

## Measuring Commercial Banks' Efficiency in Rwanda: A Stochastic Frontier Analysis

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**Abstract:** The objective of this study was to measure the efficiency of commercial banks in Rwanda for the period 2007-2013. Measuring banks' efficiency provides information on the financial healthiness of such institutions with respect to translating limited inputs into financial services and products which in turn can be used to improve their efficiency and propel also the economy. The study applied a cost stochastic frontier analysis on data collected on seven commercial banks and found a mean cost efficiency of 88.56%. This implies that banks jointly would have utilized only 88.56% of the utilized resources to achieve the same output that they produced, suggesting that 11.44% of the resources used were wasted. The study found further that the foreign bank owned have significantly improved efficiency while shorter tenure of banks' Chief Executive Officer (CEO) worsened the efficiency of banks. To achieve higher efficiency, banks in Rwanda should commit to stabilise the tenure of CEOs in office and continuously keep up with banking update technology.

**Key words:** Stochastic frontier analysis, cost efficiency, bank, Rwanda

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### INTRODUCTION

Efficiency of banks has been extensively subject to many studies and public commentators discourse. Generally, it is established in the literature that if the banking sector is performing at high efficiency levels with the existing resources, the sector can provide better services and make a larger contribution to economic growth (Freixas and Rochet, 2008). On the contrary, if the sector performs at low level of efficiency, any worthwhile contribution would either be greatly diminished or absent. A study on bank efficiency and financial development in Sub-Saharan Africa (SSA), conducted by Kablan (2010), found that SSA banks that are less developed have problems in translating deposits collected into loans to the private sector. In 2003, the whole sub-region displayed an intermediation ratio of 51%, compared to 75% for Latin America and 91% for Asia.

Important studies on bank efficiency have been conducted in developed economies at regional or at country level. A comprehensive compilation by (Berger and Humphrey, 1997) indicates that out of 116 single countries covered by the survey, 81 are from developed countries; 66 from the United States (US), 14 from Europe and 1 from Canada. Some other studies have focused on Asian countries (Bhattacharyya *et al.*, 1997;

Chen, 2001, Hardy and Patti, 2001, Xiaoqing *et al.*, 2007) and Latin America (Thompson *et al.*, 1997, Carvallo and Kasman, 2005).

A limited number of studies have covered some African countries (Chaffai, 1997; Agu, 2004; Stork *et al.*, 2005; Kablan, 2007; Chen, 2009; Ncube, 2009; Muvungi, 2015). Very few studies have focused on SSA countries (Agu, 2004; Aikaeli, 2006; Onour and Abdalla, 2010; Lelissa 2014; Murugesan *et al.*, 2015) among others but none of these applied a stochastic frontier approach. Yet, only one made mention of efficiency in the Rwanda banking sector with only 23 observations from a sample of 152 countries (Koetter *et al.*, 2009). However, to the best knowledge of the authors, there has been no exclusively published study on efficiency measures for commercial banks operating in Rwanda. Therefore, this study aims at addressing the shortcomings in a meaningful way thereby adding to the body of literature in this field. This study differs from the aforementioned study on the fact that it concerns a recent period, 2007-2013, counts more observations (49 compared to 23) and focuses on commercial banking which dominates the banking sector in Rwanda, accounting for about 78.6% of total banking assets (National Bank of Rwanda 2014). The study utilizes a more contemporary approach in analyzing efficiency, since the stochastic frontier approach seems to have been neglected in the studies

conducted in individual Sub-Saharan Less Developed Countries.

This assessment is worthwhile because stakeholders in the banking industry can make use of our findings in making rational decisions. Depositors can be to a greater extent, more confident of the soundness of the institutions in keeping their financial assets (cash, savings deposits and term deposits). Shareholders do expect dividends and business continuity while regulators can take advantage in policy formulation. The efficiency of the sector can also be a driving factor for investors to come to the country either by establishing new business or engaging in joint venture or just lending funds to banks directly or through the purchase of established companies' bonds. This kind of analysis helps banks' management to improve the possibility of their institution survival in a globalised, integrated and competitive financial market (Isik and Hassan, 2002).

This study is carried out using an effect stochastic frontier analysis approach for the period 2007-2013. The technique is classified among the more contemporary parametric measurement techniques that are the Stochastic Frontier Analysis (SFA) by Ferrier and Lovell (1990), Fu and Heffernan (2007), Assaf *et al.* (2013) and non-parametric method such as Data Envelopment Analysis (DEA) (Jackson and Fethi, 2000; Mostafa, 2007; Yang *et al.*, 2011). The study adopts the SFA approach because among the modern and most popular frontier analysis techniques, SFA is the best-fit in analyzing institutional efficiency as it accounts for statistical noise (Ferrier *et al.*, 1999; Pastor *et al.*, 2002; Coelli *et al.*, 2005; Carvallo and Kasman, 2005; Karmann *et al.*, 2006; Kao and Liu, 2009). These scholars argued that empirical efficiencies calculated from a non-parametric technique such as DEA model provide low consistent estimators of the true inefficiencies.

Furthermore, the study adopts the intermediation approach because in the recent literature most studies on bank efficiency used the intermediation approach as it has fewer data problems than the production approach (Ncube, 2009; Kablan, 2010; Aiello and Bonanno, 2013). It considers interest income and non-interest operating income as outputs and the operating costs (price of labor, price of physical and intangible assets and price of interest-bearing deposits) as inputs. In addition, this approach captures real interconnections in the banking sector as an intermediary between savers and lenders, since funds are primarily raw material in the process of banks' profit maximization objective (Berger and Humphrey, 1997).

The cost gives the minimum expenditure needed to produce a given level of output given inputs prices. A bank is inefficient if its costs exceed the theoretical

minimum of the most efficient bank using the same input-output combination (Heffernan 2005, Greene 2008). Meaning that it produces less than what is expected from the inputs used by that bank at the given level of technology. The major concern is if the bank's management responds correctly to relative input prices in choosing its inputs and outputs, aiming at minimising the technical inefficiencies, hence raising economic efficiency. Ideally, expectations are in such a way that an efficient bank remains efficient from period to period and inefficient ones improve their level of efficiency over time (Coelli *et al.*, 2005). It is important to note that technical inefficiency or (put in other words), inputs inefficiency is the consequence of ineptness or failure to effectively utilise the inputs by the producer or employing a sub-optimal combination of these inputs to produce a given quantity of output (Isik and Hassan, 2002).

Cost efficiency can be expressed as the ratio between the minimum threshold of cost of a potential efficient bank and the cost level of actual observed bank (Aiello and Bonanno, 2013). Any bank's cost must lie on or below the frontier. Deviations from the frontier reflect both technical inefficiency ( $u_i$ ) and allocative inefficiency ( $v_i$ ). Technical inefficiency refers, for example, to the over-use of inputs like expansion of staff and for allocative inefficiency when resources are not allocated efficiently like the bank's failure to react optimally to the vector of inputs prices. The higher the  $u_i$  observed at a categorical time, the more resources that bank  $i$  wastes at time  $t$  to produce a given output vector ( $y_{jit}$ ) and the more is this bank inefficient (Sanchez *et al.*, 2011).

The analysis of efficiency in banking sectors has been an issue of focus by quite a number of studies. Some studies focused on cost efficiency (Hasan *et al.* 2005; Maggie and Heffernan, 2007; Lelissa 2014) while others on cost-profit analysis (Isik and Hassan, 2002, Ncube, 2009). Given that this study applies a stochastic cost frontier analysis in measuring the commercial banks' efficiency in Rwanda, the review focused much on cost frontier related studies.

Cost efficiency models are based on expenditure to acquire total inputs (total cost), output quantity and input prices data (Kumbhakar and Lovell, 2000). They do not utilise inputs quantity data in their estimation because researchers presume that banks take present input prices and output quantities as given and then attempt to minimise costs by employing the optimal level of inputs (Isik and Hassan, 2002). Cost efficiency is considered as a measure of how far a bank's cost is from the best practice bank's cost setting, if both have to produce the same bundle of output under the same environmental conditions. Thus, the cost function specifies the minimum

cost of producing the output vector,  $y$ , given the cost drivers, such as price vector  $p$  (labour,  $P_L$ ; capital,  $P_K$  and funds,  $P_F$ ) and some exogenous factors out of managers' control. Estimation of cost frontier can be accomplished in situations in which producers produce a single output or multiple outputs (Kumbhakar and Lovell, 2000).

The measure of cost efficiency is bounded between zero and unity and attains its upper bound if and only, a producer uses a cost-minimizing input vector. Cost inefficiency can arise depending on one hand on employing an excess amount of inputs (technical inefficiency) and on the other hand in having sub-optimal mix of inputs (allocative inefficiency). Maggie and Heffernan (2007) argue that firms become more X-efficient by lowering costs, through for example, improved management and/or greater employees' productivity, which brings them closer to a more efficient way of exploiting available resources.

Empirical studies in banking sector have been carried out using translog cost functions or Cobb-Douglas cost functions and very few studies have been conducted applying effects cost frontier models (Greene, 2005). Many of these studies have found banks to be cost efficient. In a study of level of efficiency of Ethiopian Banks for the period 2008 – 2012, using a DEA approach, Lelissa (2014) found that the sector was at average level of cost efficiency of 86.7%. In the same line, Ncube (2009) applied a translog cost frontier model and found improvements in cost efficiency of 8 commercial banks in South Africa from an average mean of 40.4% in 2000-66.2% in 2005. Using a translog cost frontier function to assess bank efficiency in the West African Economic Monetary Union (WAEMU) for the period 1993-1996, Kablan (2007) found an average of cost efficiency of 67%. Conducting the test of bank efficiency using a translog cost frontier model on a sample of 152 countries, (Koetter *et al.*, 2009) found that the mean cost efficiency was between 28 and 91% with Micronesia, Ethiopia and Honduras exhibiting relatively higher efficiency. Micronesia had a score mean cost efficiency of 91.1% while Ethiopia and for Honduras had a mean cost efficiency of 90.6% each.

Adopting a DEA approach, Hauner and Peiris (2005) also found an average of bank cost efficiency of 92.6% in Uganda for the period 1999-2004, just after the introduction of privatisation of the largest state-owned Uganda Commercial Bank. Aikaeli (2006) found a level of about 8.56% of X-inefficiency of commercial banks in Tanzania for the period 1998-2004, using a translog cost frontier function whereas with DEA estimates, the overall technical efficiency were 96.1% under Constant Returns to Scale and 97.3% under Variables Returns to Scale. Analysing the bank-specific, industry-specific and

macroeconomic determinants of bank efficiency in Tanzania for the period 2005-2008 under DEA approach, Raphael (2013) found that technical inefficiency were at 13%, a slightly increase compared to previous findings, 8.56%. Explanations are in line with the effects of international global financial crisis of 2007- 2009. Closer to that period of 2009, 1997-2009, a study conducted by Kamau (2011) on efficiency of banking sector in Kenya, using DEA have the same patterns. The performance of the commercial banks in Kenya was above 40%. The technical efficiency was about 47% under the Constant Returns to Scale, 56% under Variable Returns to Scale and 84% under Scale Efficiency. Using data from 1988-1997 and employing a DEA approach to assess the cost efficiency of Taiwanese banks following financial liberalisation, Chen (2001), found bank's X-efficiency had substantially increased in the Taiwan's deregulated banking market because average X-inefficiency decreased from 3.9% in 1988-2.0% in 1997.

Some studies found weak cost efficiency estimates or even the inverse, meaning an overall decrease in cost efficiency implying an increase in total cost. Applying a translog cost frontier model to estimate X-efficiency and scale-efficiencies of banking sector of Croatia for the period 1994-1995, just after the liberalisation policy of 1990, Kraft and Tyrtyrođlu (1998) found new banks being more X-inefficient and more scale-inefficient while remaining highly profitable although the relationship was weak. They argued that probably it is due to experience that old banks operate closer to efficient scale and with comparable or even better levels of managerial efficiency than new banks. Similarly, Hao *et al.* (2001), using a translog cost frontier on data from 1985 -1995, reported that financial reforms in Korea that took place in 1991, had a little or no significant effect on banks' X-efficiency. In the same line, Hardy and Bonaccorsi (2001) observed an increase in costs, when analysing the X-efficiency of all Pakistan banks for the period 1981-1997, just aftermath the financial sector reforms of late 1981s. They argued that an increase in total cost was placing limit on banks' performance. Relative increase in cost inefficiency was also observed by Kiyota (2009) in a study conducted on 29 Sub-Saharan African countries during the period 2000-2007. Applying a translog cost frontier to estimate the efficiency of banks in these countries, he found that banks had experienced cost inefficiency of 1.05 and 1.06%. Maggie and Heffernan (2007) fitted a translog cost frontier to examine the cost X-efficiency in China's banking sector for the period 1985-2002. Their findings do not differ substantially from two previous highlighted. Their results show that banks were operating 40-60 % below the X-efficient frontier.

Other studies explored the relationship between X-efficiency and type of bank ownership, for example domestic versus foreign, public versus private. Once

more, empirical findings are mixed. In a study analysing the efficiency of Kenyan Private Banks versus Public Banks, applying a DEA approach, Murugesan *et al.* (2015) report that public banks were relatively performing better than their counterparts' private ones. Their average efficiency score was 0.995492 against 0.995188 of the private banks. Studying the impact of new financial reform in the banking sector, where by 1998, Hungary adopted to privatise banks, Hasan and Marton (2003) concluded that bank reform in Hungary improved X-efficiency scores between 1993 and 1998. Banks with higher foreign ownership involvement were associated with lower inefficiency of 20.96% compared to 24.84% for those with no any form of foreign involvement. However, they contrast those of Tahir, Bakar *et al.* (2010) in a study on the efficiency levels of domestic versus foreign banks in Malaysia for the period 2000 – 2006. Their results suggest that domestic banks had higher mean cost efficiency of 88.2%, relative to foreign banks, 75.5%. Many of these empirical studies on the efficiency in the banking sector have been carried out either in a cross-sectional cost frontier models or in panel data cost frontier models using non-parametric DEA specification or parametric translog-stochastic frontier specification (Kraft and Týrtýrođlu 1998, Hasan, Koetter *et al.* 2009). Very few studies were based on banking effects cost frontier models among others (Greene 2005). Nevertheless, none of these studies specifically covered the Rwandan commercial banking sector. Findings confirm a mean cost efficiency of 88.56%, implying that banks jointly wasted about 11.44% of available resources to produce the level of output that they produced. In addition, inefficiencies were found statistically significant decreasing over time with the penetration of foreign owned banks in the Rwandan banking sector and increasing with the short replacement of Chief Executive Officers (CEOs) in office.

## MATERIALS AND METHODS

**Model specification:** In the stochastic frontier model, it is necessary to assume that the bank-specific characteristics drivers of inefficiency enter the model in form of “effects” and are uncorrelated with the inputs levels (Greene, 2005). In this study, these effects are assumed to vary across cross-sectional units at a given point in time and also exhibit variation over time. This approach circumvents the shortcoming of the assumption that inefficiency is time invariant. In reality, to assume that bank specific deviations are time invariant is to some extent unrealistic as argued (Greene 2005). There is no persuasive reason to suppose the bank specific deviations to be time invariant because ideally,

expectations are in such way that an efficient bank constantly improve their efficiency status from period to period and inefficient ones to work to change positively their level of efficiency over time (Coelli *et al.*, 2005). The bank specific inefficiency is thus measured relative to the best performing bank in the sample. To estimate the cost efficient frontier, we adopt the Stochastic Frontier Model following (Battese and Coelli, 1995; Greene 2005) which is given by the following Eq. 1:

$$TC_{it} = f(X_{it}, Z_{it}) + v_{it} - u_{it}$$

Where:

- $TC_{it}$  = The total cost of a given bank  $i$  at period  $t$
- $X_{it}$  = The vector of explanatory variables which are the output produced by a given bank  $i$  at period  $t$
- $(Y_{it})$  = Inputs prices of a given bank  $i$  at period  $t$  ( $P_{it}$ )
- $(Y_{it})$  = Comprise interest income ( $y_{lit}$ ) and non-interest income ( $y_{nit}$ )
- $(P_{pit})$  = A vector of price of labor (PL) and price of capital (PF) and price of funds (PF)

The time Trend (T) variable is incorporated into the model accounting for Hicksian neutral technical change (Battese and Coelli 1995). The  $Z_{it}$  is a vector of exogenous variables which in this study are banks' specific characteristics not related to the cost function structure, but which influence the total cost. These banks' characteristics in this study are related to the type of ownership (foreign) and government intervention either in management or majority in shareholding (gov) and the replacement of CEO in office (mgt):

- $i = 1, \dots, N$  (N: number of banks involved in the study)
- $t = 1, \dots, T$  (T: number of years covered by the study)

$$v_{it} - u_{it} = \varepsilon_{it} \quad (1)$$

Where:

- $u_{it}$  = A non-negative random variable associated with technical inefficiency
- $v_{it}$  = Accounts for statistical noise meaning it may take any value.

The  $u_{it}$  denote a rise in cost of production due to the inefficiency factor that may result from mistake of management (managerial ineptness) as argues Isik and Hassan (2002). In other words, management has a certain level of control on such costs leading to inefficiency. The  $v_{it}$  represents a failure of employing an optimal quantity or mix inputs given their prices (Isik and Hassan, 2002). It may also temporary rise or fall in the banks' cost due to unexpected or uncontrolled random shocks that may stop

the smooth production process. Such factors are like an unusual higher number of equipment failure, power shortage, bad weather, labor strikes, war, flood and drought. These cannot be changed by the management. Meaning, deviations from frontier may not be entirely under the full control of banks' management. Random factors errors follow a symmetric distribution, mostly the standard normal. We introduce the logarithms of both sides to make the function to be estimated using the linear regressions techniques (Coelli *et al.* 2005). In so doing, Eq. 1 becomes:

$$\ln TC_{it} = \ln(Y_{it}, P_{it}, Z_{it}) + v_{it} - u_{it} \quad (2)$$

As, in accordance with the assumed constraint of linear homogeneity in inputs prices, Cost (TC), Price of Labor (PL) and Price of Funds (PF) are normalized by the Price of Labor (PL). Replacing  $Z_{it}$  by the bank form of ownership (foreign), government (gov) and management (mgt) leads to the following Eq. 3

$$\ln \left( \frac{TC_{it}}{PL_{it}} \right) = \beta_0 + \sum_{j=1}^2 \beta_j \ln y_{jit} + \sum_{n=1}^2 \alpha_n \ln \left( \frac{P_{nit}}{PL_{it}} \right) + \gamma_1 T_{it} + \delta_1 \text{foreign}_{it} + \delta_2 \text{gov}_{it} + \delta_3 \text{mgt}_{it} + v_{it} + u_{it} \quad (3)$$

Designing  $TC_{it}/PL_{it}$  by  $tc_{it}$ ,  $P_{nit}/PL_{it}$  by  $p_{nit}$ , Equation 3 becomes labeled into Eq. 4:

$$\ln tc_{it} = \beta_0 + \beta_1 \ln y_{1it} + \beta_2 \ln y_{2it} + \alpha_1 \ln p_{1it} + \alpha_2 \ln p_{2it} + \gamma_1 T + \delta_1 \text{foreign}_{it} + \delta_2 \text{gov} + \delta_3 \text{mgt} + v_{it} + u_{it} \quad (4)$$

The  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$  are vectors of unknown parameters to be estimated.  $\ln$  denotes the natural logarithm,  $\varepsilon_{it}$  is the composite error term,  $\varepsilon_{it} = v_{it} - u_{it}$ :

$$\varepsilon_{it} = TC_{it} - f(X_{it}, Z_{it})$$

In the stochastic frontier model it means that if a bank  $i$  in the sample is assessed fully efficient, meaning  $u_i = 0$  other banks are compared to it rather than to an absolute standard (Greene, 2008). Parameters are estimated by the method of maximum likelihood with assumptions of a normal truncated distribution for inefficiency term. Individual values of X-inefficiencies are calculated using the following formula of Jondrow *et al.* (1982), given by Eq. 6:

$$E(u_i | \varepsilon_i) = \sigma_u \left[ \frac{\phi \left( \frac{\varepsilon_i \lambda}{\sigma} \right)}{1 - \phi \left( \frac{\varepsilon_i \lambda}{\sigma} \right)} - \left( \frac{\varepsilon_i \lambda}{\sigma} \right) \right] \quad (6)$$

Where:

$\phi(\cdot)$  = A standard normal density function,

$\Phi(\cdot)$  = A standard normal cumulative density function

$$\lambda = \frac{\sigma_u}{\sigma_v}, \sigma^2 = \sigma_v^2 + \sigma_u^2, \sigma_u^2 = \frac{\sigma_u^2 \sigma_v^2}{\sigma^2} \text{ and } u_i = \frac{\sigma_u^2 \varepsilon_i}{\sigma^2}$$

Suppose ?? (Greene, 2005) suggests rewriting equation (6), as follows:

$$E(u_{it} | \varepsilon_{it}) = \sigma_u \left[ \frac{\phi(\alpha_{it})}{1 - \phi(\alpha_{it})} - (\alpha_{it}) \right] \quad (7)$$

where  $\pm \varepsilon_{it}/\sigma$  The sign (+) is associated with the production frontier function and (-) to cost frontier function. The main obstacle or fundamental obstacle result in that the inefficient component of the model,  $u_{it}$  is not observed directly. Data and estimates provide only  $\varepsilon_{it} = v_{it} + u_{it}$  whereas the ultimate objective is to estimate  $u_{it}$  which contains the bank specific heterogeneity.

Technical efficiency for bank  $i$  at period  $t$  is defined by the Eq. 8:

$$TE_{it} = \exp(-U_{it}) \quad (8)$$

If  $\lambda (\sigma_u/\sigma_v)$  which is under the management control, attains large values, meaning  $\lambda > 0.5$  then the inefficiency factor dominates the random factor which is beyond the management control (Aigner *et al.* 1977). In other words, by  $\lambda > 0.5$ , the inefficiency factor ( $u_{it}$ ) out weights the random factor ( $v_{it}$ ). Similarly, deviations from the frontier can be essentially due to technical inefficiency when the value of gamma ( $\gamma$ ) becomes higher towards one. It means that much of the variation in the composite error term is attributed to inefficiency component (Battese and Corra, 1977). Under any of the two cases where deviations from the frontier are much due to inefficiency factor (Battese *et al.* (2005) argue that technical efficiency is closer to cost efficiency. So, a measure of cost efficiency for banks  $i$  at period  $t$  can be defined by the following Eq. 9:

$$CE_{it} = \exp(-U_{it}) \quad (9)$$

The inefficiency effects estimates for bank  $i$  at period  $t$  are defined by Eq. 10:

$$U_{it} = \delta_0 + \delta_1 \text{foreign} + \delta_2 \text{gov} + \delta_3 \text{mgt} + e_{it} \quad (10)$$

**Data description:** To measure commercial banks efficiency in this study, the authors used data from banks' audited financial statement of seven commercial banks that were operating in Rwanda during the period covered by this research 2007 to 2013. These are the Bank of Kigali Ltd (BK), I&BM Bank (the former Banque Commerciale du Rwanda Ltd, BCR), Banque Populaire du Rwanda Ltd (BPR), ECOBANK Ltd (former Banque du Commerce de Developpement et d'Industrie, BCDI), G-T Bank (former, FINABANK Ltd and BACAR), Compagnie Générale des Banques Ltd (COGEBANQUE) and Access Bank Ltd (former Banque en la Confiance d'Or, BANCOR). The sample includes 49 observations with a minimum of seven observations per bank.

As stated earlier in study 1, the study adopts an intermediation approach which considers operating income as outputs and operating costs as inputs. Thus the variables used in this study are described on Table 1.  $TC_{it}$  in Rwandan francs (000 Rwf) is the total cost of a given bank  $i$  at period  $t$ , the total amount of interest paid on deposits and borrowed funds plus non-interest operating costs. The  $Y_{it}$  in Rwandan francs (000 Rwf), represents the total amount of interest income produced by a given bank  $i$  at period  $t$ .

The  $y_{it}$  in Rwandan francs (000 Rwf), represents the total amount of non-interest income produced by a given bank  $i$  at period  $t$ . The  $y_{it}$  is a ratio of price of capital (PK) over the Price of Labor (PL). The price of capital is the total amount spent as depreciation of equipment property and intangibles assets of a bank  $i$  at period  $t$  divided by the total assets (physical and intangibles) of that bank. The price of labor is the total expenses on compensation of employees (wages and salaries as well as fringes benefits) of a bank  $i$  at period  $t$  divided by the total number of its employees.

The  $P_{it}$  is a ratio of Price of Funds (PF) over the Price of Labor (PL). Price of funds is the total amount spent as interest on deposits and borrowed funds of a bank  $i$  at period  $t$  divided by the total amount of those funds. The  $T$  trend variable,  $T = 1, 2, 3, 4, 5, 6, 7$  for years 2007, 2008, 2009, 2010, 2011, 2012, 2013.

The Foreign, gov and mgt together represent a vector of banks' characteristics. These banks' characteristics in this study correspond to the type of ownership (foreign), government intervention either in management or majority in shareholding (gov) and the replacement of CEO (mgt). Foreign is a dummy variable that takes a value of 1 if the majority in shareholding in bank  $i$  at period  $t$  was owned by foreigners and 0 otherwise.

The Gov is a dummy variable that takes a value of 1

if major government intervention occurred to prevent bankruptcy of the bank  $i$  at period  $t$  or supervised directly by Central Bank/enjoyed government good-will and 0 otherwise.

The Mgt is a dummy variable that takes a value of 1 if a bank  $i$  had in a minimum of two CEOs in the office in the period covered by the study, 2007 and 2013 and 0 otherwise.

## RESULTS AND DISCUSSION

In this study, we present and discuss the frontier cost function estimates reported in Table 2. The parameter estimates of Price of Labor (PL) are not shown because, the cost and other input price were normalised at the price of labor. We present and discuss further cost efficiency scores (Table 3) as well as factors influencing inefficiencies in Table 4. Results were interpreted using cost efficiency scores which vary between 0 and 1 (Battese *et al.*, 2005). In percentage, the cost efficiency varies between 0 and 100. The lower the ratio, the more inefficient is the bank and the higher the ratio, the more efficient is the bank. Therefore, 1 or 100% refers to the best performing bank, meaning which is at the frontier while 0 or 0% refers to the worst bank observed in the sample. Comparison of efficiency is made within the bank over the period and across banks as well.

From the cost function estimates reported in Table 2, looking at input prices, the most expensive factor of production is capital, relative to the price of labor. This phenomena is a typical characteristic for developing countries (Isik and Hassan, 2002). It suggests that in addition to the routine costs of investment in branches expansion, banks increase their spending in acquiring core banking software so that they can be able to handle modern sophisticated banking operations, equipments for ATMs machines, computers, material for communications, equipment and material for new branches, security infrastructure at the banks' premises as well for funds transportation.

The estimated coefficient of  $t$  is positive, albeit weak and is insignificant. It indicates that the total costs have a tendency to increase by a small margin over the seven-year period. Explanations may be related to the theoretical insight from the "Schumpeterian Theory of Creative Destruction" revisited by McCraw (2007) which refers to the process whereby new production units replace the obsolete ones. Meaning banks have been constantly working on replacing old ways of conducting business by adopting new ways associated with the new technology, training new skills in bank management, hence tending to a slight increases in the total cost. The

penetration of foreign-owned banks on the Rwandan financial market has a negative significant influence on total costs. Explanations may be in line with the fact that foreign investors may have access to low cost funds and may also bring in the know-how in technology and modern techniques in financial management as well as new tools of analysis of banking operations, hence influencing the total costs to decrease. The government involvement coefficient (gov) is negative though not significant. This indicates that government gives at some extent a monopolistic position to beneficiary banks in collecting important demand deposits that may be even free of interest rate. Thus, the bank gets somehow a room for manoeuvre as it can increase its loans since, the ratio of total loans to deposits will be relaxed. So, the cost that the bank should have used pay to sensitise customers for deposits is reduced leading to a level of total cost decrease. Top management instability (mgt) while not significant, was found to contribute to an increase in total cost. The short time of CEO in the office causes the total cost to increase. This may be in relation with the fact that the new CEO of the bank needs time to master the working environment in order to give a direction to the bank which may be associated with extra costs for example, for consultancy in developing new tools as well as trainings. So, temporarily, it is possible to take time for the new CEO to be fully in control of the bank. The replacement of the CEO may also involve fees payment as final account to the outgoing CEO. The incoming CEO may also require extra benefits and in sum this can increase the total cost of the bank. From the above cost frontier estimates, the next step is to derive the mean cost efficiency.

With the value of gamma ( $\gamma$ ) equals to 0.76 (Table 2) which is high as well as estimated  $\lambda = 1.785$  higher than 0.5, it means that much of the variation in the composite error term is attributed to inefficiency component, thus, based on the frontier cost function estimates reported in Table 2, cost efficiency can be estimated by Eq. 9 following Battese *et al.* (2005). For the reminder, efficiency as well as inefficiency is a comparative measure to the best practice bank among the seven of our sample operating under the same conditions, not relative to the best practice elsewhere beyond the limits of the sample of this study.

Findings displayed on Table 3 indicate that the mean cost efficiency over the period covered by this study is 88.56%. This implies that throughout the period, banks jointly would have needed only 88.56% of resources to produce the level of output that they produced. So, about 11.44% of total costs were wasted relative to the bank on the frontier having the same inputs. Equally, cost efficiency has improved as observed on Table 3, from

85.43 in 2007 to 92.32 in 2013 and further confirmed by the positive sign of eta, as argues (Battese *et al.*, 2005). When eta ( $\eta$ ) has a positive sign (Table 2), this suggests an improvement in cost efficiency over time, although not statistically significant. Thus, making reference to the study by Hasan *et al.* (2009), the mean efficiency has improved from 57.6-88.56% found in the current study.

The bank's cost efficiency score ranges between 83.10-96.03%. The bank that operates at lower mean cost efficiency level 83.10%, suggests that it wastes about 16.90% of its resources relative to best performing bank in the sample. Out of the seven banks investigated, only three operate above the mean efficiency. It is interesting to note that two out of four of foreign owned banks say 50% have a cost efficiency score greater than the mean cost efficiency (88.56%) while only one over three domestic banks, representing 33.3% operates above the mean cost efficiency. This suggests that foreign owned banks are relatively more cost efficient than domestic banks. Explanations may be in line with the fact that foreign investors bring in the more advanced technology and best practices in bank management.

These findings line up with other previous findings in the literature, such as that of Bonin *et al.* (2005) in a study on the impact of privatization of banks in transition economies. Their findings show that foreign banks were most efficient and government-owned banks were least. Similarly, Hasan and Marton (2003) concluded that bank reform in Hungary improved X-efficiency scores between 1993 and 1998. Banks with higher foreign ownership involvement were associated with lower inefficiency. However, the results depart from the ones of Bakar *et al.* (2010) suggesting that domestic banks had higher cost efficiency of 88.2%, relative to foreign banks, 75.5% in a study on the efficiency levels of domestic versus foreign banks in Malaysia for the period 2000-2006.

Taking the inter-temporal comparison across the banks, results are mixed, but for the sector, the mean cost efficiency are at lower levels, respectively in 2007-2009 and 2012. For the period 2007-2009, there is a slight increase in the level of cost efficiency of about 1.25% in three years (85.43-86.68%). These findings seem not surprising because the period covered by the study is a period where the global financial crisis occurred (2007-2009). With the global financial crisis, the environment was not conducive in particular to financial institutions. In relation to the effects of the 2007-2009 global financial crisis, though low income countries are low financially integrated they were affected in one way or another. Ree (2011) on the impact of global crisis on banking sector soundness in Asian low-income countries found that the most possible channel of crisis spillover

was the loan-to-cross border funding. The kind of explanations pointing on the effects of international global financial crisis of 2007-2009 as among factors of efficiency decrease was highlighted by Raphael (2013) when analysing the bank-specific, industry-specific and macroeconomic determinants of bank efficiency in Tanzania for the period 2005-2008. From Table 3, it is further observed that in 2012, the mean cost efficiency of 90.55% has dropped from 90.76% in 2011, but recovered to 92.32% in 2013. This slight decrease in mean cost efficiency may be in relation with the unexpected suspension of aid to Rwanda by some donors-partners in 2012.

In light to the observed cost efficiency, the study further investigated the factors contributing to cost inefficiencies in the banking sector within the 7 year period covered by this study. As highlighted earlier, the sources of cost inefficiencies are related to banks characteristics such as the type of ownership (foreign), government intervention either in management or majority in shareholding (gov), the instability in top leadership (mgt). Table 4 gives descriptive statistics of these variables while Table 5 reports the estimated parameters of these variables in relation with estimated inefficiencies from Eq. 7.

The dependent variable inefficiencies effects ( $u_{it}$ ) was measured as a continuous variable. Variables such foreign, gov and mgt were included as dummy variables coded one respectively when the majority of total shareholding of bank  $i$  at period  $t$  was foreign owned, if bank  $i$  had a major government intervention to prevent its bankruptcy at period  $t$  was supervised directly by central bank/enjoyed government good-will and if bank  $i$  during the seven-years period had two or more CEOs in office and zero otherwise. Table 5 below reports the estimates parameters of these factors that influenced cost inefficiencies of commercial banks in Rwanda, 2007- 2013. Factors influencing inefficiency effects for bank  $i$  at period  $t$  are estimated using Eq. 10.

Results of Table 5 point out to two variables that were significantly related to change in cost inefficiency which are foreign and mgt. The negative coefficient for (foreign) indicates that banks where the majority of shareholding was foreign owned were most likely less inefficient. Findings are in line of those of (Gopalakrishnan *et al.*, 2003; Qayyum and Khan, 2007). Explanations may be probably related to the ongoing response of customers to use banks' modern technology such as Automated Teller Machines (ATMs), Short Message Service (SMS) banking, mobile money, internet banking that reduced some operating costs of banks. Using modern banking technology decreases the waiting

lines on branch-banking which in turn can increase services delivery of bank tellers, hence decrease inefficiency. As far as the management is the key in a firm's business success or failure, the positive estimate for mgt implies that the instability in top management position such of the CEO, contributed to an increase in banks' cost inefficiency, indicating a plausible positive link between management stability of top officers in the bank and efficiency. Only the variable gov was reported to be having a negative effect on cost inefficiency, but insignificant. Even though, the variable gov is not statistically significant, but joint effects of the three variables on inefficiencies in cost setting is significant based on hypothesis testing on whether or not effects of the three explanatory variables on inefficiency are related or not. Put differently, the test concerns the hypothesis that the coefficients of the three regressors are all zero, implying that there is not interaction effects ( $\delta_1 = \delta_2 = \delta_3 = 0$ ). The test statistic which is 45.25 has a  $p = 0.0000 < 0.05$ . So, the null hypothesis is strongly rejected at all level of significance, suggesting that the joint effects of the three explanatory variables is statistically significant even though the individual effects of one variable may be statistically insignificant.

## CONCLUSION

The objective of the study was to assess the efficiency of commercial banks in Rwanda for the period 2007-2013. The measure of banks' efficiency provides information on the financial robustness of such institutions to translate limited inputs into efficiently producing financial services and products. This assessment was of substantive interest because findings can be used by different stakeholders in the commercial banking sector in Rwanda. Highlighted efficiency measures can help to make rational decisions by commercial bank managers and shareholders. Depositors are convinced by the soundness of the institutions where they do keep their financial assets (cash, term deposits). Shareholders do expect dividends and business continuity while regulators can take advantages in policy formulation. The efficiency of the sector can also be a driving factor for investors to come to Rwanda, which in turn contributes to the development of the economy through job creation, payment of taxes and other spillover effects following such kind of investments. Findings reveal a mean cost efficiency of 88.56% suggesting that banks jointly would have utilized only 88.56% of resources to produce the level of output that they produced. Implying that about 11.44% total costs were wasted relative to the bank on the frontier having the same inputs.



Inefficiencies were found statistically significant decreasing over time with foreign owned bank establishment in the Rwandan banking sector and increasing with the replacement of CEO in office within short service tenure. Banks' shareholders should always work for the stability of top management officials and invest in user friendly modern technology which may lead to a cashless and branchless banking sector, hence reducing observed cost inefficiencies. Government should put incentives that attract foreign banks to Rwanda as it was found that foreign banks are contributing to the efficiency of the banking sector.

However, results of efficiency displayed in this study should be considered with caution because the bank which appears to be closer to the frontier may not be forcefully better than others, as it might attain such performance at the cost of non-performing assets. Further research may target UMURENGE Savings and Credit Co-Operatives (SACCOs) that are spread throughout the 416 sectors of the country to assess their efficiency as they are closer to population.

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