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# Assessing Bank Performance Using Malmquist Productivity Index Approach and One-Step System GMM Dynamic Panel Data Model

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## Abstract

This article evaluated the total factor productivity of Ethiopian banks from 2011 to 2020 using the DEA-based Malmquist productivity index and one-step system GMM dynamic data approaches. The study covered the 14 banks that were operational during the study period and examined the regressive, stable, and progressive nature of their productivity taking into account both the production and intermediary role of banks. We used constant returns to scale to compare the efficiency and productivity and establish a benchmark for bank performance. Interest expense, operating non-interest expense, and deposits were used as input variables and interest income, operating non-interest income, and loan and advances as output variables to analyze the productivity change of banks in their production role while deposits and loans were used as input and output variables, respectively to study productivity change of banks in their intermediation role. The study concludes nominal efficiency change both due to improved operations and management practices as well as increased economies of scale and deterioration in technological efficiency. We also conclude nominal regress in total bank factor productivity during the study period and a regressive, and progressive impact of technology, and improved management practices on the productivity of Ethiopian banks, respectively. Consequently, we suggest a thorough feasibility study in the technology choice of banks.

## Keywords

Malmquist, DEA, Bank, Productivity, Production

## 1. Introduction

The financial sector includes financial institutions, instruments, and markets, as

well as the legal and regulatory framework, that facilitate business transactions. Fundamentally, the goal of financial sector development is to reduce "costs" in the financial system. Financial contracts, markets, and intermediaries emerge in the process of lowering the costs of information asymmetry, enforcing contracts, and closing transactions (Ibrahim & Vo, 2021; Bartke & Schwarze, 2021).

The financial sector is critical to the efficient allocation of resources, economic growth, and the creation of jobs. The financial sector has grown markedly in advanced nations in the past few decades while developing economies have been reforming their financial sector during the same period to bring changes. In many emerging economies, financial development has played a key role in their economic development endeavor. Policymakers often believe that financial development boosts productivity, which in turn brings economic growth.

Given the rising problems of globalization and increasing competition, banks as one of the most important financial institutions must be capable of implementing sound financial management practices. Following the economic crisis and the subsequent decline in the demand for banking products along with the use of cutting-edge innovations in the access and production of financial services, many countries have initiated a major reorganization of their financial sectors with a focus on the banking sector (Mansour & El Moussawi, 2020). This is attributed to the dominant role of banks within the financial sector and owning of most of the sector's resources and capabilities.

Wheelock and Wilson (1999), Haralayya & Aithal (2021), and Shair et al. (2021) conceptualize efficiency as the difference between observed input and output levels, as well as related ideal values. Bank efficiency is the most important issue in the financial sector as it directly impacts the stability of the banking sector and the effectiveness of the country's economic policy (Yilmaz, 2013). Bank efficiency scores are indicators of the industry's overall performance which also is used to measure the influence of government policy and regulation on economic performance (Wheelock & Wilson, 1999; Sadalia et al., 2018; Nhan et al., 2021).

The Ethiopian banking industry is home to a large regional powerhouse like the Commercial Bank of Ethiopia with a $20 billion asset base and other very smaller banks. It operates in a fairly conventional manner with paper-pushing branches though it also parallelly makes use of sparks of "digital disruption" (Ayalew, 2021).

Ethiopia now has 17 private and 1 state-owned bank which is a significant rise from 1990's sole state-owned bank and only 7 in 2000 (Aluko & Ibrahim, 2020; Dinku, 2021; Gemeda Edeti & Chand Garg, 2021). Over the last decade, an increasing number of banks have expanded their geographic reach by relying on large-scale branch expansions, boosting key access to financial resources. As of June 2018, Ethiopian banks have a total of 4757 branches 2208 branches five years ago, and 571 branches ten years ago (National Bank of Ethiopia, 2022).

The banking industry in Ethiopia contributed to a large increase in national

savings, whether measured in deposit levels or national savings as recorded in GDP figures. This has been achieved by increasing the number of branches opened every year and reaching higher penetration levels among the people. Domestic savings, as indicated by national accounts figures, increased to 24% of GDP in FY 2017-18, up from less than 10% a decade before. Simultaneously, cash in circulation has decreased over the last decade, from 7% to 4% of GDP and 17% to 9% of banking assets. This can be ascribed to improved absorption of cash into the banking system instead of stashing it "under mattresses" and other informal methods.

Also, as Ethiopia doesn't have a capital market, the majority of saving and investment activities are carried out through the banking system. Besides, the Ethiopian banking industry appeared to be a key employer in the formal sector, with about 90,000 employees. This is a roughly threefold growth over ten years and a double growth over five years. After the government, banks are anticipated to be among the major formal sector employers in the economy although manufacturing sector employment numbers are not yet publicly available. This made bank productivity an important field of study by financial economists, practitioners, and policymakers (Garamu, 2016).

Generally, banking in Ethiopia has played a critical role in widening financial access, increasing national savings, and supporting important public and private initiatives during the last decade. Banks have recently emerged as vital suppliers of employment, income, and taxes. Despite the several outstanding achievements listed above, Ethiopian banks' performance remains limited and trailing in some key areas. In particular, Ethiopia's banking expansion is: 1) much more modest in comparison to GDP and peer countries; 2) has done more to improve proximity to the population rather than active usage by the population; 3) has provided much stronger support for the public sector rather than the private sector; and 4) has not yet provided the specific forms and features of financing to match local private sector needs.

Few studies have been carried out to examine bank efficiency and productivity in Ethiopia (Lelissa, 2014; Garamu, 2016; Lema, 2016; Lelissa & Mohammed, 2016; Ram & Mesfin, 2019; Berhe, 2021). Garamu (2016) and Berhe (2021) applied the DEA-Malmquist productivity index approach while Lelissa & Mohammed (2016) and Ram & Mesfin (2019) stated they employed DEA without specifying the type of DEA as Multistage, Cost, One-stage, and Two-stage, or Malmquist. Given this, one can question the methodological appropriateness and statistical conclusion validity of the works of Lelissa & Mohammed (2016) and Ram & Mesfin (2019).

DEA-Malquest productivity index approach is used when the purpose of the study is to measure productivity change of various banks over time. This helps to know whether bank productivity is regressing, flattening, or improving. To achieve such an objective, a dynamic panel data modeling along with the Malmquist productivity index approach is required. However, all of the

studies conducted didn't employ the two at the same time casting doubt on their findings.

The other important point in the study of bank productivity is how we understand banks: production units or intermediation units, or both. Except for Ram & Mesfin (2019) that didn't explain their approach as production or intermediation, others including Lelissa & Mohammed (2016), Berhe (2021), and Garamu (2016) used the intermediation approach. However, the intermediation model is more appropriate when the conversion of deposit to loan is a challenge: a character of well-developed financial systems. As such previous studies missed the context of underdeveloped and developing financial systems in which Ethiopia is a part.

The challenge of the Ethiopian banking system is mobilizing enough deposits, but not loan conversion, though loan conversion is also important (Bayiley, 2013). Nonetheless, using the intermediation approach over and above the production approach would add value and make the analysis more complete and robust. In addition to this, extant literature studied the productivity of Ethiopian banks up to 2017 (Berhe, 2021; Garamu, 2016; Lelissa & Mohammed, 2016; Ram & Mesfin, 2019) indicating a temporal research gap in the study of the productivity of Ethiopian banks.

From the gap analysis presented above, the current research aims to fill both methodological and temporal gaps. Therefore, the current study employed the Malmquist productivity index approach and production approach along with the intermediation approach to fill a methodological gap within the existing. The study also used a one-step system GMM dynamic panel model to capture changes in productivity of Ethiopian banks over time. A one-step system GMM dynamic panel model offers a lower bias and higher efficiency than other approaches such as the standard first-difference GMM estimator (Bayiley, 2021). Finally, the study used the most available recent data from 2011 to 2020 to fill the temporal gap.

The rest of the paper has been structured as follows. Section II covers extant literature, Section III research methodology, Section IV the results and discussions, and Section V the conclusion and policy implication aspects.

## 2. Literature Review

### 2.1. Function of Banks

The roles banks play in an economy made them one of the most closely regulated and extensively studied institutions throughout the world. Banks are involved in the financial intermediation and payment of goods and services as well as provision of a wide range of financial services, ranging from checking accounts and savings plans to loans to businesses, consumers, and governments. Investment banking, insurance protection, financial planning, guidance for merging firms, the selling of risk-management services to businesses and individuals, and a slew of other new services, including fintech (Syukriadi & Sunitiyoso, 2021;

Zavadska, 2018).

## 2.2. Measuring the Output of Banks

The empirical research on productivity measurement, as well as the assessment of cost and economies of scale, and the study of bank efficiency, all begin with measuring bank production. However, there is no agreement among academics on how to define bank production (Alfredsson et al., 2018; Gonzalez-Gomez et al., 2022). This is due to the intangible, multifaceted, and interrelated character of the services banks provide. Banks, for example, offer a diverse variety of services that are frequently difficult to separate and price separately, while other services are supplied for free.

Based on classical microeconomic theory, there are three main techniques of quantifying bank output in the literature:

1) Production Approach: Benston (1965) and Bell and Murphy (1968) proposed the production method to support the idea that banks "create" various types of loans and deposits utilizing labor and capital as inputs. Output should be assessed in terms of what banks do that causes operating expenditures to be incurred (Benston et al., 1982). However, detractors argue that the cost criteria are ineffective in distinguishing financial inputs from financial outputs. Furthermore, neither volume (number of accounts or transactions) nor value words are consistently applied in this method.

2) Intermediation Approach: Nourani et al., (2018), Piklová & Boďa (2018), Zahra & Darwanto (2019), Haralayya & Aithal (2021) highlight banks' intermediation role, i.e., how they take deposits and acquire capital, which they then transform into loans and other assets. The value of loans is used to calculate output, whereas deposits, labor, and capital are used to calculate inputs. The question of whether deposits should be regarded as output (production method) or input (intermediation approach) is very important and represents the fundamental difference between the two approaches. Deposits can be considered output if they are linked to the supply of non-directly priced services such as liquidity, safekeeping, and payment services (free checkbooks, ATM usage, and so on) that consumers get in exchange for their deposits. Deposits, on the other hand, may qualify as input because the monies collected through deposits are used to "produce" loans and other bank assets.

3) User cost Approach: The user-cost method empirically tackles the problem by determining whether a bank asset or obligation is an input or an output based on the user cost of money (Izadikhah, 2018; Isakin & Serletis, 2018; Humphrey, 2020). Hancock (1985) extended on this technique by developing a production theory for financial businesses with empirically known inputs and outputs. The difference between a benchmark rate (representing the bank's opportunity cost) and the interest rate (rate of return) associated with keeping this asset is the user cost of money for bank assets. The difference between the interest rate connected with this liability and the benchmark rate is the user cost of money for a

bank liability. If the user's cost of money is positive (negative), the asset or liability in issue is treated as an input in both circumstances (output). A positive user cost of money indicates that the asset or liability contributes to the bank's operating expenditures, whereas a negative user cost of money indicates that the asset or liability enhances the bank's revenues.

## 2.3. Productivity and Efficiency

The productivity and efficiency of banks are commonly used to determine performance (Chen et al., 2018; Djaghballou et al., 2018; Alexakis et al., 2019). The ratio of output to the elements that allow it to happen is called productivity (Raymond et al., 2015; Tsolas et al., 2020). When an index of outputs changes at a faster rate than an index of inputs, productivity changes (LEE et al., 2010; Abbott, 2018; Moutinho et al., 2018). If the unit utilizes a single input to create a single output, this ratio is simple to calculate. If the production unit, on the other hand, uses many inputs to make multiple outputs, the inputs and outputs must be aggregated such that productivity remains the ratio of two scalars. The idea of efficiency is similar, but not identical though many authors in the efficiency literature do not distinguish between productivity and efficiency. For example, both productivity and efficiency are defined as the ratio of output to input by Green & Sengupta (1996), Bouyssou (2003), Bahrini (2015), Zelenyuk (2020). Instead of being defined as the ratio of outputs to inputs, efficiency may be defined as the distance between input and output, and the amount of input and output that defines a frontier, the best feasible frontier for a business in its cluster (industry).

Finally, productivity and efficiency may be characterized in a variety of ways. First, if the frontier is defined as the ratio of outputs to inputs, productivity and efficiency are distinct, and the latter can only be measured through the relative performance of decision-making units (DMUs) (Baqaee & Farhi, 2019; Baležentis & Sun, 2020). Second, they are linked because productivity growth may be broken down into efficiency and technological advancement. The former relates to the more efficient input utilized in production under the same technology, while the latter refers to an upward movement in the production frontier as a result of a technology change.

## 2.4. Malmquist Productivity Index

Malmquist (1953) established the notion of the Malmquist productivity index, which has since been examined and expanded in a nonparametric context by various writers. In addition, it was further introduced and developed by Caves et al. (1982), Färe et al. (1997), Grifell-Tatjé & Lovell (1999), Färe et al. (2001), Oh & Lee (2009), and Homayoni et al. (2021).

With a DEA-like nonparametric technique, the Malmquist Productivity Index (MPI) evaluates productivity changes over time and can be decomposed into improvements in efficiency and technology.

To study the determinants and identify the drivers of changes in cost-side productivity and their economic consequences, Cho & Chen (2021), Yang & Soltani (2021), Parsaulian & Chalid (2021), Rusydiana & Assalafiyah (2021), Pokharel & Featherstone (2021) employed the DEA technique to establish the meta-frontier cost, using the Malmquist productivity index under variable returns to scale (VRS) whereas Shair et al. (2021) used the Malmquist productivity under constant return to scale (CRS). On the other hand, Agrawal (2021) measures the productivity of banks both under VRS and CRS. Shair et al. (2021) investigate the Pakistani banking industry's efficiency and total factor productivity (TFP) growth, as well as the influence of risk and competition on efficiency and TFP growth using the Malmquist productivity index based on data envelopment analysis (DEA). Webb (2003) used DEA window analysis to study the relative efficiency levels of UK retail banks from 1982 to 1995. In comparison to previous research on the UK banking industry, he discovered that mean inefficiency levels of UK retail banks were getting lower over time. Reisman et al. (2003) evaluated the influence of deregulation on the efficiency of eleven Tunisian commercial banks from 1990 to 2001 using three inputs: fixed assets, number of staff, and deposits while they used loans and securities portfolios as outputs. With an expanded window analysis, they followed the intermediation method to DEA and found deregulation improved the overall efficiency of Tunisian commercial banks.

## 3. Methodology and Approach

The goal of this article is to assess how Ethiopian banks' production has changed over time. A Malmquist productivity index technique is used for this purpose. The data type, data sources, and analytic method utilized to achieve the goal of interest are presented in the next section.

### 3.1. Data Type and Source

The Ethiopian Commercial Bank is constituted of 16 private banks and one state-owned bank. The current analysis includes 14 banks (13 privately held banks and 1 state-owned bank) due to data limitations. That is, the analysis excludes Enat Bank, Debub Global Bank, and Addis International Bank. To evaluate the productivity changes of the banks under study secondary data on input variables output variables are collected from the audited balance sheets and income statements of the banks under study.

### 3.2. Selection and Use of Input-Output Approach

An investigation of banking efficiency can be conducted using either production or an intermediation method. In the "production approach", the bank is viewed as a business that uses fixed assets and labor inputs to offer services such as depositing cash, disbursement of loans, and remittances. The amount of bank total deposit and or total loan is frequently used to represent the output, while the

number of employees (labor) and capital expenditures on fixed assets is used to represent the inputs (capital). Banks act as an intermediate between lenders and depositors under the "intermediation method", accepting deposits and other money to offer finance and alternative investments. The output is measured by income or profit from financing, total deposits, and any other non-interest-bearing income while inputs are usually denoted by operating costs and costs of providing financing to customers.

Based on the analysis presented above and aiming to examine the sensibility of estimated efficiency scores to alternative methods of measuring banking activity, this study focuses on two major approaches: the intermediation approach and the production approach (Table 1, Table 2).

### 3.3. Malmquist Productivity Index

This approach has three key MPI favorable conditions that distinguish it from other methods (Bansal et al., 2022; Xie et al., 2021; Dar et al., 2021). To begin with, there is no premise of cost reduction or benefit amplification. Second, information and yield expenses are not anticipated. Third, assuming board information is available, the method allows for the degradation of profitability into two categories. The MPI is based on distance functions, output distance functions for an output-oriented index, and input distance functions for an input-oriented index. The index is applied to the measurement of total factor

**Table 1.** Definition and selection of variable in intermediation approach.

| S. NO. | Code | Variable name | Definition |
|---|---|---|---|
| | | *Input variables* | |
| 1 | IE | Interest expense | The sum of payment on fixed deposits, saving and demand deposits |
| 2 | OE | Operating Expense | Expenses like salary and benefits, administrative and general expenses, provision for doubtful debt, and other audit fees |
| 3 | TD | Total Deposit | The sum of demand, time, and saving deposit |
| | | *Output variables* | |
| 1 | II | Interest income | The sum of interest on loans and advance, interest on deposits, and interest on treasury and NBE bills |
| 2 | NII | Non-interest income | Commission, fees, and charges on the letter of credit, on the letter of guarantee and local transfer, and other income |
| 3 | TL | Total loan | include real estate loan, commercial loan, industrial loan and consumer loan |

**Table 2.** Definition and selection of variables in production approach.

| S. NO. | Code | Variable Name | Definition |
|---|---|---|---|
| | | *Input variables* | |
| 1 | FA | Fixed asset | Are long-term tangible pieces of property or equipment that a bank owns and uses in its operations to generate income |
| 2 | GE | General expense | Expenses like salary and benefits, administrative and general expenses, provision for doubtful debt, and other audit fees. |
| 3 | PDLA | Provision for doubtful loans and other assets | Account for potential loan defaults and expenses to ensure they are presenting an accurate assessment of their overall financial health. |
| 4 | ESB | Employee salary and benefit | It is the total amount of salary and other benefits to employees |
| | | *Output variables* | |
| 1 | TD | Total deposit | The sum of demand, time, and saving deposit |
| 2 | TL | Total loan | Include real estate loan, commercial loan, industrial loan, and consumer loan |

productivity change over time and can be decomposed into an efficiency change index and a technological change index.

The Malmquist productivity index technique was used to assess the productivity performance of Ethiopian banks understudy during periods $t$ and $t + 1$ in comparison to technology at period t in this study. The article utilizes the yield arranged Malmquist profitability record for DMU between the period's $t$ and $t + 1$ based on the equation given by Krishnasamy et al. (2004), Battese et al. (2004), Yang & Soltani (2021), and Huang et al. (2021).

$$\text{MPI}_I^t = \frac{D_I^t\left(x^{t+1}, y^{t+1}\right)}{D_I^t\left(x^t, y^t\right)} \tag{1}$$

where $x$ denotes input and $y$ denotes the output of DMU, $\left(x^t, y^t\right)$ and $\left(y^{t+1}, x^{t+1}\right)$ represents the input and output data set for time period $t$ and $t + 1$ respectively. In addition, $\left(x^t, y^t\right)$ and $\left(y^{t+1}, x^{t+1}\right)$ represents production point at time $t$ and $t + 1$ respectively. The subscript "I" denotes the input orientation of the MPI model.

Using the technology at $t + 1$ as the reference, the period $(t + 1)$-based MPI is defined as:

$$\text{MPI}_I^t = \frac{D_I^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_I^t\left(x^t, y^t\right)} \tag{2}$$

Equation (3) is the measure of Malmquist's total productivity change index, which is the geometric mean of two MPIs in Equations (1) and (2) (Bjurek, 1996; Grifell-Tatjé & Lovell, 1999; Pastor & Lovell, 2005; Huang et al., 2014).

$$\text{MPI}_I^G = \left(\text{MPI}_I^t * \text{MPI}_I^{t+1}\right)^{1/2} = \left(\left(\frac{D_I^t\left(x^{t+1}, y^{t+1}\right)}{D_I^t\left(x^t, y^t\right)}\right) * \left(\frac{D_I^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_I^t\left(x^t, y^t\right)}\right)\right)^{1/2} \quad (3)$$

MPI in Equation (3) measures the productivity of the most recent production point $\left(y^{t+1}, x^{t+1}\right)$ relative to the earlier production point $x^t, y^t$. This means that the efficiency change is calculated by dividing the efficiency in $(t + 1)$ period by the efficiency in $t$ period. The index uses period $t$ as well as period $t + 1$ technology. A geometric mean of two MPIs is used to calculate productivity growth. When the $\text{MPI}_I^G$ value is larger than one, which means that overall productivity increased from period t to period $t + 1$. A number less than one implies a decrease in total production. $\text{MPI}_I^G = 1$ indicates stagnation in productivity between the period $t$ and $t + 1$.

Using the concepts of input-oriented efficiency change (EFFCH) and input-oriented technology change (TECHCH), the input-oriented geometric mean of MPI (i.e., Malmquist total productivity change index) may be deconstructed as shown in Equation (4).

$$\text{MPI}_I^G = \text{EFFCH}_I * \text{TECHCH}_I$$

$$= \left(\frac{D_I^t\left(x^{t+1}, y^{t+1}\right)}{D_I^t\left(x^t, y^t\right)}\right) * \left[\left(\frac{D_I^t\left(x^1, y^1\right)}{D_I^{t+1}\left(x^t, y^t\right)}\right)\left(\frac{D_I^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_I^{t+1}\left(x^{t+1}, y^t + 1\right)}\right)\right]^{\frac{1}{2}}\cdots \quad (4)$$

The first and second terms represent the efficiency change and the technology change respectively. MPI given by Equation (3) and Equation (4) can be defined using DEA like a distance function. That is, the components of MPI can be derived from the estimation of distance functions defined on frontier technology. The formal derivation of MPI was presented by Färe et al. (1997), Oh & Lee (2009), Casu et al. (2016) and it is the most common approach among the different ways created to estimate a production technology (Howcroft & Ataullah, 2006; Dorri & Rostamy-Malkhalifeh, 2017). By utilizing both CRS and VRS DEA frontiers to estimate the distance functions in Equation (4), the efficiency change (EFFCH) can be decomposed into scale efficiency change (SECH) and pure efficiency change (PECH) components. A scale efficiency change (SECH) is given in Equation (5).

$$\text{SECH} = \left[\frac{D_{VRS}^{t+1}\left(x^{t+1}, y^{t+1}\right)\Big/D_{CRS}^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_{VRS}^{t+1}\left(x^t, y^t\right)\Big/D_{CRS}^{t+1}\left(x^t, y^t\right)} * \frac{D_{VRS}^t\left(x^{t+1}, y^{t+1}\right)\Big/D_{CRS}^t\left(x^{t+1}, y^{t+1}\right)}{D_{VRS}^t\left(x^t, y^t\right)\Big/D_{CRS}^t\left(x^t, y^t\right)}\right]^{1/2}$$

$$(5)$$

In addition, the pure efficiency change (PECH) is given in Equation (6)

$$\text{PECH} = \frac{D_{VRS}^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_{CRS}^t\left(x^t, y^t\right)} \quad (6)$$

## 4. Results and Discussion

### 4.1. Descriptive Statistics

#### 4.1.1. The Intermediate Approach

The standard deviation results presented in Table 3 indicate the performance gap analyzed using the intermediate approach. It indicates the performance gap among sample banks in terms of interest and non-interest income, total loan disbursed, interest and non-interest expense, and total deposits mobilized. Also, a bank with a maximum output variable (in the year 2020) is more than 1530 times the size of a bank with a minimum output variable (in the year 2011). Also, a bank with a maximum input variable is more than 224 times the size of a bank with a minimum input variable. Both the output and input variable comparison designate a huge performance gap among sample banks.

#### 4.1.2. The Production Approach (Table 4)

Moreover, the standard deviation results presented in Table 4 indicate the performance gap measured using the production approach. The result indicates the performance gap among sample banks in terms of total deposits mobilized, total loan disbursed, employees compensation, provision for doubtful loans and other assets, general expenses, and fixed assets. Also, the result shows a bank with a maximum output variable (in the year 2020) is more than 224 times the size of a bank with a minimum output variable (in the year 2011). Likewise, a bank with a maximum input variable is more than 809 times the size of a bank with a minimum input variable. Juxtaposing both results indicate a vast performance gap among sample banks.

Table 3. Descriptive statistics for Intermediation Approach (in millions of Ethiopian Birr).

|  | Output variables | | | Input variables | | |
|---|---|---|---|---|---|---|
|  | Interest income | Non-interest income | Total loan | Interest expense | Operational expense | Total deposit |
| Mean | 2817.04 | 876.9404 | 17,494.9 | 1084.648 | 1323.208 | 34,279.57 |
| St. dev | 7302.576 | 1592.819 | 36,116.32 | 3061.841 | 3103.89 | 88,455.68 |
| Min | 4.899 | 7.443 | 158.108 | 1.104 | 15.036 | 263.83 |
| Max | 53,769.96 | 11,469.49 | 241,991.6 | 24,680.08 | 25,602.52 | 59,304.1 |

Table 4. Descriptive statistics for production approach (in millions of Ethiopian Birr).

|  | Output variables | | | Input variables | | |
|---|---|---|---|---|---|---|
|  | Total deposit | Total loan | Employee salary and benefit | Provision for doubtful loans and other assets | General expense | Fixed asset |
| Mean | 34,279.57 | 17494.9 | 730.131 | 118.4347 | 488.2643 | 987.7025 |
| St.dev | 88,455.68 | 36,116.32 | 1829.041 | 373.3252 | 1001.104 | 2048.539 |
| Min | 263.83 | 158.108 | 3.651 | -6.771 | 9.784 | 11.266 |
| Max | 59304.1 | 241991.6 | 16,747.59 | 3267.97 | 7915.2 | 13497.76 |

## 4.2. Malmquist Productivity Change

The Malmquist productivity index is made up of five components that are used to assess performance. Efficiency changes, pure efficiency changes, scale efficiency changes, technological changes, and total factor productivity changes are among them. The Malmquist productivity index allows you to compare productivity changes within the banking industry as well as between groupings. As a result, with the aid of this metric, low achievers may be able to catch up. Total factor productivity, as the name suggests, refers to all elements affecting commercial bank output; more particularly, changes in total factor productivity include increases in efficiency and technology. The following is how Malmquist's total factor productivity is interpreted.

### 4.2.1. Production Approach of Malmquist Productivity Change

An efficiency score of more than one implies progress or development. Values less than one, on the other hand, indicate deterioration or regression. Whereas one indicates that there has been no progress. The mean value of total factor productivity change (Malmquist Index) registered 0.964, indicating regress or annual negative average growth of 3.6%. This negative productivity change can be dichotomized (decomposed) into its efficiency change and technology change components. Technology change represents the innovation in the banking system that has been developed, adapted, or absorbed by the banks. The mean value of technology change registered 0.941, indicating productive regress or negative technological change of annual 5.9%. The efficiency change has a mean value of 1.025, which indicates an average growth of annual 2.5%. The efficiency change is comprised of pure efficiency and scale efficiency changes. Pure efficiency change represents core efficiency due to improved operations and management while scale efficiency change is associated with returns to scale effects. Average pure efficiency change (PECH) marked 1.025, suggesting progress in terms of operations and management by 2.5% annually. And scale efficiency change (SECH) resulted in an average value of 1.014, showing the positive scale economies effects and growth by 1.4%. (Table 5)

From Figure 1 below the total productivity change and technological productivity are increasing from 2012 to 2013 and decreased in 2014. Starting from 2014 to 2016, change increases upwards, and from 2016 to 2020, increases with a weak growth rate. On the other hand, the scale efficiency change and pure efficiency change fluctuate under the study period with a weak or no growth rate.

The mean productivity change of individual banks during nine years is shown in Table 6. Out of the 14 commercial banks, 11 have a total factor productivity score of less than one. This shows that approximately 78.6% of the banks are not able to increase their total factor productivity (regressing in total factor productivity) during the study period of nine years. The remaining 21.4 percent of the bank can increase their factor productivity. Out of the 14, only 9 (64.3%) banks

**Table 5.** Malmquist index summary of annual mean.

| Year | effch | techch | Pech | Sech | tfpch |
|------|-------|--------|------|------|-------|
| 2012 | 0.818 | 1.24 | 0.904 | 0.905 | 1.015 |
| 2013 | 1.342 | 0.657 | 1.075 | 1.249 | 0.881 |
| 2014 | 1.038 | 0.971 | 1.101 | 0.943 | 1.008 |
| 2015 | 1.043 | 0.89 | 1.01 | 1.033 | 0.929 |
| 2016 | 1.013 | 0.804 | 1.007 | 1.005 | 0.814 |
| 2017 | 1.044 | 0.938 | 1.026 | 1.017 | 0.979 |
| 2018 | 1.036 | 1.015 | 1.014 | 1.021 | 1.051 |
| 2019 | 0.948 | 1.163 | 0.976 | 0.971 | 1.103 |
| 2020 | 1.007 | 0.922 | 0.993 | 1.014 | 0.928 |
| **Mean** | **1.025** | **0.941** | **1.010** | **1.014** | **0.964** |

**Table 6.** Summary of Malmquist productivity index of bank means, 2012 to 2020.

| Bank | Efficiency change (effch) | Technology change (techch) | Pure efficiency change (pech) | Scale efficiency change (sech) | Total factor productivity change (tfpch) |
|------|------|------|------|------|------|
| CBE | 1.000 | 0.822 | 1.000 | 1.000 | 0.822 |
| AWASH | 1.000 | 0.976 | 1.000 | 1.000 | 0.976 |
| BOA | 1.006 | 0.958 | 1.013 | 0.993 | 0.964 |
| DB | 1.006 | 0.976 | 1.002 | 1.004 | 0.982 |
| CBO | 1.082 | 0.939 | 1.069 | 1.012 | 1.015 |
| HB | 0.986 | 0.953 | 1.000 | 0.986 | 0.940 |
| WB | 1.000 | 0.963 | 1.008 | 0.992 | 0.963 |
| NIB | 1.030 | 0.897 | 1.030 | 1.001 | 0.925 |
| OIB | 1.060 | 0.969 | 1.047 | 1.012 | 1.028 |
| LIB | 1.044 | 0.942 | 1.000 | 1.044 | 0.984 |
| BRB | 0.990 | 0.936 | 0.961 | 1.030 | 0.926 |
| BUIB | 1.039 | 0.925 | 0.993 | 1.047 | 0.961 |
| ZB | 1.052 | 0.934 | 1.027 | 1.025 | 0.982 |
| AB | 1.052 | 0.996 | 1.000 | 1.052 | 1.048 |
| *mean* | *1.025* | *0.941* | *1.010* | *1.014* | *0.964* |

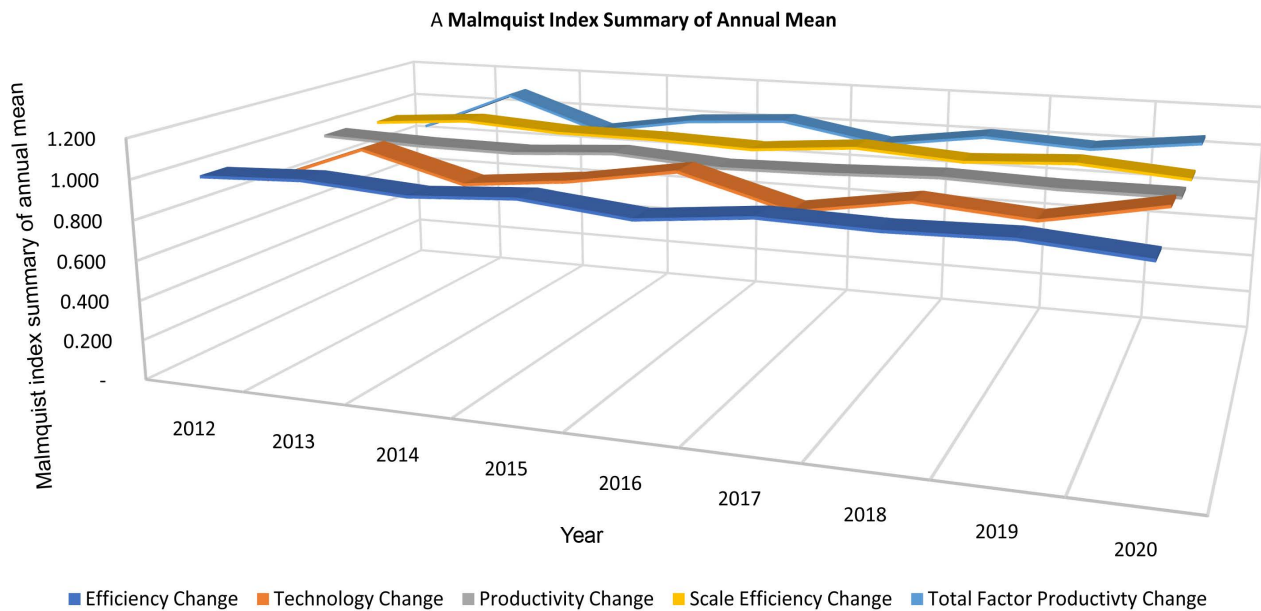A **Malmquist Index Summary of Annual Mean**



**Figure 1.** A Malmquist index summary of annual mean.

were able to increase their efficiency, whereas 3 (21.4%) remained constant, neither progress nor regress in achieving efficiency, and only 2 (14.3%) show regress of efficiency.

Pure efficiency change and scale efficiency change are two types of efficiency change. As mentioned earlier, pure efficiency improvement is attributed to improved operations and management practices, whereas scale efficiency improvement is related to returns to scale effects. Any type of efficiency change score greater than one indicates improvement, whereas less than one indicates regress. According to Table 6, Bank of Abyssinia, Dashen Bank, Cooperative Bank of Oromia, Wogagen Bank, Nib International Bank, Oromia International Bank, and Zemen Bank (50% of banks) have registered progress in their pure efficiency. Five banks including Commercial Bank of Ethiopia, Awash Bank, United Bank, Lion International Bank, and Abay Bank (35.7% of banks) maintained their pure efficiency performance, and the remaining two: Birhan Bank and Bunna International Bank (14.3% of banks) showed a regress.

Nine banks, Dashen Bank, Cooperative Bank of Oromia, Nib International Bank, Oromia International Bank, Lion International Bank, Birhan Bank, Bunna International Bank, Zemen Bank, and Abay Bank (64.3% of banks) have shown improvement in their scale efficiency. Commercial Bank of Ethiopia and Awash Bank (14.3% of banks) maintained their scale efficiency performance while Bank of Abyssinia, United Bank, and Wogagen Bank (21.4% of banks) recorded regress in their scale efficiency performance.

Finally, the mean value of efficiency change scores of banks was greater than one while the mean value of technology change scores was less than one. Given that total factor productivity is the product of efficiency change and technology

change, its score was less than one. From this, we can deduce that while banks have shown improvement in catching up to the best-practice, they were not able to increase outputs with a given level of inputs.

**Figure 2** demonstrates that Abay Bank recorded the highest mean positive change in TFP of 4.8%. As indicated in **Table 6**, the 4.8% productivity achieved for the Abay Bank contains an efficiency growth of 5.2% and technological regress of 0.4%. Commercial Bank of Ethiopia shows the lowest average TFP transform with an average deterioration of around 17.8% in the total factor productivity change.

### 4.2.2. Result Using Intermediate Approach

From the table Total factor productivity, the responsibility of commercial banks is growing constantly in Ethiopia's banking sector. The yearly average total factor productivity changes of listed commercial banks during the study period was 0.991 as shown in **Table 7**, implying that the sample banks could have reduced their input by about 0.9 percent to achieve the same point of output. This
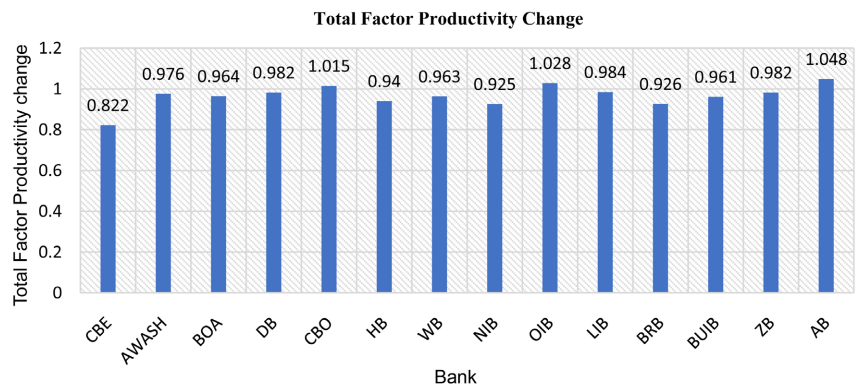
**Figure 2.** A Malmquist index summary of annual mean of total factor productivity change.

**Table 7.** Summary of Malmquist index summary of annual mean.

| year | Effch | Techch | pech | sech | tfpch |
|------|-------|--------|------|------|-------|
| 2012 | 1.001 | 0.876 | 1.009 | 0.991 | 0.877 |
| 2013 | 1.022 | 1.069 | 0.991 | 1.031 | 1.092 |
| 2014 | 0.986 | 0.932 | 0.987 | 0.999 | 0.918 |
| 2015 | 1.018 | 0.986 | 1.021 | 0.997 | 1.003 |
| 2016 | 0.966 | 1.073 | 0.986 | 0.979 | 1.037 |
| 2017 | 1.019 | 0.926 | 0.996 | 1.024 | 0.944 |
| 2018 | 1.005 | 1.014 | 1.016 | 0.988 | 1.019 |
| 2019 | 1.018 | 0.972 | 1.000 | 1.018 | 0.990 |
| 2020 | 0.977 | 1.080 | 1.002 | 0.976 | 1.055 |
| *Mean* | *1.001* | *0.989* | *1.001* | *1.000* | *0.991* |

finding signifies that on an average sample banks have comparatively low and a regressive productivity change. The decline in total factor productivity has been particularly a result of technical efficiency deterioration in listed banks. The annual average technical efficiency of listed banks over the study period was 0.989 which illustrates the sample banks would have decreased their input approximately by 1.1% to generate the same output. This finding signifies that on an average sample banks are technically inefficient. Besides, the annual mean of Pure efficiency change and scale efficiency were 1.001 and 1.00 together. When the pure technical efficiency is larger than scale efficiency, then we infer the effectiveness is caused by scale.

Figure 3 demonstrates efficiency change stretches the minimum phase in 2016, and in 2013, it stretches its climax phase. Technology change stretched the minimum phase in 2012 and stretched its climax phase in 2020. Productivity change stretches the minimum phase in 2016 and in 2015, it stretches its climax phase. As for scale efficiency change, it stretched the minimum phase in 2020 and stretched its climax phase in 2013. Total factor productivity change stretches the minimum phase in 2012 and in 2013, it stretches its climax phase. From this, we can infer the industry relatively achieved better productivity performance in 2018 and productivity performance in the years 2012 and 2014.

It can be noted that the level of efficiency change, technical efficiency change, pure efficiency change, scale efficiency change, total factor productivity change is continuously fluctuating throughout the years 2012 to 2020. This indicates a minor productivity change among the sample banks over the study period.

According to Table 8, the TFP performance of Ethiopia's listed commercial sector banks. In Ethiopia's financial system, commercial banks' responsibilities are steadily increasing. According to TFP change, 6 (42.8%) banks increased their average annual TFP, whereas 8 (57.2%) banks decreased their total factor productivity. It was also observed that technological advancement has been noted in 5 (about 35.7 percent) of the banks. On the other side, 9 banks (about 64.3 percent) show a deterioration in technology during the study period. As a result
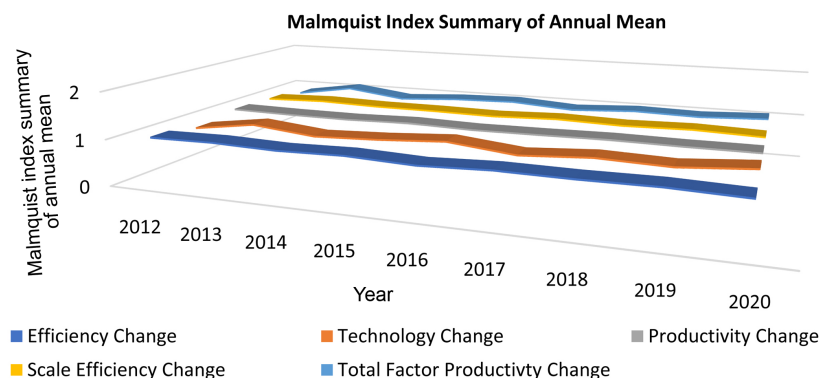


**Figure 3.** A Malmquist index summary of annual mean.

Table 8. Summary of Malmquist productivity index of bank means, 2012 to 2020.

| Firm | effch | techch | pech | sech | tfpch |
|---|---|---|---|---|---|
| CBE | 1.000 | 0.965 | 1.000 | 1.000 | 0.965 |
| AWASH | 1.018 | 0.992 | 1.005 | 1.012 | 1.010 |
| BOA | 0.994 | 1.059 | 1.002 | 0.992 | 1.053 |
| DB | 0.988 | 1.043 | 1.000 | 0.988 | 1.031 |
| CBO | 1.012 | 1.056 | 1.005 | 1.007 | 1.069 |
| HB | 1.003 | 0.983 | 1.003 | 1.001 | 0.986 |
| WB | 1.000 | 0.973 | 1.000 | 1.000 | 0.973 |
| NIB | 1.000 | 0.894 | 1.000 | 1.000 | 0.894 |
| OIB | 0.995 | 0.949 | 0.999 | 0.996 | 0.944 |
| LIB | 1.000 | 0.939 | 1.000 | 1.000 | 0.939 |
| BRB | 0.998 | 0.963 | 1.000 | 0.998 | 0.961 |
| BUIB | 1.010 | 0.984 | 1.000 | 1.010 | 0.994 |
| ZB | 0.988 | 1.049 | 1.000 | 0.998 | 1.047 |
| AB | 1.000 | 1.020 | 1.000 | 1.000 | 1.020 |
| **Mean** | **1.001** | **0.989** | **1.001** | **1.000** | **0.991** |

of the empirical data, the total factor productivity variation is 0.991, which is less than 1, indicating a 0.9% decline throughout the research period (2012-2020). Total factor productivity has fallen as a result of deteriorating technological efficiency in privately held commercial banks.

Figure 4 demonstrates that the Cooperative Bank of Oromia has the highest mean positive change in TFP of 6.9%. The 6.9% productivity achievement for the Cooperative Bank of Oromia contains an efficiency growth of 1.2% and technological increases of 5.6%. Nib international bank reported the lowest average TFP transform with an average deterioration of around 10.6% in the total factor productivity index.

## 4.3. Determinants of Bank Efficiency

After looking at efficiency as an important determinant factor of performances, we have moved the quantitative analysis to explore which of the inputs and outputs variables are the determinant factors of efficiency. The bank efficiency score is regressed using one-step system GMM using efficiency as the dependent variable with the previous year bank efficiency, total deposit growth, total loan growth, branch expansion growth, and size as explanatory (determining variable) without separating the bank into distinct categories. From the result, we can infer that the lag of individual bank efficiency, deposit growth rate, loan growth rate, bank growth rate (natural logarithm of the total asset) has a significant and positive impact on the efficiency of the banks. On the other hand, branch expansion has a negative and insignificant impact on the efficiency of the bank (Table 9).
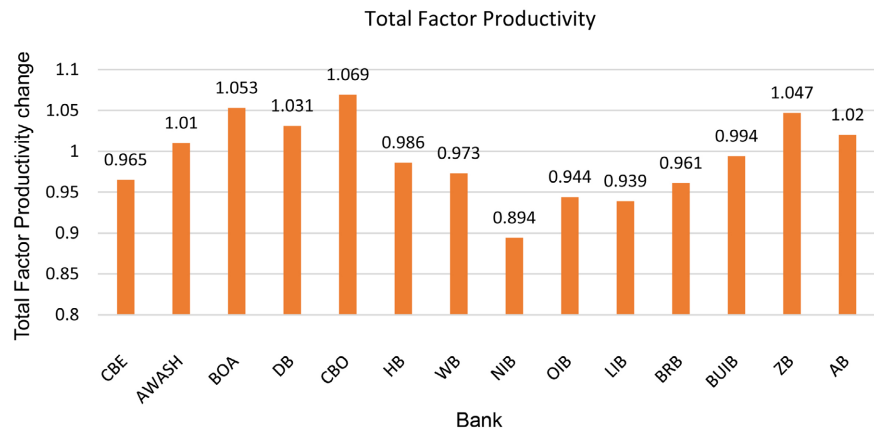
**Figure 4.** A Malmquist index summary of annual mean of total factor productivity change.

**Table 9.** Empirical results on efficiency determinants.

| Regressors | One-step system GMM result | |
| --- | --- | --- |
| | Coefficients | P-value |
| l.Eff | 0.201 | 0.029** |
| ln(TD) | 0.636 | 0.000*** |
| ln(TL) | 0.432 | 0.020** |
| ln(BE) | −0.043 | 0.283 |
| ln(TA) | 0.024 | 0.000*** |
| Cons_ | 86.22 | 0.002*** |
| Hansen Test of Overid. Restrictions | chi2 (43) = 47.88 | Pr > chi2 = 0.453 |
| Arellano-Bond Test for Autocorrelation | AR (1): z = −2.13 | Pr > z = 0.033 |
| | AR (2): z = 1.18 | Pr > z = 0.236 |
| No of Observation | 14 Commercial Banks * 10 years = 140 Observations | |

## 5. Conclusion and Implication

### 5.1. Conclusion

The current study used the DEA-based Malmquist Index and measures the changes in total factor productivity and efficiency of Ethiopian commercial banks during the period 2011-2020. The paper used aggregate panel data covering the 14 commercial banks that were operational in Ethiopia during the study period. The total factor productivity change, measured by the Malmquist productivity index, was decomposed into efficiency change and technology change while the efficiency change was decomposed into pure and scale efficiency changes. The technology change represented innovation in the banking system and the pure efficiency changes the core efficiency gained due to improved operations and

management practices. Besides, the scale efficiency change was used to measure efficiency gains due to scale effects.

We found nominal efficiency change both due to improved operations and management practices as well as increased scales. However, a deterioration in efficiency was observed as a result of technological change. Moreover, total factor productivity, which entails the overall changes in efficiency and technology, showed a nominal regress during the studied period. Hence, we conclude a regressive, and progressive impact of technology, and improved management practices on the productivity of Ethiopian banks, respectively.

The paper also concludes private banks were more efficient in mobilizing resources than the state-owned bank though no notable difference was observed in converting deposits to loans. Following this, we also conclude the production approach as the preferred model in analyzing Ethiopian banks' productivity change compared to the intermediation approach. Moreover, we conclude little difference in total factor productivity change using both the production (0.964) and the intermediation (0.991) approaches.

Finally, via the one-step system GMM paned data model we conclude deposit growth rate, loan growth rate, bank size has a significant and positive impact on the efficiency of Ethiopian banks except for branch expansion.

## 5.2. Practical Implication

The nominal regress in productivity owing to technological change cast doubt on the appropriateness of technology choice of Ethiopian banks. Thus, banks need to make a thorough feasibility study in their choice of technology.

## 5.3. Policy Implication

The relatively poor performance of the state-owned bank in resource mobilization may partially be related to its monopoly in accessing the financial resources of the Federal government. Such preferred treatment might have limited the competitiveness of the bank in deposit mobilization. Thus, if the state-owned bank has to improve its efficiency in deposit mobilization, it has to recraft its deposit mobilizing strategy and align such performance with attractive incentives.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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