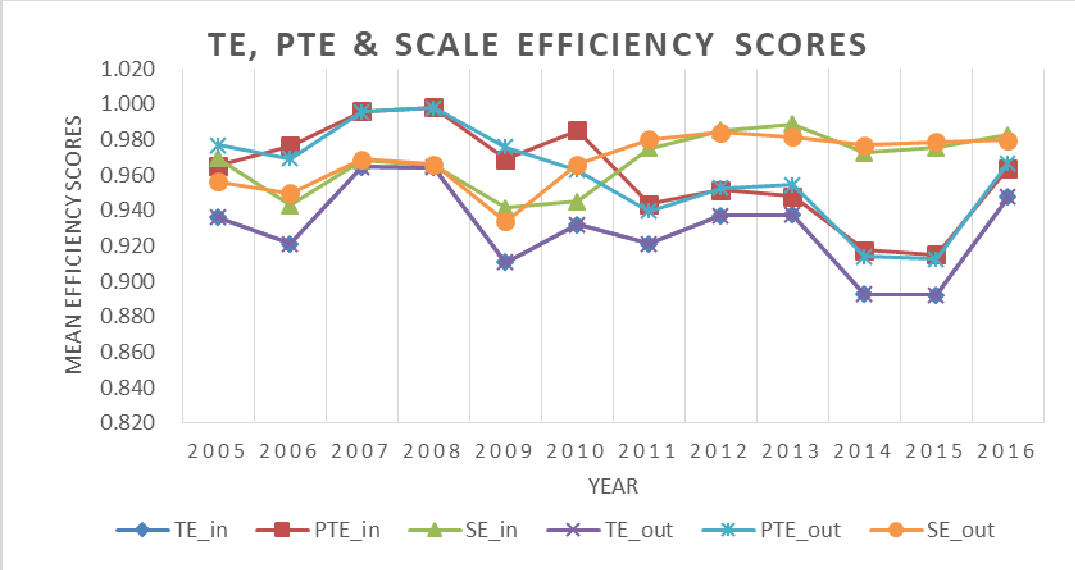
Year	Input Oriented			Output Oriented		
	TE	PTE	SE	TE	PTE	SE
2005	0.936	0.965	0.969	0.936	0.977	0.956
2006	0.921	0.977	0.943	0.921	0.969	0.950
2007	0.964	0.996	0.968	0.964	0.995	0.969
2008	0.964	0.998	0.966	0.964	0.998	0.966
2009	0.911	0.969	0.941	0.911	0.976	0.934
2010	0.932	0.985	0.945	0.932	0.963	0.966
2011	0.921	0.944	0.975	0.921	0.940	0.980
2012	0.937	0.951	0.985	0.937	0.953	0.984
2013	0.938	0.948	0.989	0.938	0.954	0.982
2014	0.893	0.918	0.972	0.893	0.914	0.977
2015	0.892	0.915	0.975	0.892	0.912	0.979
2016	0.947	0.964	0.983	0.947	0.967	0.980

Table 5: Mean Efficiency Scores for the period 2005 to 2016

As per the table, under input oriented approach, the maximum mean technical efficiency & pure technical efficiency are recorded during the year 2008 with score of 96.4% & 99.8% respectively, whereas the maximum mean scale efficiency is reported during the year 2013 at 98.9%. Under the output oriented approach, the maximum TE & PTE were recorded during the same year 2008 with the same scores, but that of the scale efficiency were recorded during 2012 at 98.4%.

It is also indicated in the table that the minimum mean TE & PTE scores were reported during the year 2015 with score of 89.2% & 91.5% respectively, and the minimum of the SE is the rate indicated in the year of 2009 at 94.1% under the input oriented approach. During the same years that the minimum mean TE & PTE were recorded at 89.2% & 91.2% respectively, and 98.4% for that of scale efficiency under the output oriented approach.

The mean technical, pure technical & scale efficiency scores of the banks have been depicted in the following graph.



Graph 1: Technical, Pure Technical & Scale Efficiencies

As indicated in the graph, there was a fluctuating trend in their mean of technical, pure technical and scale efficiency scores of the commercial banks in Ethiopia during the period under study. These increases (decreases) in the efficiency scores could be indications that the commercial banks were becoming more (less) efficient but the ranged values for the efficiency scores of the Ethiopian commercial banks were similar to that of other developing countries around the globe (Xiaofeng & Sun, 2013), (Hassan, 2007), (Mostafa, 2007) and (Chen, 2009).

4.2 Cost and Scale Efficiency of the Commercial Banks

The cost efficiency of the commercial banks in Ethiopia including the allocative efficiency, under both the constant & variable returns to scale, for the period from 2005 to 2016 have been described in the following table.

Under	*Variable*	*Mean*		*Std. Dev.*	*Min*	*Max*	*Observations*
Variable Returns to scale	*ae*	*overall*	*0.963*	*0.062*	*0.719*	*1*	*N = 154*
		between		*0.037*	*0.87*	*1*	*n = 18*
		within		*0.052*	*0.773*	*1.084*	*T-bar = 8.55556*
	ce	*overall*	*0.927*	*0.102*	*0.595*	*1*	*N = 154*
		between		*0.059*	*0.778*	*1*	*n = 18*
		within		*0.086*	*0.616*	*1.142*	*T-bar = 8.55556*
Constant Returns to scale	*ae*	*overall*	*0.875*	*0.125*	*0.443*	*1*	*N = 154*
		between		*0.095*	*0.591*	*0.996*	*n = 18*
		within		*0.074*	*0.652*	*1.072*	*T-bar = 8.55556*
	ce	*overall*	*0.806*	*0.13*	*0.443*	*1*	*N = 154*
		between		*0.089*	*0.591*	*0.996*	*n = 18*
		within		*0.096*	*0.572*	*1.024*	*T-bar = 8.55556*

Table 6: Summary Statistics of CE, TE & AE Scores

As indicated in the table, the overall mean efficiency score of the commercial banks have found to be 96.3% & 92.7% of allocative and cost efficiency respectively under the variable returns to scale assumption. It is also reported that the overall mean scores of 87.5% & 80.6% allocative and cost efficiency scores respectively under the variable returns to scale assumption.

Under the variable returns to scale, the summary statistics shows that the minimum allocative & cost efficiency scores of 71.9% & 59.5% are reported by Dashen bank and Bank of Abyssinia during the years 2011 & 2015 respectively. Whereas, under the constant returns to scale, the minimums of allocative and cost efficiency score of 44.3% both during the year by the commercial bank of Ethiopia during the year 2007. It is noted that though the commercial bank of Ethiopia is found to be the most allocative & cost efficient bank with score of 100% under the variable returns to scale, it is the same bank reported the minimum scores under the constant returns to scale during the year 2007.

It has been found that under the variable returns to scale assumption, there are three banks namely Adis International Bank, Commercial bank of Ethiopia & Debub Global bank, which are on the DEA frontier during all the period covered by the study. This indicates that the banks mentioned are found to be the most efficient banks relative to others in terms of allocative efficiency and cost efficiency during all the 12 years. Oromia International Bank was found to be the inefficient bank with 87.0% & 77.8%, allocative & cost efficiency scores respectively under the variable returns to scale assumption.

Whereas, under the constant returns to scale assumption, no bank was found to be on the DEA frontier during all the years, and the Adis International Bank has found to be the most efficient bank with the average of both 99.6% allocative & cost efficiency scores during the period 2005 to 2016. It is also indicated that the commercial bank of Ethiopia is the least efficient one with the average of 59.1% of both allocative & cost efficiency scores in the period under study under the same assumption.

Moreover, the average allocative and cost efficiency scores have been summarized in tabular form below.

	VRS		**CRS**	
Year	**ae_vrs**	**ce_vrs**	**ae_crs**	**ce_crs**
2005	**0.983**	**0.949**	**0.900**	**0.838**
2006	**0.954**	**0.932**	**0.801**	**0.735**
2007	**0.959**	**0.956**	**0.769**	**0.735**
2008	**0.978**	**0.977**	**0.862**	**0.827**
2009	**0.998**	**0.947**	**0.875**	**0.768**
2010	**0.965**	**0.951**	**0.879**	**0.813**
2011	**0.952**	**0.901**	**0.822**	**0.754**
2012	**0.953**	**0.984**	**0.873**	**0.818**
2013	**0.979**	**0.928**	**0.944**	**0.883**
2014	**0.943**	**0.866**	**0.895**	**0.794**
2015	**0.924**	**0.850**	**0.840**	**0.745**
2016	**0.989**	**0.954**	**0.955**	**0.904**

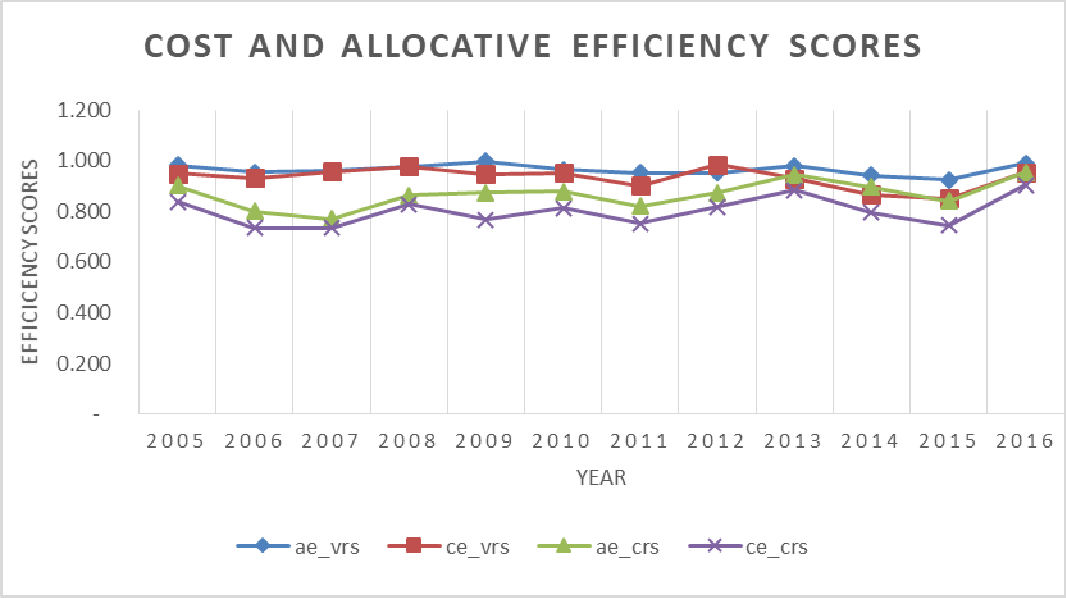
Table 7: Mean cost and Allocative Efficiency covering 20015 to 2016

The table above shows that, under the variable returns to scale, maximum of 99.8% & 98.4% mean

allocative & efficiency scores were reported during the years 2009 & 2012 respectively. Whereas the minimums mean allocative & cost efficiency scores of 92.4% & 90.1% were recorded during the years 2015 & 2011 respectively.

It was during 2016 that maximum mean of 95.5% & 90.5% allocative & cost efficiency scores were reported under the constant returns to scale assumption. And the minimum mean allocative & cost efficiency scores of 76.9% & 73.5% are recorded in the years 2007 & 2006 respectively under the same assumption.

The trends in the mean allocative and cost efficiency scores estimated for the years during 2005 to 2016 have been depicted graphically as follows;



Graph 2: Mean Cost & Allocative Efficiency for the period 2005-2016

As depicted in the graph, the mean allocative and cost efficiency scores of the commercial banks were fluctuating under both the variable and constant returns to scale, except that of the mean allocative efficiency scores under the variable returns to scale which seems to be somehow with less variable across all the years.

4.3 Revenue and Profit Efficiency of the Commercial Banks

Summary statistics of the revenue and profit efficiency scores of the commercial banks under study for the period covered have been presented in the table given below (table …).

Variable	Mean		Std. Dev.	Min	Max	Observations
pe	overall	0.776	0.236	0.074	1.000	N = 154
	between		0.159	0.489	1.000	n = 18
	within		0.181	0.100	1.275	T-bar = 8.55556
re	overall	0.912	0.121	0.376	1.000	N = 154
	between		0.082	0.749	1.000	n = 18
	within		0.093	0.539	1.163	T-bar = 8.55556

Table 8: Summary statistics of profit & revenue efficiency scores

The summary table indicated that the overall mean profit and revenue efficiency scores are 77.6% & 91.2%, with standard deviation of 0.236 & 0.121 respectively. The minimum revenue efficiency in the study period is found to be 37.6% whereas the minimum profit efficiency was 7.4%, which is very far from the mean efficiency score.

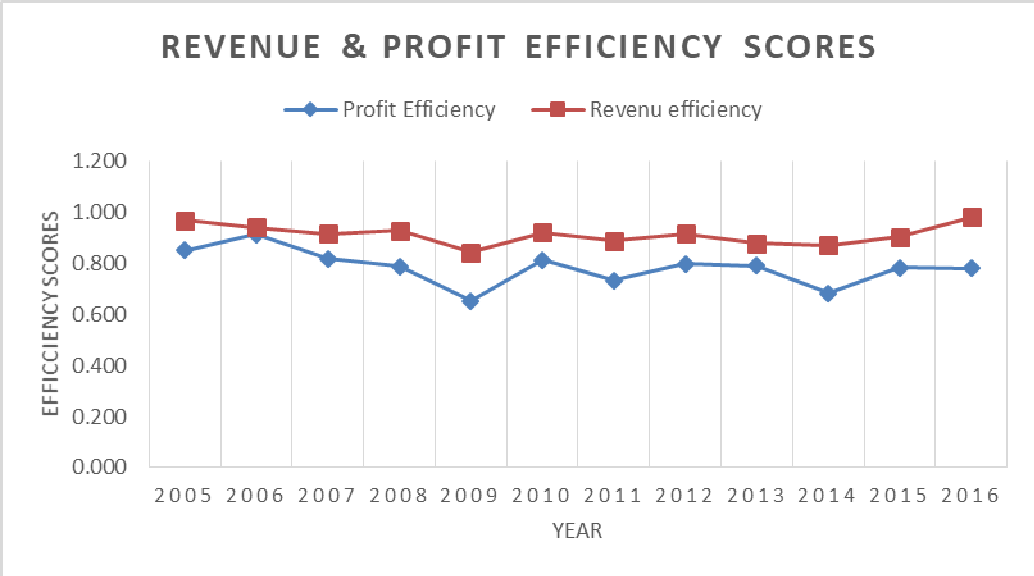
The finding shows that Adis International Bank and Commercial Bank of Ethiopia are the two most profit & revenue efficient banks (with 100% efficiency), and found to be on the DEA frontier for all the periods covered by the study. The next most efficient banks is found to be Zemen Bank with 95.3% & 99.0% profit & revenue efficiency scores respectively.

Moreover, the yearly mean profit and revenue efficiency scores have also been computed and presented in tabular form, and also depicted graphically as follows.

Year	Profit Efficiency	Revenue Efficiency
2005	0.852	0.970
2006	0.915	0.942
2007	0.820	0.916
2008	0.790	0.931
2009	0.653	0.846
2010	0.813	0.922
2011	0.735	0.891
2012	0.800	0.918
2013	0.791	0.880
2014	0.683	0.872
2015	0.784	0.903
2016	0.781	0.982

Table 9: *Mean Profit and Revenue Efficiencies covering 20015 to 2016*

It is presented that it was during the year 2009 that the minimum of both profit and revenue efficiency scores were reported at 65.3% & 84.6% for profit & revenue efficiencies respectively. The maximum profit efficiency (91.5%) was reported during the year 2006, whereas that of the maximum revenue efficiency was recorded at 98.2% during the year 2016. The trend in the profit and revenue efficiency scores during the period covered by the study, have also been depicted graphically as follows.



Graph … Mean Profit & Revenue Efficiency for the period 2005-2016

As indicated in the graph, the profit and revenue efficiency scores were moving almost parallel except the year 2006 during which profit efficiency is a slight below the revenue efficiency. The graph shows 2006 was the year during which the commercial banking sector in Ethiopia were most inefficient in terms of profit and revenue followed by the year 2014.

5. Conclusion and Summary

The chapter have measured the various types of efficiencies of the commercial banks in Ethiopia, using banks level data of 18 commercial banks for the period covered 2005 to 2016. The study make use of the financial data of the banks extracted from the annual financial reports and also use financial data from the international banking data base (Orbis Data Base).

The nonparametric, Data Envelopment Analysis (DEA) have been used, with the inputs and outputs of the banks selected following the intermediation approach. Total deposits, personnel costs including salary & other employee benefits and other operating expenses of the banks were included as input variables, whereas total loans & advances & noninterest income were the outputs used in measuring the efficiencies. For the estimation of cost, revenue & profit efficiencies, ratio of interest expense to total deposits, salary & benefits to total assets, and other operating expenses to total assets have been used as indicators of price for the three input variables respectively. Moreover, ratio of interest income to loans & advances and noninterest income to total assets have also been used to indicate prices for the two outputs indicated above. Additionally, to make the measurement of

the efficiency of the banks more comprehensive, the research have estimated efficiency under both input and output orientations, using both constant returns to scale (CRS) & variable returns to scale (VRS) approach.

The finding shows that among the 18 commercial banks, four banks namely Commercial bank of Ethiopia, Adis International bank, Zemen bank & Enat bank are the most efficient banks in terms of Technical Efficiency, and are found to be on the DEA frontier under both input & output orientations. When we see the Cost Efficiency the giant commercial bank of Ethiopia, Adis International Bank and Debub Global Bank are found to be on the DEA frontier being the most efficient ones, on the other hand, the Oromia International Bank is found to be the least efficient one. Moreover, the research finding shows that Commercial Bank of Ethiopia and Adis International Bank are 100% efficient compared to other participants under both revenue & profit efficiency, followed by Zemen bank with revenue & profit efficiency close to the two.

6.Suggestion for Future Research

The objective of this paper was to measure the relative efficiency of the commercial banks operation in Ethiopia using the Data Envelopment Analysis (DEA). And hence, the study estimated the different efficiency scores and identified the most efficient and least efficient ones relative to other competing banks. The study does not investigate the underlying causes for the variation of the efficiency scores. Therefore examining the determinants of the technical, cost and profit efficiency of the Ethiopian commercial banks is a fertile research gap for future study.

References

Ab Rahim, R. (2016). DOES COMPETITION FOSTER EFFICIENCY? EMPIRICAL EVIDENCE FROM MALAYSIAN COMMERCIAL BANKS. *Asian Academy of Management Journal of Accounting & Finance, 12*(1).

Adjei-Frimpong, K., Gan, C., & Hu, B. (2013). Efficiency and Competition in the Ghanaian Banking Industry: a Panel Granger Causality Approach. *Annals of Financial Economics, 8*(01), 1350004.

Adusei, M. (2016). Determinants of bank technical efciency: Evidence fro Rural and Community banks in Ghana. *Cogent Business & Management*, 1-15.

Ahn, H., & Le, M. H. (2014). An insight into the specification of the input-output set for DEA-based bank efficiency measurement. *Management Review Quarterly, 64*(1), 3-37.

Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of econometrics, 6*(1), 21-37.

Al-Attafi, M. A. M. (2014). *Determinants of technical efficiency of banks in Yemen.* Universiti Utara Malaysia.

Alhassan, A. L., & Ohene-Asare, K. (2016). Competition and bank efficiency in emerging markets: empirical evidence from Ghana. *African Journal of Economic and Management Studies, 7*(2), 268-288.

Ally, Z. (2013). Efficiency analysis of commercial banks in Tanzania: An application of data envelopment analysis (DEA) approach: The case study of regional & small banks. *Journal of Business Management, 5*(31), 193-203.

Andries, A. M. (2011). The determinants of bank efficiency and productivity growth in the Central and Eastern European banking systems. *Eastern European Economics, 49*(6), 38-59.

Arrawatia, R., Misra, A., & Dawar, V. (2015). Bank competition and efficiency: empirical evidence from Indian market. *International Journal of Law and Management, 57*(3), 217-231.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science, 30*(9), 1078-1092.

Berger, A. N., Hasan, I., & Zhou, M. (2009). Bank ownership and efficiency in China: What will happen in the world's largest nation? *Journal of Banking & Finance, 33*(1), 113-130.

Berger, A. N., & Humphrey, D. B. (1992). Measurement and efficiency issues in commercial banking *Output measurement in the service sectors* (pp. 245-300): University of Chicago Press.

Berger, A. N., & Mester, L. J. (1997). Efficiency and productivity change in the US commercial banking industry: A comparison of the 1980s and 1990s.

Bikker, J. A. (2010). Measuring performance of banks: an assessment. *The Journal of Applied Business and Economics, 11*(4), 141.

Bikker, J. A., & Bos, J. W. (2005). Competition and efficiency in banking: international comparisons. *Economic & Financial Modelling, 12*, 103-148.

Bikker, J. A., & Bos, J. W. B. (2008). *Bank Performance A theoretical and empirical frame work for the analysis of profitability competition and efficiency*. New York: Routledge.

Casu, B., & Girardone, C. (2009). Does competition lead to efficiency? The case of EU commercial banks.

Casu, B., & Molyneux, P. (2003). A comparative study of efficiency in European banking. *Applied Economics, 35*(17), 1865-1876.

Charnes, A., Cooper, W. W., Lewin, A. Y., & Seiford, L. M. (2013). *Data envelopment analysis: Theory,*

methodology, and applications: Springer Science & Business Media.
Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429-444.
Chen, C. (2009). Bank Efficicency in Sub-Saharan African middle income countries. *IMF Working Paper, WP/09/14*.
Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis*: Springer Science & Business Media.
Dharmendra, S., & Bashir, A. F. (2015). Technical efficiency and its determinants: an empirical study on banking sector of Oman. *Problems and Perspectives in Management, 13*(1), 168-175.
Djalilov, K., & Piesse, J. (2014). The Determinants Of Bank Efficiency In Central Asia. *Corporate Ownership & Control, 12*(1), 656-670.
Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (General), 120*(3), 253-290.
Fiorentino, E., Karmann, A., & Koetter, M. (2006). The cost efficiency of German banks: a comparison of SFA and DEA.
Garza-García, J. G. (2012). Determinants of bank efficiency in Mexico: a two-stage analysis. *Applied Economics Letters, 19*(17), 1679-1682.
Girardone, C., Molyneux, P., & Gardener, E. P. (2000). *Analysing the determinants of bank efficiency: the case of Italian banks*. University of Wales Bangor(School of Accounting, Banking and Economics).
Grigorian, D. A., & Manole, V. (2006). Determinants of commercial bank performance in transition: an application of data envelopment analysis. *Comparative Economic Studies, 48*(3), 497-522.
Gwahula, R. (2013). Bank-Specific, Industry Specific and macroeconomic determinants of bank Efficiency in Tanzania: A two stage analysis. *Journal of Business Management, 5*(3), 142-154.
Hassan, K. a. B. S. (2007). Efficiency Determinants and dynamic efficiency changes in Latin American banking industries. *Network Financial Institute Working Paper, 32*, 306-314.
Kamau, A. W. (2011). Intermediation efficiency and productivity of the banking sector in Kenya. *Interdisciplinary Journal of Research in Business, 1*(9), 12-26.
Karim, M. Z. A., Chan, S.-G., & Hassan, S. (2010). Bank efficiency and non-performing loans: Evidence from Malaysia and Singapore. *Prague Economic Papers, 2*(2010), 118-132.
Kaur, P., & Kaur, G. (2013). A study of cost efficiency of Indian commercial banks-An impact of mergers. *African Journal of Business Management, 7*(15), 1238.
Kočišová, K. (2014). Application of data envelopment analysis to measure cost, revenue and profit efficiency. *Statistika: Statistics and Economy Journal, 94*(3), 47-57.
Louati, S., & Boujelbene, Y. (2015). Banks' stability-efficiency within dual banking system: a stochastic frontier analysis. *International Journal of Islamic and Middle Eastern Finance and Management, 8*(4), 472-490.
Martin, B., & Zimková, E. (2015). Efficiency in the Slovak banking industry: a comparison of three approaches. *Prague Economic Papers, 2015*(4), 434-451.
Mester, L. J. (1997). Measuring efficiency at US banks: Accounting for heterogeneity is important. *European Journal of Operational Research, 98*(2), 230-242.
Moh'd, M. A., Mohammad, W. H., & Waleed, H. (2011). The Relative Efficiency of Jordanian Banks and its Determinants Using Data Envelopment Analysis. *Journal of Applied Finance & Banking, 1*(3), 33-58.
Molyneux, P., & Thornton, J. (1992). Determinants of European bank profitability: A note. *Journal of Banking & Finance, 16*(6), 1173-1178.
Mostafa, M. (2007). Modeling the efficiency of GCC banks: A data envelopment analysis approach. *International Journal of Productivity Performance Management, 56*, 21.
Musonde, A. (2008). *An Investigation Into the Determinants of Cost Efficiency in the Zambian Banking Sector"*. Paper presented at the 13 th Annual African Econometric Society Conference.
Muvingi, J., & Hotera, S. (2015). *Zimbabwe commercials banks efficiency and productivity analysis through DEA Malmquist approach: 2002-2012*.
Ngoc Nguyen, T., & Stewart, C. (2013). Concentration and efficiency in the Vietnamese banking system between 1999 and 2009: a structural model approach. *Journal of Financial Regulation and Compliance, 21*(3), 268-283.
Nguyen, T. P. T., Nguyen, T. P. T., Nghiem, S. H., & Nghiem, S. H. (2016). Market concentration, diversification and bank performance in China and India: An application of the two-stage approach with double bootstrap. *Managerial Finance, 42*(10), 980-998.
Noulas, A. G., Glaveli, N., & Kiriakopoulos, I. (2008). Investigating cost efficiency in the branch network of a Greek bank: an empirical study. *Managerial Finance, 34*(3), 160-171.
Peng, J.-L., Jeng, V., Wang, J. L., & Chen, Y.-C. (2017). The impact of bancassurance on efficiency and profitability of banks: Evidence from the banking industry in Taiwan. *Journal of Banking & Finance, 80*, 1-

13.
Řepková, I., & Stavárek, D. (2013). Relationship between competition and efficiency in the Czech banking industry. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 61*(7), 2701-2707.
San, O. T., Theng, L. Y., & Heng, T. B. (2011). A Comparison on Efficiency of Domestic and Foreign Banks in Malaysia: A DEA Approach. *Business Management dynamics*, 33-49.
Seelanatha, S. L. (2012). Drivers of Technical Efficiency of Sri Lankan Commercial Banks. *International Journal of Applied Economics, 9*(1), 41-58.
Tan, Y. (2016a). *Efficiency and Competition in Chinese Banking*: Chandos Publishing.
Tan, Y. (2016b). The impacts of risk and competition on bank profitability in China. *Journal of International Financial markets, Institutions & Money*, 58-110.
Tan, Y. (2017). Competition and Profitability in the Chinese Banking Industry: New Evidence from Different Banking Markets.
Tan, Y., Tan, Y., Floros, C., Floros, C., Anchor, J., & Anchor, J. (2017). The profitability of Chinese banks: impacts of risk, competition and efficiency. *Review of Accounting and Finance, 16*(1), 86-105.
Tecles, P. L., & Tabak, B. M. (2010). Determinants of bank efficiency: The case of Brazil. *European Journal of Operational Research, 207*(3), 1587-1598.
Tesfaye, T. (2016). Determinants of Commercial Banks Efficiency: Evidence from Selected Commercial Banks of Ethiopia. *International Journal of Scientific and Research Publications, 6*(5), 551-556.
Titko, J., Stankevičienė, J., & Lāce, N. (2014). Measuring bank efficiency: DEA application. *Technological and Economic Development of Economy, 20*(4), 739-757.
Triki, T., Kouki, I., Dhaou, M. B., & Calice, P. (2017). Bank regulation and efficiency: What works for Africa? *Research in International Business and Finance, 39*, 183-205.
Tulkens, H. (1993). On FDH efficiency analysis: some methodological issues and applications to retail banking, courts, and urban transit *Productivity Issues in Services at the Micro Level* (pp. 179-206): Springer.
Tung-Hao, L., & Shu-Hwa, C. (2013). Does financial regulation affect the profit efficiency and risk of banks? Evidence from China's commercial banks. *North American Journal of Economics and Finance, 26*, 705–724.
Uri, N. D. (2001). Technical efficiency, allocative efficiency, and the implementation of a price cap plan in telecommunications in the United States. *Journal of Applied Economics, 4*(1), 163-186.
Vittas, D. (1991). *Measuring commercial bank efficiency: use and misuse of bank operating ratios* (Vol. 806): World Bank Publications.
Xiaofeng, H. B., & Sun, S. J. (2013). Commercial Bak efficiency in Nepal: Application of DEA and Tobit Model *Information Technology Journal, 12*(2), 306-314.
Xiaotian, T. Z., & Yong, W. (2014). Production efficiency of Chinese banks: a revisit. *Managerial Finance, 40*(10), 969–986.
Zawadi, A., & Patel, G. N. (2014). Evaluating Efficiency of Commercial Banks in Tanzania and identifying efficiency drivers. *Journal of Business and Management, 16*(7), 50-64.
Zhu, J. (2014). *Quantitative models for performance evaluation and benchmarking: data envelopment analysis with spreadsheets* (Vol. 213): Springer.