Managerial Finance

Technical efficiency: the pathway to credit union cost efficiency in Ghana

Benjamin Amoah, Kwaku Ohene-Asare, Godfred Alufar Bokpin, Anthony Q.Q. Aboagye,

Received 26 October 2017
Revised 4 May 2018
30 July 2018
Accepted 11 August 2018

Technical efficiency: the pathway to credit union cost efficiency in Ghana

Benjamin Amoah
Department of Banking and Finance, Business School, Central University, Accra, Ghana
Kwaku Ohene-Asare
Department of Operations and Management Information Systems, Business School, University of Ghana, Accra, Ghana, and
Godfred Alufar Bokpin and Anthony Q.Q. Aboagye
Department of Finance, Business School, University of Ghana, Accra, Ghana

Abstract

Purpose – The purpose of this paper is to investigate the factors that tend to influence credit union efficiency, specifically examining cost efficiency (CE) and technical efficiency.
Design/methodology/approach – Using a two-stage method, the authors first estimate CE using Tones' SBM data envelopment analysis method and technical efficiency in a variable returns to scale setting during the period 2008–2014. The authors estimate a mixed-effects and two-limit Tobit regression to examine the effect of credit union specific characteristics, banking industry and macroeconomic conditions, on efficiency.
Findings – Credit unions' CE averaged 38.9 percent compared to 54.4 percent for technical efficiency. The authors find that technical efficiency does not translate into CE and vice versa.
Practical implications – The authors suggest that when targeting CE, credit union managers would have to make technical efficiency a priority. A monopolized and inefficient banking sector does not challenge efficiency improvement in the credit unions industry.
Originality/value – This study employs data from a frontier market.

Keywords Efficiency, Banks, DEA, Macroeconomics, Credit union
Paper type Research paper

1. Introduction

Credit unions exist to provide their members financial services that are also offered by other financial institutions, namely, banks, thrifts institutions and finance companies, among others. From McKillop and Wilson (2011), credit unions are self-help cooperative financial organizations geared to attaining the economic and social goals of members and wider local communities. The credit union is governed by its members, members elect (from within that membership), unpaid volunteer, paid officers and directors, who establish the policies under which the credit union operates.

For their members to continue to do business with them requires credit unions' financial services to be provided at lower cost than other financial institutions. In the absence of this, the member-owners of these credit unions would see no reason to patronize the credit union. The effect of this, of course, would be that the credit union would cease to exist as competing financial institutions would take over the markets they serve. However, other members join the credit unions for non-pecuniary reasons as noted by Smith (1984). One way of achieving this survival objective is for credit unions' management to make efficient use of resources allotted to them by the owners of the union. In the credit union setting, business is conducted with owners and for owners. This presents a natural margin squeeze which calls for a good control over expenses if the value creation for the owners of the credit union is to stay intact (Taylor, 1977).

Managerial Finance
Vol. 44 No. 11, 2018
pp. 1292-1310

0307-4358
DOI 10.1108/MF-10-2017-0431

The inability to control expenses might mean managers have to report declines in performance to owners. The manager of the credit union is therefore presented with a situation where they have to continuously work on improving efficiency both from within, technical efficiency, through their production process, and from without, cost efficiency (CE), a market space where banks pose a major threat.

Currently there exist 34 licensed banks, 4 licensed representative offices, 71 specialized depository institutions, 140 licensed rural and community banks, 417 licensed Forex Bureaux and over 435 licensed credit unions in Ghana. The current Ghanaian financial industry is particularly worrying as in July 2015, the central bank, Bank of Ghana (BoG) revoked the license of 70 microfinance companies and a money lending company. These institutions had their operations suspended because of inefficiencies. In the year 2017, two banks (UT Bank and Capital Bank) had their banking license withdrawn and the BoG declared them illiquid and deficient in capital. In the midst of all these, the credit union sector of the financial institutions industry in Ghana has been relatively safe. This situation demands an inquiry into how resources are used in the credit union, should technical or cost should be made a priority by the management in the pursuit of overall efficiency in the credit union setting? This is the problem the paper attempts to explore.

This study sets to achieve a number of objectives. First, it aims to estimate and discuss the CE of credit unions using the non-parametric Tones' efficiency from data envelopment analysis (DEA) approach. Second, we estimate and discuss overall technical efficiency of the credit unions. Third, appraise the nature of relationship that exists between cost and technical efficiency. Finally, using regression analysis, we explain discretional and non-discretional factors, particularly banking sector development and how they relate to credit union efficiency. The paper is structured as follows: Section 2 discusses literature review, Section 3 discusses method, data, specification of input and outputs variables and Section 4 discusses results and discussion. Section 5 discusses conclusion and recommendations.

This paper contributes to the debate on cost and technical efficiency in a cooperative setting. We empirically assess the heterogeneous ability of credit unions in accessing input at different prices on efficiency. Our study also examines technical efficiency, an empirical gap yet to receive sufficient attention in the credit union literature. By including the banking sector development in our study, the impact of the "no boundary effects" in terms of conducting business with owners and non-owners in the case of banks especially on credit unions' efficiency is carefully examined. Furthermore, by focusing on Ghanaian credit union industry, we provide empirical evidence of the factors that drive efficiency from a frontier economy context and make some recommendations.

2. Literature review

Worthington (1998) showed that non-core commercial activities do not have a significant influence on the level of cost inefficiency although asset size, capital adequacy regulation, branch and agency networks are significantly associated with CE in Australian credit unions. In Worthington (1999), a large number of credit unions in Australia were best-practice efficient, and any efficiency found appears to flow from x-inefficiencies. Worthington (2000) employed a two-stage procedure to evaluate non-bank financial institution CE and revealed that the major source of overall cost inefficiency appears to be allocative inefficiency rather than technical inefficiency. McKillop *et al.* (2002) examined relative efficiency of UK credit unions using radial and non-radial efficiency measures to investigate cost performance and revealed that credit unions have considerable scope for efficiency gains using both measures of efficiency. Esho's (2001) sample of Australian credit unions demonstrates that bond type, size, age, average deposit size and interest rate spreads are significant determinants of relative CE from stochastic frontier and distribution-free methodology.

Frame *et al.*'s (2003) work estimates a translog cost function for credit unions and mutual thrifts focusing on the unique objectives of mutually owned depository institutions and shows that credit unions with residential common bonds have higher costs than mutual thrifts; however, they noted that single common bond occupational and associational credit unions are more cost efficient. Using stochastic frontier analysis, McKillop *et al.* (2005) concluded that UK credit unions from the period 1999–2001 were subject to high levels of inefficiency and that the environment in which a credit union operates plays a vital role in relative efficiency, with large credit unions being more cost efficient.

Battaglia *et al.* (2010) analyzed the impact of environmental factors on cost and profit efficiencies of cooperative banks including credit unions in Italy for the period 2000–2005. Cooperative banks in the Northeast of Italy are shown to be the more cost efficient, benefiting from a favorable environment. Wilcox and Dopico (2011) considered credit union mergers and efficiency, in situations where the acquirer is much larger than the target credit union, target members benefit in terms of lower loan rates and higher deposit rates, while acquirer members see little change as cost benefits are shared equally when the merging credit unions are equal in size.

Wheelock and Wilson (2013) used an adapted version of the "order-a quantile" frontier estimate to compare larger and smaller size credit unions, and showed that small size credit unions confronted a shift in technology that increased the minimum cost required to produce given amounts of output and that all but the largest credit unions also became less scale efficient over time. Glass *et al.* (2014) demonstrated that Japanese cooperatives over the period 1998–2009 have secured both technical progress and a decrease in technical inefficiency. Wijesiri *et al.* (2015) provided evidence for credit unions from Sri Lanka on technical efficiency that age, type of the institution and return on assets are the crucial determinants of technical efficiency.

3. Methodology

The method for estimating efficiency is divided into two: the econometric (parametric) and the mathematical programming (non-parametric) approach. The distinction between the parametric methods and non-parametric methods is that the former assigns a density function to the stochastic component of the model, while the latter only defines the deterministic part. DEA is a non-parametric method introduced by Charnes *et al.* (1978) from the works of Farrell (1957), which presents a mathematical linear programming-based technique for measuring relative efficiency of decision-making unit (DMU) that has multiple inputs and outputs. Originally developed for measuring the efficiency of not-for-profit, public sector enterprises, DEA has found widespread applications in the context of profit-oriented organizations.

DEA has several advantages: it is easy to use, it allows for multiple inputs and multiple outputs in a single framework, it does not require specification of functional form for the frontier, it does not require *a priori* specification of weights for inputs and outputs and, finally, inputs and outputs can be expressed in different measurement units. The weakness includes the assumption that the distance from the frontier is entirely due to inefficiency without considering random errors such as errors of measurement or unforeseen events impacting the DMU. Also, the technique is sensitive to outlier data. Further DEA does not measure "absolute" efficiency but relative efficiency and finally statistical hypothesis tests are difficult to conduct in the DEA method.

For the purpose of this study, we chose the non-parametric DEA technique to examine the CE of credit unions in Ghana using Tone's (2002) CE approach. Very few studies have, however, adopted Tone's (2002) cost efficiency model in banking more so in credit unions, or openly discussed it (Tone and Sahoo, 2005; Tone and Tsutsui, 2007; Dong *et al.*, 2014).

The original DEA by Charnes *et al.* (1978) which assumes constant returns to scale has been extended to the variable returns (VRS) (Banker *et al.*, 1984), profit maximization (Fried *et al.*, 1993) and cost minimization (Färe and Grosskopf, 1985). From Maudos *et al.* (2002), CE is the ratio between the minimum cost at which it is possible to attain a given volume of production and the realized cost. From this definition, a DMU is cost efficient if it uses minimum level of cost as compared to the actual cost observed at the end of a production period. It is the product of allocative and technical efficiency (Fethi and Pasiouras, 2010).

Technical efficiency refers to the ability to use the right resources appropriately. A DMU is technically efficient only when it uses the least amount of inputs to produce maximum outputs (Koopmans, 1951 cited in Fried *et al.*, 1993). The CE of observed credit unions is given by the distance of its detected cost point from a constructed cost frontier (Dong *et al.*, 2014). Thus, the CE of an evaluated credit union is modeled as follows:

$$\mathrm{CE} = \frac{w_{iJ}x^{*}_{iJ}}{w_{ij}x_{ij}}, \tag{1}$$

where w_{iJ} is a set of input prices for a vector of inputs i, for credit union J, x^{*}_{iJ} denotes the cost minimizing vector of inputs quantities for the credit union J under observation, x is input and x^{*} is optimal inputs. The traditional CE DEA model by Färe *et al.* (1985a) assumed that input prices are the same across all DMUs, and though actual markets may function under imperfect competition, unit input prices may not be the same across all DMUs. Tone (2002) identified these drawbacks in the conventional CE DEA model and henceforth proposed a new scheme to measure CE. The new CE was further extended to the decomposition of CE by Tone and Tsutsui (2007). Under the new CE model, DMUs with dissimilar input prices will provide different measures of CE (Dong *et al.*, 2014). The traditional (Färe *et al.*, 1985a; Farrell, 1957) and new CE DEA (Tone, 2002) models are expressed in the following equations:

$$\min_{\lambda,x_i} w_{iO}x^{*}_{iO}, \tag{2}$$

subject to:

$$\sum_{j=1}^{n} \lambda_j y_{ri} - y_{ro} \geqslant 0 \quad ; \; r = 1, 2, \; \ldots, \; s,$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} - x^{*}_{iO} \leqslant 0 \quad ; \; i = 1, 2, \; \ldots, \; m,$$

$$\sum_{j=1}^{n} \lambda_j = 1 \text{ (VRS)},$$

$$\lambda_j \geqslant 0 \quad ; \; j = 1, 2, \; \ldots, \; n,$$

where x^{*}_{jO} denotes the cost minimizing vector of inputs quantities for the credit union under observation, given the vector of output weights y_{ro} and input prices w_{jo}. Hence, a hypothetical credit union with the same input price vector as the observed credit union j will have a CE score of $w_{jO}x^{*}_{jO}$:

$$\min_{\lambda,\bar{x}} C_T = e\bar{x}^{*}_{iO}, \tag{3}$$

subject to:

$$\sum_{j=1}^{n} \lambda_j y_{rj} - y_{ro} \geqslant 0; \quad r = 1, 2, \ldots, s,$$

$$\sum_{j=1}^{n} \lambda_j \overline{x}_{ij} - e\overline{x}^*_{iO} \leqslant 0; \quad i = 1, 2, \ldots, m,$$

$$\sum_{j=1}^{n} \lambda_j = 1 \text{ (VRS)},$$

$$\lambda_j \geqslant 0; \quad j = 1, 2, \ldots, n\,,$$

where $e \in R^m$ a row vector with all elements equal to 1 and $\overline{x}_{ij} = (w_{1j}x_{1j}, \ldots, w_{ij}x_{ij})^{\mathrm{T}}$. The λ is the weights. The Tone (2002) cost model differs from the traditional model because under the latter, for observing the credit union unit cost of credit union j fixed at w_{io}, we search for the optimal input mix x^*_O for producing y_o. However, under the former the optimal input $\overline{x}^*_O$ that produces the output y_o can be found independently of the credit union's prevailing unit price w_O. Thus, based on the optimal solution (Tone, 2002), $\mathrm{CE_T}$ is defined as follows:

$$\mathrm{CE}_T = \frac{e\overline{x}^*_{iO}}{e\overline{x}}. \tag{4}$$

For technical efficiency θ_{TE}, the input-oriented value-based framework is set up as follows:

$$\theta_{\mathrm{TE}} = \min_{\lambda,\theta} \theta, \tag{5}$$

subject to:

$$\sum_{j=J} \lambda_j x_o \leqslant \theta x_{io}, \quad j = 1, \ldots, m,$$

$$\sum_{j=J} \lambda_j y_{rj} \geqslant y_{ro}, \quad r = 1, \ldots, s,$$

$$\sum_{j=J} \lambda_j = 1, \quad \lambda_j \geqslant 0, \ \forall j \in J.$$

3.1 Inputs and outputs specification

In defining the inputs and outputs in financial institutions, the approaches used in literature include the intermediation approach, the production approach, the user cost approach and the value-added approach. We use the intermediation approach by considering financial institutions as intermediaries, converting and using factors of production paid for by owners to transfer financial saving from surplus units to deficit units in the form of loans.

Three input variables are used by the credit union: Labor, Non-current asset and Deposits; the three outputs are: Loan, Liquid-financial investment and Non-loan income. The three input prices are Price of labor, Price of non-current asset and Price of funds. The cost of labor is proxied by personnel costs. The study would have benefitted from data on fulltime and part-time employees to be able to estimate an exact cost of labor; these were unavailable. Nonetheless, we believe that the current approach can serve as a good proxy for cost of labor.

3.2 Sample and data source

We sample firm-specific data from the annual financial report of 66 credit unions operating under the association of Credit Unions Association (CUA) of Ghana for the period 2008–2014. The panel data set permits us to control for variables like differences in business practices across the sampled credit unions which account for firm-specific heterogeneity. Banking industry indicators are sourced from Global Finance Development database, real Treasury bill rate calculated from data provided by the BoG and GDP growth rate from the World Development Indicators.

3.3 Econometric estimation

In examining the factors that could influence credit union efficiency, we adopt the two-stage semi-parametric process. In the first stage, we estimated cost and technical efficiency scores for all credit unions in our sample as specified in Equations (4) and (5). We follow Mercieca *et al.* (2007) by constructing a Herfindahl–Hirschman Index (HHI) measure for each credit union to account for income diversification from non-loan income activities. We construct a combined non-loan income diversification index which measures the income generated from all non-loan income activities of the credit union. This is given as follows:

$$\mathrm{HHI}_{(\mathrm{COMB})} = \left(\frac{\mathrm{LFI}}{\mathrm{TNLNI}}\right)^2 + \left(\frac{\mathrm{OFI}}{\mathrm{TNLNI}}\right)^2 + \left(\frac{\mathrm{ENT}}{\mathrm{TNLNI}}\right)^2 + \left(\frac{\mathrm{COM}}{\mathrm{TNLNI}}\right)^2 + \left(\frac{\mathrm{OTI}}{\mathrm{TNLNI}}\right)^2, \quad (6)$$

$\mathrm{HHI}_{(\mathrm{COMB})}$ is diversification index for combined non-loan income. LFI is liquid-financial income, OFI is other liquid-financial income and ENT is one-time entrance fees charged new members. $_{\mathrm{COM}}$ is commission income, OTI is other non-interest income and TNLNI is total non-loan income. An increasing $\mathrm{HHI}_{(\mathrm{COMB})}$ implies the credit union is concentrating on one type of non-loan income focusing less on other non-loan income generating activity. The credit union *Z*-score (ZSCOR) captures financial stability, higher financial performance and capitalization implies stability. The *Z*-score measure is given as follows:

$$Z - \mathrm{score} = \frac{\mathrm{ROA} + \mathrm{E/TA}}{\sigma \mathrm{ROA}}. \quad (7)$$

In the second stage, the efficiency estimates obtained from Equations (4) and (5) are regressed on the selected internal and external variables as specified in Equation (8) using mixed-effects and a two-limit Tobit regression method.

We estimate the following panel regression model:

$$\theta_{i,t} = \beta_1 \sum_{n=1}^{9} \mathrm{CU\ \ Factors}_{i,t} + \beta_2 \sum_{n=1}^{3} \mathrm{Banking\ \ Industry}_{i,t} + \beta_3 \sum_{n=1}^{2} \mathrm{Macro}_t + \varepsilon_{i,t}, \quad (8)$$

where $\theta_{i,t}$ is the estimated CE and technical efficiency derived from the input-oriented VRS Tone DEA, CU Factors is a vector of credit union specific characteristics, where Banking Industry is a set of banking industry condition and Macro is a set of macroeconomics variables as presented in Table I, $\varepsilon_{i,t}$ is the error term, and the subscripts i and t represent individual credit union and time period, respectively. The use of the mixed-effects allows for inference on populations but not on individual credit union. Again mixed effect models credit union change across time. Finally, mixed effect model permits repeated observations

Variables	Description	Source
Inputs		
Labor	Total expenditures on employees (personal expenses)	CUAFS
Non-current asset	Non-current asset	CUAFS
Deposits	Total deposits mobilized	CUAFS
Outputs		
Loan	Total loan	CUAFS
Liquid-financial investment	Sum of interest income from liquid-financial investment	CUAFS
Non-financial income	Sum of non-interest income	CUAFS
Input price		
Price of labor	Total personal expenses scaled by the total funds	Authors' own calculation
Price of non-current asset	Depreciation expenses scaled by non-current asset	Authors' own calculation
Price of funds	Interest expenses on deposits and non-deposits funds plus other operating expenses divided by the total funds	Authors' own calculation
Dependent		
θ_{CE}	Cost efficiency score generated from the input-oriented VRS Tone SBM DEA approach	Authors' own calculation
θ_{TE}	Technical efficiency score generated from the input-oriented VRS approach	Authors' own calculation
Explanatory		
SIZE	Total asset in natural log	CUAFS
ZSCOR	Insolvency risk; σ is the standard deviation of ROA for credit union	Authors' own calculation
NWTA	Net worth to total asset (%)	Authors' own calculation
BDLN	Loan loss to loans (%)	CUAFS
$HHI_{(COMB)}$	Herfindahl–Hirschman diversification measure for combined non-loan income	Authors' own calculation
NIETA	Net interest expense to total asset (%)	CUAFS
LOTA	Loan total asset (%)	CUAFS
AGE	Number of years a credit union has been in existence	Authors' own calculation
LITA	Liquid asset to total asset (%)	CUAFS
BKCN	Asset of five largest banks as a share of total commercial banking asset	GFDD
BKZS	It captures the probability of default of a country's commercial banking system. It is estimated as (ROA + (equity/asset))/σ (ROA); σ (ROA) is the standard deviation of ROA	GFDD
BOCTA	Operating expenses of a bank as a share of the value of all assets held	GFDD
RLTB	Inflation adjusted 1 year Treasury bill rate (%)	BoG
GDP	Gross domestic products (%)	WDI

Notes: CUAFS, credit unions' annual financial statements; GFDD, Global Finance Development Database; BoG, Bank of Ghana; WDI, World Development Indicator Series

Table I.
Efficiency and regression variables

within individual credit unions types (community, workplace and society). We also use a two-limit Tobit regression because the cost and technical efficiency estimates are censored lower and upper values and no estimates fall outside this range. The usage of the Tobit model uses all of the information, that is censored, and leads to consistent estimates. In using these regression methods, the embedded maximum likelihood treats the correlation challenge asymptotically albeit at a measured rate.

The credit union firm-specific factors are size captured by natural log of total asset, where LOTA is loan-to-asset ratio and LITA is liquidity (see McKillop *et al.*, 2002). We use BDLN to capture loan quality similar to Worthington (2000). Instead of using non-interest income to total revenue as Worthington did, we capture income diversification using $HHI_{(COMB)}$ and this we believe gives us a good measure of income from non-loan activities. Age is used to capture the years of existence of a credit union (see Esho, 2001). NWTA is net worth to total asset, a measure of equity holder's contribution. *Z*-score captures solvency risk; NIETA is the net interest expense to total asset, used to measure management control expenses.

For the external variables, we employ the following in our regression. BKCN5 (concentration ratio of the five largest banks in terms of asset) is to measure banking sector concentration, BKZS is Bank *Z*-score (banking industry stability), and BOCTA is bank overhead cost to total asset, a measure of banking sector efficiency. We also introduce GDP (growth in gross domestic products), to control for cyclical output effects, and RLTB (nominal one-year Treasury bill rate adjusted for inflation), to control for monetary policy stance.

The descriptive statistics in Table II reveal that during 2008–2014 some credit unions in Ghana were cost efficient scoring 1, with laggards scoring CE of 0.1078 with a mean value of 0.3888. For technical efficiency, best performing credit unions score 1, with an average efficiency score of 0.5439. On the average, most credit unions in Ghana were more technically efficient than cost efficient. The size of credit unions ranges from 17.3709 to 8.9551. The *Z*-score has the highest variability level of 38.6848, implying unstable solvency levels during the 2008–2014 period. The average net worth to total asset was 94.3705 percent. The highest bad loan recorded was 59.0278 percent. The NEITA ranged between 0.3810 and 39.7088. Loan scaled by total asset averaged 54.7368 percent. The longevity measure was from 1 year to 45 years of operations. Top 5 bank asset concentration ranged 55.71–87.32 during the period. Bank *Z*-score was 6.3229 on the average. Bank over cost to total asset was 55.5071 on the average with a mean real Treasury bill rate of 5.107.

From Table III, the mean loan granted over the seven-year sampled period was GH₵920,769.50 with a maximum loan of GH₵22,500,000. Liquid investment ranged between GH₵832.34 and GH₵7,560,580. Non-financial income had a variability of GH₵38,903.09, and the highest output of non-financial income is GH₵324,865.10. The input section of Table IV shows that personal cost hovered between GH₵60 and GH ₵469,839.60. Non-current assets have a mean of GH₵77,633.70. Regular savings ranged

Variable	Mean	SD	Min.	Max.
θ_{CE}	0.3888	0.2149	0.1078	1
θ_{TE}	0.5439	0.2514	0.1102	1
SIZE	13.4276	1.3662	8.9551	17.3709
ZSCOR	50.1611	38.6848	2.1966	263.778
NWTA	94.3705	5.3158	54.9623	100
BDLN	2.9143	5.3307	0	59.0278
$HHI_{(COMB)}$	0.6062	0.1982	0.2254	0.9954
NIETA	8.431	4.7808	0.381	39.7088
LOTA	54.7368	15.0991	0	96.8126
AGE	16.7403	10.595	1	45
LITA	1.2867	0.4117	−0.4609	2.0343
BKCN5	63.4629	10.5217	55.71	87.32
BKZS	6.3229	0.8641	4.93	7.53
BOCTA	55.5071	6.5347	46.53	63.02
RLTB	5.1071	3.8059	1.9	14.06
GDP	8.076	3.0751	3.9859	14.046

Table II.
Descriptive statistics

Variable	Mean	SD	Min.	Max.
Outputs				
Loan	920,769.50	1,789,777.00	300	22,500,000.00
Liquid investment	444,078.30	898,365.10	832.34	7,560,580.00
Non-financial income	17,826.51	38,903.09	0	324,865.10
Inputs				
Personnel cost	35,407.84	63,221.41	60	469,839.60
Non-current asset	77,633.70	147,144.50	10	980,877.40
Regular savings	1,280,355.00	2,307,906.00	2,874.50	25,200,000.00
Inputs price				
Price of labor	2.6	1.97	0.1	16.27
Price of non-current asset	190.65	3,047.46	0.03	65,331.40
Price of regular savings	15.45	5.66	3.16	45.49

Table III.
Variables in first-stage DEA

between GH₵2,874.50 and GH₵25,200,000. Price of labor averaged 2.57 and a maximum value of 16.27. Price of non-current asset ranged between 0.03 and 65,331.40. The mean price of regular savings was 15.45.

4. Cost efficiency analysis

From Table IV, we measure overall improvement in the efficiency over the seven years using the geometric mean because it is less influenced by very small or large values in skewed data. The CE overall shows that few credit unions recorded more than 50 percent CE during the sample period. The top 5 most efficient credit unions during the period 2008–2014 were Abosom, UG, DunkwaTrd, KAMCCU and Dunkwa Area Tea with efficiency scores of 83.8, 81.3, 73.6, 72.9 and 66.6 percent, respectively. These credit unions also recorded geometric mean CE as follows: Absomo, UG, DunkwaTrd, KAMCCU and Dunkwa Area Tea 80.9, 78.9, 67, 71.9 and 57.5 percent, respectively.

The worst performers in CE were Alu works, UGARS, Uni of Edu, NAFTI and St Maggi with score of 23.5, 12.5, 20.2, 18.6 and 13.7 percent, respectively. On the other hand, Alu recorded 23.4 percent, UGARS 20.3 percent, Uni of Edu 20 percent, NAFTI 18.5 percent and St Maggi 13.6 percent geometric mean in CE. On the whole, CE has ranged between 33 and 44 percent, with an average score of 38.9 percent and with a geometric mean of 36.4 percent. From this, we conclude that CE for credit unions is generally very low, implying production costs for most credit unions are very high.

5. Technical efficiency analysis

From Table V, the most technically efficient credit union over the period was GRA at 97.1 percent followed by Asawinso 95.4 percent, Minechso 93 percent, TOR 92.5 percent and KAMCCU 90.4 percent. These top performances GRA, Asawinso, Michenso, TOR and KAMCCU recorded geometric mean of 97, 94.9, 90.8, 92 and 89.8 percent, respectively. The least technically efficient credit unions are AAK Teachers, Samatex, Kadjebi, UG Med and Uin of Edu with scores of 28.6, 25.5, 25, 24.4 and 21.1 percent. For the same period, AAK Teach, Samatex, Kadjebi Tea, UG Med and Uni of Edu recorded 28.3, 25.3, 24.4, 24.4 and 20.9 percent, respectively, of geometric mean.

On the whole, the average technical efficiency ranged between 50.5 and 59.7 percent with an average of 54.4 percent. There has been more variation in technical efficiency as seen in the standard deviation ranging from 21.7 to 27.4 percent with an average of 19.4 percent. The overall geometric mean in technical efficiency is 52.1 percent. We can see from the technical efficiency scores that resources are being used more efficiently in credit unions, thereby avoiding a lot of waste.

Table IV.
Tone cost efficiency

DMU	2008	2009	2010	2011	2012	2013	2014	Average	Rank	Geometric mean
Abosom	1	0.501	0.573	0.793	1	1	1	0.838	1	0.809
UG	0.489	0.645	0.709	0.941	0.907	1	1	0.813	2	0.789
DunkwaTrd	0.304	0.375	0.628	0.843	1	1	1	0.736	3	0.670
KAMCCU	0.547	0.577	0.739	0.792	0.843	0.711	0.897	0.729	4	0.719
DunAreaTea	0.299	0.281	0.366	0.676	1	1	1	0.66	5	0.575
Ebenezer	0.372	0.431	0.556	0.696	0.659	0.806	0.778	0.614	6	0.593
Asawinso	0.576	0.465	0.594	1	0.565	0.485	0.586	0.61	7	0.592
TOR	0.596	0.783	0.547	0.879	0.365	0.546	0.52	0.605	8	0.584
Minescho	0.4	0.284	0.444	0.906	0.903	0.759	0.258	0.565	9	0.502
NkoranATea	0.233	0.26	0.325	0.424	0.906	1	0.78	0.561	10	0.480
WATER	0.115	0.359	0.47	1	0.42	1	0.316	0.526	11	0.427
Gh Stats	0.476	0.355	0.583	0.156	1	0.561	0.264	0.485	12	0.419
Adoagyiri	0.412	0.286	0.392	0.532	0.527	0.585	0.66	0.485	12	0.469
Navrongo	0.526	0.485	0.611	0.555	0.375	0.433	0.343	0.475	13	0.467
Aapostolic	0.914	0.655	0.451	0.253	0.276	0.39	0.343	0.469	14	0.425
Bawku hos	0.345	0.293	0.423	0.234	0.538	0.674	0.749	0.465	15	0.430
St Paul	1	0.369	0.356	0.33	0.453	0.423	0.293	0.46	16	0.423
Nkoran Vic	0.307	0.341	0.357	0.252	0.17	0.969	0.807	0.458	17	0.385
Standard	0.392	0.306	0.394	0.494	0.674	0.402	0.406	0.438	18	0.427
West ManT	0.276	0.568	0.641	0.291	0.626	0.335	0.33	0.438	18	0.412
West power	0.29	0.339	0.295	0.318	0.314	0.467	1	0.432	19	0.389
GREL	0.311	0.22	0.223	0.26	0.492	0.681	0.823	0.43	20	0.378
Baw Teach	0.176	0.222	0.357	0.488	0.694	0.558	0.514	0.43	20	0.389
Jointchurch	0.691	1	0.397	0.286	0.287	0.149	0.136	0.421	21	0.333
Kekekrachi	0.541	0.36	0.547	0.483	0.234	0.27	0.491	0.418	22	0.399
JACCU	0.228	0.24	0.32	0.325	0.116	0.823	0.828	0.411	23	0.333
Tec Are Tea	0.196	0.226	0.227	0.34	0.555	0.574	0.583	0.386	24	0.349
CRIG Tafo	0.335	0.257	0.261	0.332	0.367	0.49	0.592	0.376	25	0.361
Wenchi	0.299	0.433	0.347	0.403	0.366	0.547	0.231	0.375	26	0.363
North Tema	0.178	0.184	0.326	0.271	0.428	0.522	0.703	0.373	27	0.333
Sege	0.328	0.298	0.368	0.614	0.443	0.258	0.219	0.361	28	0.342
GRA	0.232	0.282	0.234	0.347	0.364	0.562	0.45	0.353	29	0.337
Bole Cath	0.399	0.392	0.41	0.305	0.243	0.113	0.606	0.353	29	0.318

(*continued*)

Table IV.

DMU	2008	2009	2010	2011	2012	2013	2014	Average	Rank	Geometric mean
Acc Aca	0.783	0.503	0.156	0.287	0.201	0.207	0.293	0.347	30	0.299
Kwaebibi	0.3	0.274	0.242	0.416	0.335	0.234	0.557	0.337	31	0.322
UG MED	0.394	0.288	0.386	0.343	0.346	0.348	0.241	0.335	32	0.331
Trinity	0.538	0.394	0.334	0.293	0.25	0.214	0.319	0.335	32	0.321
Anajichrist	0.222	0.195	0.414	0.395	0.418	0.316	0.351	0.33	33	0.318
ECG	0.479	0.265	0.293	0.267	0.268	0.284	0.428	0.326	34	0.317
Waworkers	0.289	0.239	0.307	0.277	0.334	0.309	0.518	0.325	35	0.316
Chr of Pent	0.256	0.294	0.305	0.305	0.275	0.393	0.389	0.317	36	0.313
Soil Research	0.321	0.181	0.204	0.291	0.365	0.417	0.428	0.315	37	0.301
TrinityGAR	0.327	0.28	0.321	0.172	0.34	0.37	0.374	0.312	38	0.304
TUC NAT	0.217	0.248	0.315	0.289	0.287	0.375	0.413	0.306	39	0.300
Atico	0.509	0.414	0.209	0.26	0.278	0.243	0.171	0.298	40	0.279
Apapam	0.253	0.36	0.403	0.347	0.192	0.265	0.253	0.296	41	0.288
AAK TEACH	0.34	0.316	0.234	0.299	0.203	0.28	0.338	0.287	42	0.283
UDS	0.295	0.301	0.275	0.31	0.317	0.165	0.342	0.286	43	0.280
GUTA	0.353	0.305	0.392	0.328	0.148	0.226	0.246	0.285	44	0.273
St Paul	0.338	0.27	0.314	0.295	0.282	0.219	0.278	0.285	44	0.283
Kadjebi Tea	0.373	0.361	0.367	0.227	0.249	0.188	0.227	0.285	44	0.275
St Joseph	0.258	0.204	0.257	0.227	0.316	0.305	0.416	0.283	45	0.276
Ghana Nat Cul	0.223	0.218	0.23	0.246	0.348	0.373	0.322	0.28	46	0.274
Kpandnewera	0.215	0.289	0.304	0.305	0.202	0.315	0.175	0.258	47	0.252
Adido Tea	0.193	0.272	0.298	0.258	0.359	0.279	0.137	0.257	48	0.247
Bunso CRIG	0.285	0.278	0.267	0.235	0.233	0.234	0.206	0.248	49	0.247
Nkawkaw	0.288	0.199	0.203	0.317	0.216	0.223	0.276	0.246	50	0.242
Jas/golden	0.2	0.226	0.324	0.21	0.371	0.193	0.177	0.243	51	0.234
Samatex	0.22	0.182	0.179	0.197	0.244	0.319	0.32	0.237	52	0.231
Ghatomic	0.255	0.13	0.223	0.369	0.254	0.195	0.231	0.237	52	0.227
N Fadama	0.323	0.265	0.275	0.188	0.212	0.27	0.123	0.237	53	0.227
Alu	0.248	0.23	0.249	0.252	0.232	0.209	0.224	0.235	54	0.234
UGARS	0.134	0.131	0.181	0.23	0.222	0.231	0.377	0.215	55	0.203
UniEdu win	0.226	0.234	0.197	0.183	0.171	0.174	0.228	0.202	56	0.200
NAFTI	0.212	0.204	0.182	0.142	0.19	0.175	0.196	0.186	57	0.185
St Maggi	0.108	0.178	0.136	0.135	0.143	0.138	0.122	0.137	58	0.136
Mean	0.360	0.330	0.355	0.390	0.408	0.436	0.442	0.389		0.364
SD	0.190	0.152	0.140	0.222	0.240	0.258	0.253	0.151		0.139

Table V.
Technical efficiency

DMU	2008	2009	2010	2011	2012	2013	2014	Average	Rank	Geometric mean
GRA	1	0.979	1	1	0.926	1	0.892	0.971	1	0.970
Asawinso	1	0.949	1	1	1	1	0.732	0.954	2	0.949
Minescho	1	1	1	1	1	1	0.509	0.93	3	0.908
TOR	1	1	0.843	1	0.793	0.837	1	0.925	4	0.920
KAMCCU	0.737	0.811	0.97	1	1	0.81	1	0.904	5	0.898
TUC NAT	0.602	0.695	1	0.986	1	1	1	0.898	6	0.881
UG	0.547	0.639	0.888	1	1	1	1	0.868	7	0.846
Abosom	1	0.526	0.65	0.765	1	1	1	0.849	8	0.826
WATER	0.958	0.698	0.641	0.675	0.892	1	0.774	0.806	9	0.794
Ebenezer	0.449	0.54	0.681	0.889	0.804	0.887	1	0.75	10	0.724
St Paul	1	1	0.461	1	0.767	0.601	0.355	0.741	11	0.691
Ghana Nat Cul	1	0.82	0.625	0.521	0.618	0.636	0.78	0.714	12	0.699
DunkwaTrd	0.357	0.4	0.569	0.732	0.91	1	1	0.71	13	0.659
St Paul	0.938	0.772	0.788	1	0.512	0.314	0.429	0.679	14	0.630
Gh Stats	1	0.462	0.62	0.373	1	0.936	0.309	0.672	15	0.609
Jointchurch	1	1	0.718	0.708	0.463	0.413	0.391	0.67	16	0.627
Wenchi	1	1	0.978	0.558	0.383	0.36	0.382	0.666	17	0.602
NkoranATea	0.384	0.386	0.438	0.553	0.916	1	0.983	0.666	17	0.612
ECG	1	1	0.363	0.385	0.548	0.535	0.805	0.662	18	0.614
Acc Aca	1	0.662	0.427	0.793	0.67	0.509	0.503	0.652	19	0.628
Adoagyiri	0.388	0.393	0.553	0.634	0.709	0.717	0.809	0.6	20	0.580
Bawku hos	0.548	0.365	0.642	0.487	0.585	0.723	0.826	0.597	21	0.579
North Tema	0.315	0.3	0.541	0.471	0.727	0.82	1	0.596	22	0.545
N Fadama	0.515	0.604	0.356	0.455	0.552	0.656	0.956	0.585	23	0.561
Navrongo	0.664	0.584	0.616	0.52	0.532	0.63	0.485	0.576	24	0.573
Atico	1	1	0.392	0.418	0.488	0.389	0.319	0.572	25	0.517
Jas/golden	0.281	0.313	0.536	0.384	0.684	0.936	0.831	0.567	26	0.515
NAFTI	0.414	0.564	0.595	0.762	0.589	0.53	0.462	0.559	27	0.550
Anajichrist	0.258	0.276	0.58	0.665	0.745	0.649	0.709	0.555	28	0.514
DunAreaTea	0.202	0.249	0.31	0.439	0.783	0.893	0.944	0.546	29	0.462
Trinity	0.727	0.566	0.611	0.591	0.424	0.39	0.499	0.544	30	0.533
West power	0.473	0.505	0.448	0.405	0.375	0.582	1	0.541	31	0.514
JACCU	0.34	0.348	0.343	0.388	0.319	1	1	0.534	32	0.469

(continued)

Table V.

DMU	2008	2009	2010	2011	2012	2013	2014	Average	Rank	Geometric mean
Standard	0.526	0.379	0.451	0.571	0.636	0.617	0.526	0.529	33	0.522
West ManT	0.678	0.701	0.624	0.372	0.429	0.372	0.402	0.511	34	0.493
Apapam	0.597	0.454	0.484	0.503	0.476	0.525	0.524	0.509	35	0.507
Baw Teach	0.301	0.316	0.394	0.608	0.718	0.569	0.647	0.508	36	0.482
CRIG Tafo	0.42	0.589	0.391	0.451	0.401	0.471	0.694	0.488	37	0.478
St Joseph	0.56	0.392	0.412	0.357	0.482	0.518	0.535	0.465	38	0.459
St Maggi	0.502	0.51	0.42	0.401	0.315	0.376	0.728	0.465	38	0.450
Adido Tea	0.379	0.491	0.504	0.591	0.606	0.501	0.178	0.464	39	0.436
Waworkers	0.341	0.351	0.423	0.359	0.473	0.426	0.753	0.447	40	0.431
Tec Are Tea	0.293	0.302	0.326	0.366	0.558	0.589	0.629	0.438	41	0.417
Sege	0.359	0.434	0.493	0.56	0.628	0.326	0.254	0.436	42	0.418
Bole Cath	0.507	0.432	0.421	0.466	0.396	0.35	0.476	0.435	43	0.433
Church of Pent	0.351	0.397	0.433	0.373	0.385	0.546	0.514	0.428	44	0.423
Ghatomic	0.326	0.269	0.353	0.442	0.535	0.535	0.454	0.416	45	0.405
Aapostolic	0.738	0.434	0.304	0.262	0.348	0.429	0.357	0.41	46	0.389
Nkoran Vic	0.391	0.389	0.417	0.123	0.11	0.709	0.71	0.407	47	0.331
GREL	0.247	0.246	0.282	0.268	0.441	0.604	0.743	0.404	48	0.368
TrinityGAR	0.785	0.43	0.258	0.334	0.306	0.302	0.377	0.399	49	0.373
Soil Research	0.471	0.278	0.268	0.33	0.383	0.497	0.533	0.394	50	0.381
UDS	0.327	0.38	0.391	0.435	0.419	0.312	0.364	0.375	51	0.373
Kwaebibi	0.309	0.291	0.285	0.458	0.353	0.301	0.56	0.365	52	0.354
UGARS	0.332	0.316	0.406	0.348	0.313	0.322	0.516	0.365	53	0.359
Nkawkaw	0.316	0.327	0.301	0.349	0.381	0.373	0.477	0.361	54	0.357
Kpandnewera	0.328	0.429	0.568	0.448	0.206	0.262	0.229	0.353	55	0.332
Bunso CRIG	0.426	0.367	0.338	0.345	0.362	0.312	0.303	0.35	56	0.348
Alu	0.411	0.262	0.253	0.306	0.305	0.272	0.232	0.292	57	0.287
Kekekrachi	0.401	0.275	0.315	0.224	0.215	0.256	0.332	0.288	58	0.282
GUTA	0.405	0.291	0.321	0.281	0.249	0.223	0.235	0.286	59	0.281
AAK TEACH	0.243	0.306	0.297	0.246	0.243	0.293	0.374	0.286	59	0.283
Samatex	0.233	0.226	0.252	0.266	0.226	0.256	0.329	0.255	60	0.253
Kadjebi Tea	0.34	0.298	0.304	0.201	0.195	0.161	0.249	0.25	61	0.242
UG MED	0.259	0.234	0.261	0.239	0.237	0.254	0.226	0.244	62	0.244
UniEdu Win	0.22	0.213	0.172	0.189	0.199	0.2	0.287	0.211	63	0.209
Mean	0.552	0.506	0.505	0.525	0.549	0.573	0.597	0.544		0.521
SD	0.274	0.243	0.217	0.245	0.251	0.261	0.263	0.194		0.191

6. Comparing cost efficiency and technical efficiency; which one should be pursued first?

For brevity, we analyze the performance of the top 3 credit unions, comparing their cost and technical efficiency scores, with the bottom 3 credit unions' technical and CE score in Tables IV and V, to verify if technical efficiency translates into cost technical efficiency.

Abosom ranked first with a score of 83.8 percent CE but was ranked 8th in technical efficiency with even higher score of 84.9 percent. Similarly, the second ranked cost efficient credit union, UG, with a score of 81.3 percent ranked 7th under technical efficiency with a score of 86.6 percent. The 3rd ranked cost efficient credit union, DunkwaTrd, with a score of 73.6 percent, ranked 13th under technical efficiency with score of 71 percent.

The worst ranked 63rd technical efficient credit union, Uni of Edu, with a score of 21.1 percent, was ranked 56th under CE with a score of 20.2 percent. The next worst ranked credit union under technical efficiency was UG Med, 62nd with a score of 24.4 percent, it ranked 32nd under CE with a score of 33.5 percent. Finally, the 61st ranked credit union based on technical efficiency, Kadjebi Tea, scored 25 percent and ranked 44th on CE with a score of 28.5 percent. We can conclude from this analysis that technical efficiency does not necessarily translate into CE. We are of the opinion that pursuing technical efficiency, an internal production process, should lead the charge over CE, a technique that requires prices which the credit union has to compete for in the open market.

The CE estimates show direct and significant relations with the size of the credit union. Table VI suggests that increasing the size of the credit union would improve CE in all the four models. The inference here is that bigger-sized credit union is more cost efficient than small-sized credit unions. This agrees with Esho (2001) that size is a significant determinant of credit union efficiency. Increasing provision for bad and doubtful debt infers that credit unions are, on the average, most likely not to be efficient, an issue that should be of concern to managers of credit unions. Income diversification activities, $HHI_{(COMB)}$, in non-loan activities significantly associate with CE, and increase the inefficiency of credit unions,

Variables	1	2	3	4
SIZE	0.0529*** (7.6200)	0.0551*** (7.1294)	0.0548*** (7.1006)	0.0809*** (4.2721)
ZSCOR	−0.0002 (−1.1061)	−0.0003 (−1.1625)	−0.0003 (−1.1631)	0.0030 (0.9703)
NWTA	0.0027* (1.7551)	0.0029* (1.8363)	0.0028* (1.7945)	0.0011 (0.4540)
BDLN	−0.0047** (−2.5594)	−0.0045** (−2.4659)	−0.0046** (−2.4925)	−0.0060*** (−3.1238)
$HHI_{(COMB)}$	−0.0935** (−2.1178)	−0.0942** (−2.1099)	−0.0905** (−2.0122)	−0.0770 (−1.4652)
NIETA	−0.0106*** (−4.8663)	−0.0107*** (−4.8369)	−0.0107*** (−4.8446)	−0.0120*** (−4.2960)
LOTA	−0.0014** (−2.2201)	−0.0015** (−2.3240)	−0.0015** (−2.2791)	−0.0020*** (−2.8257)
AGE	0.0030*** (3.3771)	0.0030*** (3.4117)	0.0030*** (3.3791)	0.0027 (0.4775)
LITA	0.1455*** (6.1449)	0.1465*** (6.1967)	0.1461*** (6.1849)	0.1194*** (4.1326)
BKCN5		−0.0013 (−1.1963)	−0.0008 (−0.7370)	−0.0015 (−1.3179)
BKZS		−0.0613** (−1.9902)	−0.0675** (−2.0882)	−0.0891*** (−2.6404)
BOCTA		−0.0081* (−1.9369)	−0.0095** (−2.1442)	−0.0104*** (−3.0385)
RLTB			−0.0007 (−0.2982)	−0.0005 (−0.2613)
GDP			0.0037 (0.9976)	0.0034 (1.1742)
Constant	−0.5660*** (−3.3880)	0.3144 (0.6486)	0.3862 (0.7855)	0.5543 (1.2887)
Credit union dummy	No	No	No	Included
Wald χ^2	279.74	286.24	288.08	873.95
Prob. > χ^2	0.0000	0.0000	0.0000	0.0000
Observations	462	462	462	462
Credit unions	66	66	66	66

Notes: *t*-statistics in parentheses. $*p < 0.1$; $**p < 0.05$; $***p < 0.01$

Table VI. Regression results of Tone cost efficiency a conclusion similar to Worthington (2000). Thus, credit unions aiming at reducing cost must be wary of non-loan income activities.

Increasing management expense, NIETA implies that CE level in credit union would decline, a relation that is very significant in Table V. The loan business of the credit union captured by LOTA reveals a negative coefficient, implying that high levels loans granted can cause inefficiencies; in Model 1, a 1 percent increase in loans would result in a 0.0014 decrease in CE. In Models 2 and 3, a 1 percent increase in loans would imply a 0.0015 reduction in CE. An increase in Age of the credit union suggests an improvement in CE as Esho (2001) and Wijesiri *et al.* (2015) also observed. This may be attributable to experience and learning curve effect as the credit union would not want to repeat decisions that might have led to inefficiency in the past. Liquidity implies improved CE for credit unions in all three models.

In Model 2, all the relationships afore-mentioned still hold with the same level of significance. As the banking sector's cost to total asset increases, credit unions stand to become cost efficient. This can be as a result of the direct competition that exists between credit unions and banks. Additionally, the temptation to win the same customer would mean each competitor would end up spending much more, hence this nature of relationship while top 5 bank size concentration is insignificant. All banking sector development indicators have negative coefficients to credit union cost efficiencies. From this, it is obvious that the banking sector matters in credit union efficiency as also found in Battaglia *et al.* (2010). This can be attributable to the competition that exists between these two competing financial institutions in the financial market.

On the economy wide level, there exists a negative, insignificant relation between CE of credit unions and real return one-year Treasury bill rate. A growing economy can lead to improvement in CE for credit unions as indicated by the positive coefficient between GDPs. In Column 4 of Table VI, the insignificant coefficient of NWTA, $HHI_{(COMB)}$ and Age is when credit union fixed effect is accounted for as an explanatory variable in the model.

Technical efficiency measures management's ability to make use of resources and avoiding wastage as much as possible. In Table VII, size has positive and significant relations with technical efficiency comparable to Wijesiri *et al.*'s (2015) conclusions. Credit unions with higher new worth to asset are more technically efficient. The relationship between $HHI_{(COMB)}$ that is income diversification and technical efficiency is positive, i.e. an increase in credit unions' investment in non-loan income leads to an increase in technical efficiency. It must be explained that these non-loan investments need a lot of management commitment; less technically efficient credit unions may stick to loan business and make less adventure into non-loan activities. The more credit unions spend on non-interest expense, NIETA, the less technically efficient that credit union.

Loan to asset of credit unions shows an inverse relation with technical efficiency. Inherent is the loan business is bad loans, increasing loans comes with commensurate bad loans, loan increase implies a decrease in technical efficiency in all case. Increasing bad loans leads to higher levels of inefficiencies on the part of management of the credit union. The Age of the credit union has the same nature of relationship as in the case of CE. The more stable the banking sector, as measure by the BKZS, the less technically efficient the credit unions become, probably because labor may then move to banks, denying the credit union of quality management. An increase in the banking sector's efficiency implies a decline in technical efficiency of credit unions. Top 5 bank concentration, real Treasury bill and GDP growth do not significantly influence technical efficiency in the credit union. When credit union fixed effect is accounted for in the model as an explanatory variable in Column 4 of Table VII, the coefficient of SIZE, NWTA, $HHI_{(COMB)}$, NIETA and AGE becomes insignificant while BDLN becomes significant.

We again use a two-limit Tobit regression to evaluate Equation (7). The range CE scores are scaled from 0.1078 to 1.000 and for technical efficiency, scaled from 0.1102 to 1.000 for

Variables	1	2	3	4
SIZE	0.0158* (1.7672)	0.0169* (1.6962)	0.0165* (1.6600)	0.0133 (0.5880)
ZSCOR	−0.0002 (−0.6075)	−0.0002 (−0.6178)	−0.0002 (−0.6216)	−0.0012 (−0.3158)
NWTA	−0.0051** (−2.5582)	−0.0050** (−2.5162)	−0.0051** (−2.5641)	−0.0028 (−0.9904)
BDLN	−0.0030 (−1.2502)	−0.0025 (−1.0715)	−0.0027 (−1.1269)	−0.0038* (−1.6590)
$HHI_{(COMB)}$	0.2392*** (4.1954)	0.2315*** (4.0158)	0.2394*** (4.1246)	0.0479 (0.7633)
NIETA	−0.0044 (−1.5649)	−0.0048* (−1.6825)	−0.0048* (−1.6804)	−0.0054 (−1.6105)
LOTA	−0.0020** (−2.3379)	−0.0020** (−2.3819)	−0.0020** (−2.3176)	−0.0009 (−1.0154)
AGE	0.0023** (1.9805)	0.0023** (2.0275)	0.0023** (1.9777)	0.0031 (0.4691)
LITA	0.1857*** (6.0729)	0.1885*** (6.1791)	0.1877*** (6.1582)	0.1382*** (4.0066)
BKCN5		−0.0006 (−0.4392)	0.0001 (0.0622)	0.0003 (0.2197)
BKZC		−0.0708* (−1.7822)	−0.0842** (−2.0194)	−0.0712* (−1.7669)
BOCTA		−0.0094* (−1.7512)	−0.0118** (−2.0647)	(−2.7150)
RLTB			0.0003 (0.1168)	−0.0000 (−0.0112)
GDP			0.0058 (1.2320)	0.0049 (1.3911)
Constant	0.5541** (2.5690)	1.5472** (2.4738)	1.6787*** (2.6466)	1.8294*** (3.5635)
Credit union dummy	No	No	No	Included
Wald χ^2	147.32	153.13	155.15	821.93
Prob. > χ^2	0.0000	0.0000	0.0000	0.0000
Observations	462	462	462	462
Credit unions	66	66	66	66

Notes: *t*-statistics in parentheses. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table VII. Regression results of technical efficiency

both lower limit and upper limit, respectively. In these results, we see that if credit unions increase their size by 1 percent, the expected size effect would increase 0.056 and 0.002 on cost and technical efficiency, respectively, while holding all other variables in the model constant. For every 1 percent increase in NWTA, there exists 0.0029 increase in CE and 0.0061 decline in NWTA in the technical efficiency. Increase loan loss would lead to a decrease in the expected bad loan value by 0.0047 in CE.

The expected value of non-loan income diversification activities declines by 0.0977 in the CE model, and 0.2645 increase in the technical efficiency for every 1 percent increase in $HHI_{(COMB)}$; these relations are significant. There exists a decrease of 0.0108 for every increase in NIETA in relation to CE. The loan business exhibits a reduction as expected both in the CE and technical efficiency estimation. A 1 percent increase in loan to asset leads to a 0.0016 and 0.0022 decline in expected values of loan to asset. An increase in Age by one year implies an increase in value as given in the coefficient under both cost and technical efficiency. Liquidity captured by LITA shows an increase in expected value of 0.1494 under CE and 0.2052 under technical efficiency, on the average, from a 1 percent increase in LITA. The stability of the banking sector shows a decline of 0.0701 and 0.1036 decline in expected values for a unit increase in the case of the two dependent variables, respectively, in Table VIII. The efficiency level of the banking sector implies negative relations with CE and technical efficiency, a 1 percent increase in banking sector overhead cost leads to an increase of 0.0099 and 0.0014 in expected value. The real Treasury bill rate and GDP growth are not statistically significant. With the addition credit union fixed effect in the model in Table VIII, there was no change in the significance of coefficient under the CE model; however, in the fixed effect technical efficiency (FSTE), SIZE, NWTA, $HHI_{(COMB)}$, NIETA, AGE become insignificant while BDLN is significant.

7. Conclusion

The current study estimates cost and technical efficiency for credit unions for Ghanaian credit unions during the period 2008–2014. Credit unions operated at CE average of 38.9 percent, while technical efficiency averaged 54.4 percent for the period. The results show that many

Table VIII.
Tobit
regression results

Variables	CE	TE	FSTE
SIZE	0.0561*** (6.9523)	0.0229** (1.9985)	0.0179 (0.6973)
ZSCOR	−0.0003 (−1.2511)	−0.0003 (−0.8129)	−0.0013 (−0.2962)
NWTA	0.0029* (1.8077)	−0.0061*** (−2.6123)	−0.0037 (−1.0859)
BDLN	−0.0047** (−2.4768)	−0.0030 (−1.1134)	−0.0047* (−1.7917)
$HHI_{(COMB)}$	−0.0977** (−2.0797)	0.2645*** (3.9982)	0.0385 (0.5317)
NIETA	−0.0108*** (−4.6967)	−0.0053 (−1.6162)	−0.0054 (−1.4016)
LOTA	−0.0016** (−2.2806)	−0.0022** (−2.2509)	−0.0008 (−0.8233)
AGE	0.0033*** (3.4929)	0.0024* (1.8426)	0.0036 (0.4882)
LITA	0.1494*** (6.0609)	0.2052*** (5.9469)	0.1523*** (3.8649)
BKCN5	−0.0009 (−0.7525)	0.0000 (0.0018)	0.0001 (0.0666)
BKZS	−0.0701** (−2.0786)	−0.1036** (−2.1817)	−0.0875* (−1.9266)
BOCTA	−0.0099** (−2.1540)	−0.0140** (−2.1516)	−0.0133*** (−2.8620)
RLTB	−0.0007 (−0.3000)	0.0003 (0.0991)	−0.0002 (−0.0896)
GDP	0.0036 (0.9537)	0.0071 (1.3150)	0.0060 (1.5199)
Constant	0.4056 (0.7910)	1.9229*** (2.6530)	2.1736*** (3.6636)
Credit union dummy	No	No	Included
Observations	462	462	462
Credit unions	66	66	66
LR χ^2	219.23	128.58	465.04
Prob. > χ^2	0.0000	0.0000	0.0000

Notes: *t*-statistics in parentheses. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

credit unions are on the average technically efficient. We also realized that CE does not necessary translate into technical efficiency as there exist varying scores and positions for the same credit union among the sample credit unions. From the mixed effect and the two-limit Tobit regression estimates, the efficiency of the credit union is driven by factors like size, net worth to asset, bad loans, non-loan income, non-interest expense, loan to asset, liquidity and Age. Credit union efficiency is also significantly associated with competition and efficiency of the banking sector, with the wider economy bearing no statistical significant relations.

From the evidence in this study, managers must aim at deploying every resource fully to avoid waste in their efforts to create value for the owners. Managers of credit unions must improve their production aspects of operations to cut down production cost. Pursuing technical efficiency should lead CE in the credit union setting. A monopolized banking sector and an inefficient banking sector do not challenge efficiency improvement in the credit unions industry. It is therefore appropriate for credit union managers to monitor the banking industry and craft strategies that would help improve their efficiency. It is recommended that policy makers for the financial institutions industry also look beyond the banking sector and consider the effect of their actions on smaller deposit taking financial institution like the credit union, since from this study we see that there exist rippling effects of banking sector activities on credit unions.

References

Banker, R.D., Charnes, A. and Cooper, W.W. (1984), "Some models for the estimation of technical and scale inefficiencies in data envelopment analysis", *Management Science*, Vol. 30 No. 9, pp. 1078-1092.

Battaglia, F., Farina, V., Fiordelisi, F. and Ricci, O. (2010), "The efficiency of cooperative banks: the impact of environmental economic conditions", *Applied Financial Economics*, Vol. 20 No. 17, pp. 1363-1376.

Charnes, A., Cooper, W.W. and Rhodes, E. (1978), "Measuring the efficiency of decision making units", *European Journal of Operational Research*, Vol. 2 No. 6, pp. 429-444.

Dong, Y., Hamilton, R. and Tippett, M. (2014), "Cost efficiency of the Chinese banking sector: a comparison of stochastic frontier analysis and data envelopment analysis", *Economic Modelling*, Vol. 36, pp. 298-308.

Esho, N. (2001), "The determinants of cost efficiency in cooperative financial institutions: Australian evidence", *Journal of Banking & Finance*, Vol. 25 No. 5, pp. 941-964.

Färe, R. and Grosskopf, S. (1985), "A nonparametric cost approach to scale efficiency", *The Scandinavian Journal of Economics*, pp. 594-604.

Farrell, M.J. (1957), "The measurement of productive efficiency", *Journal of the Royal Statistical Society*, Vol. 120 No. 3, pp. 253-281.

Fethi, M.D. and Pasiouras, F. (2010), "Assessing bank efficiency and performance with operational research and artificial intelligence techniques: a survey", *European Journal of Operational Research*, Vol. 204 No. 2, pp. 189-198.

Frame, W.S., Karels, G.V. and McClatchey, C.A. (2003), "Do credit unions use their tax advantage to benefit members? Evidence from a cost function", *Review of Financial Economics*, Vol. 12 No. 1, pp. 35-47.

Fried, H.O., Schmidt, S.S. and Lovell, C.K. (Eds) (1993), *The Measurement of Productive Efficiency: Techniques and Applications*, Oxford University Press, Oxford, London.

Glass, J.C., McKillop, D.G., Quinn, B. and Wilson, J. (2014), "Cooperative bank efficiency in Japan: a parametric distance function analysis", *The European Journal of Finance*, Vol. 20 No. 3, pp. 291-317.

McKillop, D. and Wilson, J.O. (2011), "Credit unions: a theoretical and empirical overview", *Financial Markets, Institutions & Instruments*, Vol. 20 No. 3, pp. 79-123.

McKillop, D.G., Glass, J.C. and Ferguson, C. (2002), "Investigating the cost performance of UK credit unions using radial and non-radial efficiency measures", *Journal of Banking & Finance*, Vol. 26 No. 8, pp. 1563-1591.

McKillop, D.G., Glass, J.C. and Ward, A.M. (2005), "Cost efficiency, environmental influences and UK credit unions, 1991 to 2001", *Managerial Finance*, Vol. 31 No. 11, pp. 72-86.

Maudos, J., Pastor, J.M., Perez, F. and Quesada, J. (2002), "Cost and profit efficiency in European banks", *Journal of International Financial Markets, Institutions and Money*, Vol. 12 No. 1, pp. 33-58.

Mercieca, S., Schaeck, K. and Wolfe, S. (2007), "Small European banks: benefits from diversification?", *Journal of Banking & Finance*, Vol. 31 No. 7, pp. 1975-1998.

Smith, D.J. (1984), "A theoretic framework of the analysis of credit union decision making", *The Journal of Finance*, Vol. 39 No. 4, pp. 1155-1168.

Taylor, R.A. (1977), "Credit unions and economic efficiency", *RivistaInternazionale Di ScienzeEconomiche E Commerciali*, Vol. 24 No. 3, pp. 239-247.

Tone, K. (2002), "A strange case of the cost and allocative efficiencies in DEA", *Journal of the Operational Research Society*, Vol. 53 No. 11, pp. 1225-1231.

Tone, K. and Sahoo, B.K. (2005), "Evaluating cost efficiency and returns to scale in the life insurance corporation of India using data envelopment analysis", *Socio-Economic Planning Sciences*, Vol. 39 No. 4, pp. 261-285.

Tone, K. and Tsutsui, M. (2007), "Decomposition of cost efficiency and its application to Japanese-US electric utility comparisons", *Socio-Economic Planning Sciences*, Vol. 41 No. 2, pp. 91-106.

Wheelock, D.C. and Wilson, P.W. (2013), "The evolution of cost-productivity and efficiency among US credit unions", *Journal of Banking & Finance*, Vol. 37 No. 1, pp. 75-88.

Wijesiri, M., Viganò, L. and Michele, M. (2015), "Efficiency of microfinance institutions in Sri Lanka: a two-stage double bootstrap DEA approach", *Economic Modelling*, Vol. 47, pp. 74-83.

Wilcox, J.A. and Dopico, L.G. (2011), "Credit union mergers: efficiencies and benefits", *FRBSF Economic Letter*, pp. 1-5.

Worthington, A. (2000), "Cost efficiency in Australian non-bank financial institutions: a non-parametric approach", *Accounting & Finance*, Vol. 40 No. 1, pp. 75-98.

Worthington, A.C. (1998), "The determinants of non-bank financial institution efficiency: a stochastic cost frontier approach", *Applied Financial Economics*, Vol. 8 No. 3, pp. 279-287.

Worthington, A.C. (1999), "Measuring technical efficiency in Australian credit unions", *The Manchester School*, Vol. 67 No. 2, pp. 231-248.

Further reading

Berger, A.N. (1993), "Distribution-free estimates of efficiency in the US banking industry and tests of the standard distributional assumptions", *Journal of Productivity Analysis*, Vol. 4 No. 3, pp. 61-92.

Berger, A.N. and Humphrey, D.B. (1991), "The dominance of inefficiencies over scale and product mix economies in banking", *Journal of Monetary Economics*, Vol. 28 No. 1, pp. 117-148.

Berger, A.N. and Humphrey, D.B. (1997), "Efficiency of financial institutions: international survey and directions for future research", *European Journal of Operational Research*, Vol. 98 No. 2, pp. 175-212.

Camanho, A.S. and Dyson, R.G. (2005), "Cost efficiency, production and value-added models in the analysis of bank branch performance", *Journal of the Operational Research Society*, Vol. 56 No. 5, pp. 483-494.

Camanho, A.S. and Dyson, R.G. (2008), "A generalisation of the Farrell cost efficiency measure applicable to non-fully competitive settings", *Omega*, Vol. 36 No. 1, pp. 147-162.

Coelli, T. (1996), "A guide to DEAP Version 2.1: a data envelopment analysis (computer program)", working paper, CEPA, University of New England, Armidale.

Debreu, G. (1951), "The coefficient of resource utilization", *Econometrica*, Vol. 19 No. 3, pp. 273-292.

Kumbhakar, S.C. and Lovell, C.A.K. (2000), *Stochastic Frontier Analysis*, Cambridge University Press, Cambridge and New York, NY.

Lim, B., Lee, K. and Lee, C. (2016), "Free Disposal Hull (FDH) analysis for efficiency measurement: an update to DEA", *The Stata Journal*, pp. 1-8.

Sahoo, B.K., Mehdiloozad, M. and Tone, K. (2014), "Cost, revenue and profit efficiency measurement in DEA: a directional distance function approach", *European Journal of Operational Research*, Vol. 237 No. 3, pp. 921-931.

Tone, K. and Tsutsui, M. (2009), "Network DEA: a slacks-based measure approach", *European Journal of Operational Research*, Vol. 197 No. 1, pp. 243-252.

About the authors

Benjamin Amoah holds a PhD degree in Finance and is Lecturer at the Department of Banking and Finance at the Central Business School, Central University, Accra, Ghana. His research interest includes investment fraud, financial institutions management, cooperative studies with special emphasis on credit unions, efficiency, risk in financial institutions, financial literacy, pension and retirement planning. Benjamin Amoah is the corresponding author and can be contacted at: benjamintoamoah@yahoo.com

Dr Kwaku Ohene-Asare holds a PhD degree in Operations Research and Management Science and is Economics Lecturer at the University of Ghana Business School. He holds a PhD degree from Warwick Business School, the University of Warwick. He previously taught in the Economics Department and Warwick Business School at the Warwick University and is now Associate Fellow with them. Areas of teaching interest include data envelopment analysis, operations research and management science techniques.

Professor Godfred Alufar Bokpin is currently Head at the Department of Finance. His research focuses on macro-finance linkages, market microstructure, asset pricing, fiscal policy or monetary interaction, economic and firm-level governance, disclosure and transparency. Professor Bokpin investigates issues with funding mostly from African Economic Research Consortium (AERC), African Development Bank, Canadian Government and University of Ghana as well as Corporate Ghana.

Anthony Q.Q. Aboagye is currently Associate Professor and former Head of the Department of Finance, University of Ghana Business School. He received PhD in Finance from McGill University. He also holds an MBA degree from the University of Toronto, an MA degree from York University, Canada and a BSc degree from the University of Ghana. Professor Aboagye is an active consultant. A partial list of his clients includes: Ministry of Finance and Economic Planning and the Ministry of Trade and Industries, Ghana, USAID, Ghana Health Service and the Ghana Stock Exchange.