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Research article

Examining the determinants of bank efficiency in transition: empirical evidence from Ghana

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ABSTRACT

This paper measures and evaluates the relative pure technical efficiency and cost-efficiency of Ghanaian banks over the period 2008–2019 using a nonparametric DEA technique. The study also examines the factors that determines bank efficiency in Ghana using both static panel and dynamic panel regression estimators. The results show that the overall average bank efficiency (pure-technical and cost) levels in Ghana are relatively low compared to the benchmark "best-practice" efficiency level of 1. However, the results indicate that there are remarkable improvements in both the pure technical efficiency and cost-efficiency levels since the coming into effect of the new banking Act in 2016. Further, the study depicts bank size, GDP growth rate and inflation to be the most important factors that must be considered in the determination of bank efficiency in Ghana. Also, bank capitalization is depicted to have a significant impact on bank cost-efficiency. In contrast, the findings reveal that return on assets (ROA), liquidity and loan loss provision are, however, not important factors in the determination of both banks pure technical and cost-efficiency. Bank capital is further depicted to have insignificant impact in the determination of bank pure technical efficiency in Ghana.

1. Introduction

Studies that examine the impact of banking reforms and deregulations on efficiency and its policy implications in both the developed and the developing economies are well documented. The analysis of banking industry efficiency, according to Berger and Humphrey (1997), is very vital for policymakers/regulators, bank executive management and academicians. The efficiency of banks in the financial sector is, therefore, a major factor in maintaining confidence, trust and soundness in the banking system. According to Berger and Humphrey (1997), the efficient performance of banks helps them to better compete more effectively and survive in the financial sector. Banks would be exposed to the risk of default, impairment, or insolvency without trust and soundness. The persistent inefficient performance of banks could also lead to a higher likelihood of bank failure that could affect the other sectors of the economy such as Agriculture, Commerce and Industry. Efficient banks are also considered to have a higher rate of return relative to cost than their inefficient counterparts. More so, efficient banks can compete more effectively and participate better in economic growth and development than their inefficient counterparts.

The Ghanaian banking system is considered to be a universal banking-based system as the total assets of the universal banking subgroup constitute about 91% of the total assets of the entire banking sector and play a major role in financing the economic activities in the country. Universal banking practice started in earnest in the early years of 2003 and since then the central bank of Ghana has initiated several reforms to make the system more resilient, competitive and efficient. Such reforms included increasing the minimum paid-up capital, removal of restrictions (on foreign entry, the flow of foreign exchange operations, interest rates, etc.), the introduction of corporate governance guidelines, prudential reporting standards, credit reference bureaus, enterprise risk management, etc. More reforms were also undertaken since the global financial meltdown in 2008 and the reform is still ongoing. Despite the recent banking crises that saw the revocation of the licenses of about 420 banks and specialized deposit-taking institutions (SDIs) by the Central Bank, there have been remarkable improvements in the assets and liabilities as well as financial soundness indicators (profitability, solvency, liquidity, etc.) of the Ghanaian banking system since the promulgation of the recent banking Act in 2016 and the other ensuing reforms. For instance, the total assets of the licensed universal banks in Ghana increased

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exponentially from GH¢10.3 billion in 2008 to GH¢82.64 billion in 2016 then to GH¢129.06 billion in 2019 representing about 91% of the total assets of the entire banking sector in Ghana. Total deposits also grew intensively during the study period from GH¢7.6 billion in 2008 to GH¢ 52.69 billion in 2016 then to GH¢83.46 billion in 2019. Again, there was an astronomical growth in total loans and advances from GH¢8.5 billion in 2008 to GH¢31.23 billion in 2016 and then to GH¢39.96 billion in 2019. The growth in total assets, deposits, loans and advances in the Ghanaian banks reflects the growth in the Ghanaian banks and the growing importance of the industry to Ghana's economic growth and development during the study period.

Despite the remarkable progress of the Ghanaian banking system aftermath of the 2008 global financial crisis as a result of the ongoing banking reforms and deregulation, no study has been conducted to examine the relative efficiency and the determinant of the efficiency of the tier 1 banks that currently operate in Ghana during the period 2008–2019. This study attempts to fill this literature gap by providing empirical evidence on both pure technical efficiency (PTE) and cost-efficiency (CE) levels in the Ghanaian banking industry. Further, a better understanding of the sources of inefficiency and the relative efficiency of the disaggregated banking subgroups is vital to the executive managers of banks, the regulator or policymakers as well as researchers. To the executive managers of the universal banks, the identification of the sources of inefficiency will help improve input utilization and cost-efficiency. The regulator or the policymakers, on the other hand, will better understand the factors affecting the efficient allocation of assets in the financial sector given the efficiency levels of banks that operate in the system. Last but not the least, the 2007–2008 global financial crises and the ongoing banking crisis in Ghana have reignited the debate about the issue of financial soundness, financial integration and banking sector regulation and governance. Therefore, evaluating the effect of the bank level, banking industry level and macroeconomic factors (as the result of the ongoing banking reforms) on bank efficiency in Ghana (as in any other emerging or transitioning economy) is important for assessing the overall effects of the recent spate of banking reforms in emerging economies such as Ghana (Andries and Capraru, 2013; Banyen and Biekpe, 2020; Casu and Girardone, 2009). The objective of this study is twofold. The first is to determine whether the ongoing banking reforms have improved the relative levels of both the PTE and CE of the universal banking industry in Ghana during the period 2008–2019 using a nonparametric data envelope analysis (DEA) technique. The second is to examine the factors that account for the variations in bank efficiency in Ghana during the study period using both static panel and dynamic panel regression techniques.

The rest of the paper is organized as follows. The next section will discuss and review the extant bank efficiency literature. Section 3 will present and analyze the methodology and the data employed in the study. The empirical findings will be presented in section 4 and section 5 will conclude the paper.

2. Literature review

Conceptually, a firm or a decision-making unit (DMU) is said to be efficient when it can optimally combine its scarce resources or input to produce a given level of goods and services or output. Also, a firm or a DMU within a particular group, industry or region, according to Kablan (2010), is said to be efficient among its peers when that firm or DMU can be found on or close to the production possibility frontier or curve. So, in the context of this study, a bank is said to be efficient when it can optimally combine its resources or input (say customers deposits, staff cost, capital-related expenses, etc.) to produce the desired level of output (say loan, advances, investments, etc.). Essentially, efficiency measurement can help one to ascertain the "best-practice" (efficient) or "worse-practice" (inefficient) DMU or bank. Thus, the performance of a bank branch within a given bank, a deposit money bank within a given banking sector in a country or a banking sector of a particular country within a particular region, etc. could be measured comparatively. This will allow for peer learning and the tailoring of policy initiatives for optimal results at the group level. So, for instance, the effect of the ongoing banking reforms in emerging economies such as Ghana could be examined (Adjei-Frimpong, 2013; Adjei-Frimpong et al., 2013; Banya, 2017; Sarpong-kumankoma, Abor, Aboagye and Amidu, 2017a). There are two broad categories of efficiency that could be measured. A firm that can optimally combine its resources or input to maximize output is considered technically (i.e. pure or scale) efficient. On the other hand, given the availability of prices of input (i.e. cost) and prices of output (i.e. revenue) a firm that is able to limit its cost of production to maximize its revenues is considered profit or allocative efficient. So, a profit-efficient firm can either be cost-efficient if it can minimize the cost to generate more revenues; or revenue-efficient if it can maximize revenue with a minimum cost of production (Badunenko et al., 2012). Methodologically, one could distinguish between the measurement of efficiency either by a frontier parametric or frontier nonparametric techniques. In using the frontier parametric techniques such as the Stochastic Frontier Approach (SFA), the Thick Frontier Approach (TFA) or the Distribution Free Approach (DFA) to measure efficiency, the researcher must first specify a functional form in an empirical econometric model. The nonparametric frontier technique, such as the Data Envelopment Analysis (DEA) or the Free Disposal Hull Analysis (FDH), on the other hand, does not require any functional form to be specified or any econometric model to be employed but uses a linear programming technique to measure efficiency. Further, the frontier parametric technique allows noise or random errors to be captured in the efficiency measurement, whereas the nonparametric techniques does not. Thus, the nonparametric technique suffers the drawback of handling all form of noise (internal or external; exogenous or endogenous) as an inefficiency. However, the parametric approach needs to specify the functional form and the random error for the efficiency measurement and this makes this approach more difficult to handle (Coelli, Rao, O'Donnell and Battese, 2005). Also, one needs to identify the input and the output variable combination in estimating the efficiency score. Two techniques could be employed in deciding input and output variable selection. One could either choose the production approach or the intermediation approach depending on the availability of financial data on the input and output variables (Mokhtar et al., 2006). In banking practice, the intermediation approach is the most widely used technique, and this assumes banks as intermediaries that collect deposits from customers by the use of their labour, capital and other related expenses and then intermediate those sources of funds into loans and other earning assets (Berger and Humphrey, 1997; Kwan and Eisenbeis, 1997b). The production approach, on the other hand, views banks as producers of financial services that use physical inputs such as labour and capital to provide a deposit, loans and other earning assets to its customers (Lindley and Sealey, 1977). After employing the above techniques in estimating the efficiency scores, the results will be bounded by zero (0) and one (1). A score of one (1) denotes an "efficient-frontier" or "best-practice" DMU or bank in the banking industry, whereas an efficiency score of zero (0) represents all the "inefficient" or "worst-practice" DMU's in the banking industry (Coelli et al., 2005). A DMU or a bank is said to be efficient when it is on the efficient-frontier line, obtains a score of one (1), or is more closer to the efficient-frontier line or more closer to one (1). The banking industry in Ghana, in almost all of the empirical literature reviewed, has documented an efficiency score of less than one (1) but not close to zero (0).

Studies that examine the link between bank efficiency and banking reforms (i.e. bank capital reforms, removal of repressive measures to improve competition, asset quality or risk reforms etc.) revolve around several competing traditional theories such as the efficient structure hypothesis (ESH) of Demsetz (1973), the market power hypothesis, the quiet-life hypothesis (QLH) of Hicks (1935), market-structure hypothesis, the structure-conduct-performance hypothesis (SCPH) of (Bain, 1951) and Baumol (1982), etc. The "efficient structure" hypothesis (ESH) of Demsetz (1973) and the "market power" hypothesis, in particular, postulate that there is a positive link or association between efficiency and competition. In terms of banking, the 'efficient structure' hypothesis, for instance, postulates that the banking industry structure arises out of superior operating efficiency by the 'efficient frontier' or 'best-practice' players in the industry, and that, reforming the banking system to make the players efficient may compel them to minimize cost, be competitive and remain profitable in the industry (Andries and Capraru, 2013; Andrieş and Căpraru, 2012). The quiet-life hypothesis (QLH) of Hicks (1935), and the "market-structure" hypothesis argue that superior market power in the hands of the players (as a result of reforms) will cause them to, for instance, lower their efforts in improving their managerial or operational efficiency. Thus, in terms of banking, the "the quiet-life-hypothesis" explains that managers of banks, for instance, given a superior market power, may not have the incentive to work as hard to keep their cost of operation under control and may do whatever it takes to raise their market power regardless of cost (Andries and Capraru, 2013; Banyen and Biekpe, 2020). In supporting this view, Berger and Hannan (1998) reiterate the point that bank managers tend to relax on cost-cutting on minimizing measures when the banking environment is less competitive. Koetter and Oliver (2008), in supporting this view, also documented a positive relationship between market power and efficiency. Their findings suggest that a decline in bank competition will lead to a rather decrease in the efficiency level of the financial institution within the sector. Similar to the quiet-life hypothesis is the structure-conduct-performance (SCP) hypothesis of Bain (1951) and Baumol (1982). The 'structure-conduct-performance' hypothesis framework postulates that a small number of banks with independent market power may collude to charge higher prices by paying lower rates on deposits while charging higher rates on loans so as to earn abnormal profits. This view of the 'structure-conduct-performance' hypothesis stipulates that superior performance of a banking system is incumbent on the policymakers or regulators to either deregulate or do away with repressive measures in order to make the system to be more opened, well integrated, highly competitive or more liberalized. Claessens (2009), asserted that a competitive banking system will lead to an improved superior banking operations with highly qualitative and innovative financial products and services. Berger (1995) and Cobbinah et al. (2020), also posited that the competiveness of any banking system could be driven by the nature of banking supervision, governance and regulatory regimes. Both the views of the 'efficient structure' hypothesis, the 'quiet-life' hypothesis or the 'structure-conduct-performance' paradigm suggest that the choices of banking reforms that improves both the bank-specific or banking industry-specific factors may either have a positive or negative impact on bank efficiency as well. Although these hypothetical theories have been applied severally to analyse the impact of the choices of banking reforms (i.e. capital reforms, removal of repressive measures, etc.) on bank efficiency in advanced countries, evidence from transitioning countries, such as Ghana appear very little (Banyen and Biekpe, 2020).

The second set of literature reviews in the bank efficiency studies, according to Berger and Humphrey (1997), has been concerned with methodological literature for the bank efficiency researcher. Issues concerning the choices of frontier estimation techniques, the choice of inputs and output definitions, the use of static or dynamic data or models, etc. to improve the quality or robustness of estimations. Researchers significantly address one or more specific methodological issues in an attempt to reach some degree of conclusion based on a variety of econometric modelling, mathematical or statistical testing techniques. This direction of research, according to Berger and Humphrey (1997), would result in more reliable or valid efficiency estimates and thus guide the regulator or policymakers to make more useful or appropriate policy decisions. For instance, various studies have employed more rigorous frontier efficiency estimation techniques such as the parametric stochastic frontier approach (SFA) originally developed by Aigner et al. (1977) or the nonparametric data envelope analysis (DEA) technique originally developed by Charnes et al. (1978) to estimate bank efficiency (See Banyen and Biekpe, 2020; B. Moyo, 2018; J. Moyo, Nandwa, Oduor and Simpasa, 2014). The frontier methods are said to be robust and provide more rigorous efficiency estimates for efficiency researchers or policymakers than say the less subjective accounting ratios (See Maude and Ahmad, 2021; Winful et al., 2014) or the more subjective interview techniques (See, for instance, the various editions of Ghana banking surveys by PricewaterhouseCoopers, 2017, 2018, 2020). Again, some studies have, for instance, used the nonparametric frontier techniques such as the DEA due to the small sample size of their panel data (See Adjei-Frimpong, Gan and Hu, 2014a; Banya, 2017). The more deterministic parametric frontier estimation technique such as the SFA requires a high frequency or large sample size data to produce more valid efficiency estimates (See Banyen and Biekpe, 2020; B. Moyo, 2018). To examine the determinants of bank efficiency some studies have employed only static panel data regression technique (See Banya, 2017), whilst others have used dynamic panel data regression techniques (See Adjei-Frimpong et al., 2014a) to also examine the effects of the dynamic changes in the estimated bank efficiency scores on bank efficiency estimates. Due to the unbalanced nature of the sample data or the small sample size, some studies have employed a forward orthogonal deviation following the recommendations of (Roodman, 2009) instead of the first differencing in the dynamic panel data regression analysis (See Adjei-Frimpong et al., 2014a).

Empirically, a large volume of scholarly scientific research has contributed to a rich and well-established body of scientific literature on bank efficiency even though the evidence from emerging African economies appears to be very scanty. The purpose of this empirical bank efficiency research, according to Berger and Humphrey (1997), could be categorized into three broad mutually exclusive directions. The first set of purposes has been to inform the regulator or policymakers on the effect of various regulatory or policy choices on bank efficiency at the industrial or regional level. Industrial or regional level regulatory or policy variables may include the removal of repressive measures or deregulation, financial liberalization, mergers and acquisitions, market structure, foreign entry, privations, etc. By examining or interrogating the impact of such regulatory or policy choices on bank efficiency in detail, the various efficiency studies could engender valuable scientific information to guide the regulator or policymakers to either modify, encourage or discourage specific industry or regional level policy. For instance, Banyen and Biekpe (2020) found that there is a positive relationship between efforts of financial integration and bank efficiency using panel data of 405 banks from 47 emerging African countries. Also, Sarpong-kumankoma et al. (2017b) found that banking reforms spurred competitiveness among Sub-Sahara African banks and promoted operational efficiency in the banking industry between 2006 and 2012. Similarly, Adjei-Frimpong, Gan and Hu (2014) found that banking sector reforms had a significant direct positive effect on the efficiency of Ghana's banks from 2001–2010. Using data from 17 South African banks for 2004–2015, Moyo (2018) argue that policies that engenders financial soundness in the banking sector enhance bank efficiency in South Africa. A recent study by Maude and Ahmad (2021) confirms the positive effect of bank-specific and banking industry-specific factors on efficiency in the Nigerian banking industry between 2010 and 2018. They concluded that banking sector reforms in Nigeria have stimulated financial soundness in the banking sector and had had a positive effect on bank efficiency.

Many of the studies on the efficiency of the Ghanaian banks have considered the vectors of either bank-level data alone, or bank-level combined with industry-level data, or combined bank-level, industry-level and macroeconomic data in examining the variations in the efficiency levels of banks in Ghana. Adjei-Frimpong et al. (2014) and Alhassan et al. (2016) estimated the impact of banking reforms on bank efficiency in Ghana using panel data analysis and reported that the determinants at both the bank and the macroeconomic level were significant in explaining the variations in bank efficiency of the Ghanaian banks. Ohene-Asare (2011) also examined the determinants of bank efficiency in Ghana for the period 2002–2010 and reported the bank-specific factors to be significant in determining bank efficiency in Ghana. As shown in Ohene-Asare (2011), Bokpin (2013), Adjei-Frimpong (2013), Adjei-Frimpong et al. (2014) and Alhassan et al. (2016), bank-specific characteristics include size, capital, profit, asset quality, liquidity, specialization, ownership type, corporate governance, etc. Changes in these bank-specific factors could positively or negatively affect bank cost-efficiency in Ghana. It is expected that the effect of bank size, bank capital, profitability and liquidity as bank-specific factors used in this study on the efficiency of the universal banks would either be positive or negative. However, it is expected that the effect of the high nonperforming loan (NPL) ratio or loan-loss provision (LLP) on the efficiency of the universal banks in Ghana will be negative. The GDP growth rate, inflation and exchange rates were used as macroeconomic factors in many of the empirical bank efficiency studies on developing countries. Contrary to the expectations of this study, Adjei-Frimpong (2013), reported a negative effect of GDP growth rate on bank cost-efficiency in Ghana. Alhassan et al. (2016), on the other hand, found a positive and significant relationship between GDP growth rate and the efficiency of the banks in Ghana. The studies of Adjei-Frimpong et al. (2014) and A. L. Alhassan et al. (2016) all revealed a negative and significant effect of inflation on cost-efficiency in Ghana's banks. The literature reviewed in this study, so far, shows that there is no common consensus that exists among researchers on the effects of either bank-level, industry-level or macroeconomic factors in explaining the changes in bank efficiency in Ghana. Also, many of the reviewed bank efficiency studies on Ghana have, so far, examined the impact of both bank-specific and macroeconomic factors on bank efficiency in Ghana but none have considered bank efficiency estimation and determination, particularly after the passage of the new banking act in 2016.

3. Methodology

3.1. Data

The study covers the universal banking sector in Ghana during the period 2008–2019. The selection of a bank in this study depends on the number of years that particular universal bank has been in operation in Ghana, the amount of information available for each bank and if the bank is still in operation at the time of writing the report. Therefore, the universal banks in operation from the beginning of January 2008 to end-December 2019 in Ghana were used in the sample. Again, banks that were not in operation before 2008 and those that were liquidated during the period 2008–2019 were excluded. Universal banks whose available information is not up to three years were also excluded. This study, therefore, employs a sample panel data comprising 21 out of the 23 tier 1 banks in Ghana with 198 annual observations. An unbalanced panel data was used due to some missing values of the banks used in the sample in some of the years which were omitted from the panel data. The bank-level data was collected from the annual reports of the sampled banks and the annual Ghana banking surveys of PricewaterhouseCoopers (PwC). The macroeconomic variables were obtained from the World Development Indicators (WDI) of the World Bank. The bank efficiency scores were estimated using the Max DEA Ultra 8 software package whilst the regression analysis was performed in Version 15 of the STATA software package.

3.2. Estimating bank efficiency in Ghana

As shown from the empirical literature, the measurement of efficiency has methodological implications for the researcher. Issues concerning the choices of frontier estimation techniques, the choice of inputs and output definitions, the use of static or dynamic data or models, etc. to improve the quality or robustness of estimations. Researchers significantly address one or more specific methodological issues in an attempt to reach some degree of conclusion based on a variety of econometric modelling, mathematical or statistical testing techniques, etc. This direction of research, according to Berger and Humphrey (1997), would result in more reliable or valid efficiency estimates and thus guide the regulator or policymakers to make more useful or appropriate policy decisions. For instance, various studies have employed more rigorous frontier efficiency estimation techniques such as the parametric stochastic frontier approach (SFA) originally developed by Aigner et al. (1977) or the nonparametric data envelope analysis (DEA) technique originally developed by Charnes et al. (1978) to estimate bank efficiency (See Banyen and Biekpe, 2020; Moyo, 2018; Moyo, Nandwa, Oduor and Simpasa, 2014). The frontier methods are said to be robust and provide a more rigorous efficiency estimate for efficiency researchers or policymakers than say the less subjective accounting ratios (See Maude and Ahmad, 2021; Winful et al., 2014) or the more subjective interview techniques (See, for instance, the various editions of Ghana banking surveys by PricewaterhouseCoopers, 2017, 2018, 2020). This study, therefore, employs the more objective and rigorous frontier estimation techniques in estimating bank efficiency in Ghana as opposed to the less subjective accounting ratios or the more subjective interview techniques.

3.3. Data envelope analysis as a measure of bank efficiency in Ghana

This study employs a data envelope analysis (DEA) approach in estimating bank efficiency in Ghana. The DEA is a nonparametric frontier efficiency estimation technique which uses a linear programing technique in efficiency estimations. This is opposed to the parametric frontier techniques such as the stochastic frontier analysis (SFA) which is more complex to estimate and uses an empiric econometric estimation technique. The variable returns to scale (VRS) of the DEA techniques of Banker et al. (1984) instead of the constant returns to scale (CRS) technique by Charnes et al. (1978) was used. The VRS technique was used since the sampled banks are assumed to be operating in imperfect Ghanaian banking industry with financial constraints, and the CRS technique requires a perfect market environment.

To estimate bank efficiency in Ghana, this study employs an input-oriented nonparametric DEA technique which is expressed in linear Eq. (1) below:

$$\text{Minimize} \ \ \lambda, K_{i^*} P_{i'} K_{i^*} \tag{1}$$

Subject to $-Q_i + Q\lambda \geq 0 K_{i^*} - K\lambda \geq 0 NI'\lambda = I\lambda \geq 0 \ i = 1, \ldots N$where K_i and Q_i represent the input and output variables of the universal banks (represented by N) in the sampled data; input price is represented by P_i; the vectors of cost/input-minimizing bank are represented by K_i*, and λ is an Nx1 vector of constants. To finally estimate the levels of bank efficiency in Ghana, the estimated optimal values of the input values K_i* for the i^{th} bank (from Eq. (1) above) were then included in Eq. (2).

$$PTE/CE = \frac{P_{i'} K_{i^*}}{P_{i'} K_i} \tag{2}$$

As shown from the empirical literature, after employing Eq. (2) above in estimating the efficiency scores, the results produced an efficiency score bounded by zero (0) and one (1). A score of one (1) denotes an "efficient-frontier" or "best-practice" DMU or bank in the banking industry, whereas an efficiency score of zero (0) denotes all the "inefficient" or "worst-practice" banks in the banking industry (Coelli et al., 2005). Again, the banking industry in Ghana, in almost all of the empirical literature reviewed has documented an efficiency score of less than one (1) but not close to zero (0).

3.4. Variables used in the nonparametric DEA model

One of the advantages that the nonparametric DEA technique has over the parametric frontier techniques is that it can handle the combined inputs, input prices and outputs variables in the linear equation. The intermediation approach, originally developed by Lindley and Sealey (1977), as opposed to the production approach was employed by this study to select customer deposits, staff cost and capital-related expenditure as input variables; loans including advances and other earning assets such as investments as output variables. Further, prices of (deposits, staff costs and capital-related expenses) were considered as input prices for the cost-efficiency estimates. The production approach was not considered because of the difficulties involved in obtaining detailed bank information on various financial documents and other related bank transactions in Ghana, which are the basic requirements in the production approach (See Adjei-Frimpong et al., 2014a).

3.5. Empirical model for the determination of bank efficiency in Ghana

Next, the determinants of purely technical and cost-efficiency of the Ghanaian banking industry were estimated using both static and dynamic panel estimators. The PTE/CE were each regressed on the combined vectors of bank-specific and macroeconomic explanatory variables. From the literature, some studies employ the vectors of both bank-specific and macroeconomic variables whilst other studies employ only the bank-specific factors for the regression analysis. This study used both vectors in the regression analysis.

The static Eq. (3) below follows the static panel equation model of Staub et al. (2010) where the estimated average PTE/CE score of the universal banks (dependent variable) is regressed on the explanatory variables, that is, vectors of bank-specific and macroeconomic explanatory variables for the period 2008–2019.

$$EFF_{it} = \alpha_1 CAP_{it} + \alpha_2 ROA_{it} + \alpha_3 LNSIZE_{it} + \alpha_4 LIQ_{it} + \alpha_5 LLP_{it} + \alpha_6 INFit + \alpha_7 GDP_{it} + \eta_i + \mu_{it} \tag{3}$$

where the individual bank is represented by *i* and time is denoted by *t*, α is the parameters to be estimated, η_i represents individual bank specific-effect, μ_{it} is the error term, EFF_{it} denotes the logistic transformed bank pure technical/cost-efficiency score, CAP_{it} represents capital, ROA_{it} denotes return on assets measured as a proxy for profitability, $LNSIZE_{it}$ represents the natural log of total asset and a proxy for bank size, LIQ_{it} represents liquidity, LLP_{it} represents loan loss provision, $GDPG_{it}$ represents GDP growth rate and INF_{it} represents the rate of inflation.

All the explanatory variables specified in this static model are assumed to be strictly exogenous. Following Staub et al. (2010) and Adjei--Frimpong (2013), the static panel model as specified in Eq. (3) above was modified by including a one-year lagged PTE/CE pre-determined explanatory variable (EFF_{it-1}) to capture the dynamic nature of the universal banking industry in Ghana. Staub et al. (2010) hypothesized that the accumulation of experience and technological advancement emanating from a previous year's banking operations could cause bank efficiency to persist over time. In other words, the authors posited that the one-year's lagged cost-efficiency variable could have a significant positive (or negative) impact on the current year's bank cost-efficiency score. Thus, the studies of Staub et al. (2010) confirm the significant influence of a previous year's cost-efficiency estimates. Their findings were also confirmed by the findings of Berger and Humphrey (1991).

The dynamic panel equation model with the inclusion of a one year lagged pure technical/cost-efficiency predetermined explanatory variable is presented in Eq. (4) below:

$$EFF_{it} = \beta_1 EFF_{it-1} + \beta_2 CAP_{it} + \beta_3 ROA_{it} + \beta_4 LNSIZE_{it} + \beta_5 LIQ_{it} + \beta_6 LLP_{it} + \beta_7 INFit + \beta_8 GDP_{it} + \eta_i + \varepsilon_{it} \tag{4}$$

where the individual bank is represented by *i* and time is denoted by *t*, β is the parameters to be estimated, η_i represents individual bank specific-effect, ε_{it} is the error term, EFF_{it} denotes the logistic transformed bank pure technical/cost-efficiency score, $\beta_1 EFF_{it-1}$ represents the one-year lagged logged bank PTE/CE, CAP_{it} represents capital, ROA_{it} denotes return on assets measured as a proxy for profitability, $LNSIZE_{it}$ represents the natural log of total asset and a proxy for bank size, LIQ_{it} represents liquidity, LLP_{it} represents loan loss provision, $GDPG_{it}$ represents GDP growth rate and INF_{it} represents the rate of inflation.

Since the DEA efficiency scores will range from zero to one, a logit transformation technique was conducted to transform the estimated average cost-efficiency scores into natural log odds (See for example Adjei-Frimpong et al., 2014a) as follows:

$$LNEFF_R = Ln\left(\frac{EFF_u}{1 - EFF_u}\right) \tag{5}$$

However, there would have been a loss of data when the transformed DEA score is either zero or one. To overcome this weakness, 1/2N (i.e. half of the total number of observations) was added to both the numerator and the denominator of the natural log formula as shown in Eq. (5) above (See for example Adjei-Frimpong, 2013; Adjei-Frimpong et al., 2014a). One major advantage of the modified logistic transformation method, according to the authors, is that the problem with missing variables associated with the DEA calculation is curtailed.

3.6. Model variable definitions

Both the dependent and the explanatory variables for the static and the dynamic equations used in this study are described in Table 1 below. The table showcases the estimated logged DEA PTE/CE score as the only dependent variable in both the static and the dynamic models. Explanatory variables such as lagged PTE/CE scores (i.e. applicable to only the dynamic panel data model), bank size, bank capital, profitability and liquidity are presented under the bank-specific category in the equations. The GDP growth rate and the inflation rate are grouped under the macroeconomic variables in this study's static and dynamic equation models.

3.7. Empirical estimation techniques

The coefficients of the static Eq. (3) above are estimated by both the fixed effect (FE) generalized least square (GLS) estimator and the random (RE) effect generalized least square (GLS) estimator. A Hausman specification test was conducted in the first place to find out whether the fixed effect estimator or the random effect estimator is appropriate to estimate the coefficients in the static equation. Also, a Breusch-Pagan Lagrange test was conducted to choose the appropriate estimator between the pooled ordinary least square (OLS) and the random effect GLS estimators. Furthermore, the coefficients in the static equation for this study were estimated using the White/Huber 1980 standard robust errors test to control for potential heteroscedasticity. Finally, to test whether the static panel model is correctly specified, this study used the F-test.

On the other hand, this study employs the generalized methods of moments (GMM) estimator to estimate the dynamic model above. This

Table 1. Empirical model variables.

Variable	Description	Expected sign
Dependent Variable:		
Bank Cost-Efficiency (CEFF)	Estimated using DEA method	
Bank-specific Factors:		
Lagged Efficiency ($LNEFF_{1-t}$)	Lagged logged DEA estimated cost-efficiency	(+/-)
Bank Size (LNSIZE)	Natural logarithm of total assets of banks	(+/-)
Bank Capital (CAP)	Total owners' equity over total assets	(+/-)
Profitability (ROA)	Returns measured as a proxy for profitability	(+/-)
Liquidity (LIQ)	Ratio of liquid funds to total assets	(+/-)
Credit Risk (LLP)	Impairment allowances over gross loans	(-)
Macroeconomic Factors:		
GDP Growth Rate (GDPG)	Growth rates between two consecutive years	(+/-)
Inflation Rate (INF)	Change in consumer price index	(+/-)

Table 2. Descriptive statistics of the explanatory variables.

Variable	Observations	mean	Std. Dev.	Minimum	Maxim.
SIZE	198	2,638	2,528	148	13,197
CAP	198	0.166	0.095	0.044	0.896
ROA	198	0.027	0.023	-0.102	0.074
LIQ	198	0.540	0.143	0.240	0.890
LLP	198	0.082	0.103	-0.045	0.720
GDPG	198	0.066	0.031	0.022	0.140
INFL	198	0.128	0.039	0.071	0.193

CAP, ROA, LIQ, LLP, GDPG, and INFL are recorded in ratios; SIZE is in million Ghana Cedis.

was chosen because it can accommodate lagged-dependent variables, unobserved heterogeneity and both exogenous and endogenous explanatory variables. Further, the GMM technique, according to Baltagi (2008), is superior to the static equation estimators which generate inconsistent estimates in the presence of lagged dependent and endogenous variables in empirical regression analysis. This study employs the system GMM variation of the GMM techniques, which according to Arellano and Bover (1995) and Blundell and Bond (1998), is superior to the static equation estimators and the first difference GMM technique for small sample estimates. Also, following the recommendation of Roodman (2009), this study used the forward mean deviation (FMD) otherwise known as forward orthogonal deviation (FOD) in place of the first-difference because of the unbalanced nature and small sample data used in this study. Again, the coefficients in the dynamic equation for this study were estimated using the two-step system GMM of Windmeijer (2005) to correct the least biases in small samples and control for potential autocorrelation and heteroscedasticity.

Further, based on the existing empiric literature on bank efficiency and as shown in, capital and loan loss provision is assumed to be endogenous explanatory variables to bank efficiency, and for that matter, are instrumented with their lags in the two-step system GMM model. To avoid instrument proliferation in the system GMM estimations, the second and third lags of capital and loan loss provision were used as collapsing instruments. This technique, according to Roodman (2009), will allow this study to have a more reliable estimation. Finally, to test the validity of the instruments used in the system GMM for the dynamic equation, this study used the Hansen and second-order autocorrelation test.

4. Results and discussions

Analysis of the explanatory variables and a pairwise correlation matrix were presented in Tables 2 and 3 below respectively. The minimum and maximum values of the bank-specific factors depict large variations across the universal banks in Ghana from the period 2008–2019. The dispersions (i.e. standard deviations) in bank size (i.e. std. Dev. = GH¢ 2,528,449) and bank capital (i.e. std. Dev. = 0.0954) suggest that the universal banks in Ghana are not the same in size and capital structures. Also, Table 2 depicts a worrying trend in the values of the ratio of loan loss provision (LLP) in Ghana. The maximum ratio of 72 percent and the average ratio of 8.2 percent suggest that the rate of deterioration in the asset books of the banks in Ghana is still worrying. However, the liquid assets levels of Ghana's banking system is relatively high during the study period from 2008-2019. On average, banks in Ghana have a liquidity ratio of 14.3 percent with the highest recording a ratio of 89 percent. There is, however, a mixed trend in the profitability ratio. Whereas some of the banks are profitable, others proved not to be profitable. The minimum ROA is -10.2 percent and the highest return is 7.4 percent. The average ROA for the period under review is 2.7% (see Table 4).

To allay the fear of multicollinearity in the explanatory variables, a pairwise correlation matrix was conducted. Table 3 above shows there are low correlations among the explanatory variables employed in this study and that allays the fear of multicollinearity problems with this study.

4.1. Estimation of the relative bank efficiency scores in Ghana

The descriptive statistics of the input, output and input price variables for the year-on-year pure technical and cost efficiency scores for the universal banks in Ghana for the study period 2008–2019 using a nonparametric DEA technique is shown in this section. The dispersions (i.e. standard deviations) in the input and the output variables suggest that Ghana's banks are not the same in customer deposit and total assets market shares. Table 5 also depicts the year-on-year average PTE/CE scores of Ghana's banks, and the average PTE score as shown in the table is 0.92, and this compares to the average overall CE score of 0.80. This implies that the average Ghanaian bank wastes about 8% of its scarce resources or overspends 20% of its cost of operations relative to the "best-practice" or "efficient-frontier" bank.

As shown in Table 5, the scores of both the PTE and the CE suggest that the banks in Ghana are operating below the "efficient-frontier" line or the "best-practice" benchmark score of one (1). These scores can, however, be improved if the average bank in Ghana can reduce its managerial and cost inefficiencies by 8% and 20% respectively. From the empirical literature, the inefficiency of the Ghanaian banks could be attributable to the inability of the executive management of banks to put proper input utilization measures in place for efficient bank performance. The ongoing expansion works and the heavy investment in fixed assets and technology by banks during the study period could as well impact heavily on the cost of operations and thereby causing the Ghanaian banks to be cost-inefficient. Further, the low cost-efficiency levels of the Ghanaian banks during the study period, according to Adjei-Frimpong (2013), could be attributed to high-interest rates or capital. The study of Adjei-Frimpong (2013) also depicts that the banks in Ghana are pure technical inefficient and at the same time cost-inefficient. To this end, it is recommended in this study that the Ghanaian banks, during the period under consideration and against the backdrop of the ongoing banking reforms, should focus on cost management strategies in order to curtail their growing cost of operations to improve their efficiency levels.

Further, Table 5 depicts the year-on-year PTE score for the Ghanaian banking industry to have deteriorated before the passage of the new banking act in 2016 given the 0.909 mean scores in 2008 and the 0.858

Table 3. Pairwise correlation matrix of bank efficiency determinants.

	SIZE	CAP	ROA	LIQ	LLP	GDP	INFL
Bank Size (LNSIZE)	1.000						
Capitalization (CAP)	-0.263	1.000					
Profitability (ROA)	0.303	-0.233	1.000				
Liquidity ratio (LIQ)	-0.124	0.415	-0.170	1.000			
Loan loss provision (LLP)	-0.196	-0.190	-0.123	-0.170	1.000		
Gross domestic product (GDP)	-0.216	0.089	0.036	0.026	0.150	1.000	
Inflation (INFL)	-0.178	-0.098	-0.107	-0.191	0.034	-0.665	1.000

CAP, ROA, LIQ, LLP, GDPG, and INFL are in ratios; SIZE is in natural log form.

Table 4. Summary statistics of the input and output variables.

Variable	Obs	Mean	Std. Dev.	Minimum	Max.
Input Variables					
TCD	198	1,887,869	1,821,176	1,464	10,900,000
TSC	198	83,510	83,164	2,572	496,732
CRE	198	105,779	101,320	1,190	569,096
Output Variables					
L&D	198	1,065,075	938,032	3,044	5,318,113
OEA	198	915,791	1,093,242	32,841	6,442,387
Input Prices					
Deposit Price	198	0.108	0.649	0.010	9.178
Staff Price	198	0.034	0.017	0.001	0.136
Capital Price	198	1.998	1.867	0.032	17.171

TCD = Total Customer Deposits; TSC = Total Staff Cost; CRE = Capital Related Expenses; L&D = Loans and Advances; and OEA = Other Earning Assets.

Table 5. Overall year-on-year average bank efficiency scores (2008–2019) in Ghana.

Year	Number of Banks	PTE		CE	
		Mean	Std.Deviation	Mean	Std.Deviation
2008	12	0.909	0.187	0.818	0.225
2009	12	0.985	0.052	0.909	0.154
2010	13	0.968	0.067	0.862	0.185
2011	14	0.937	0.136	0.725	0.269
2012	15	0.964	0.065	0.773	0.237
2013	15	0.939	0.107	0.810	0.241
2014	17	0.725	0.249	0.725	0.249
2015	20	0.858	0.153	0.686	0.258
2016	20	0.944	0.953	0.822	0.205
2017	20	0.922	0.105	0.810	0.172
2018	20	0.904	0.110	0.816	0.139
2019	20	0.948	0.097	0.851	0.140
Total		0.913	0.143	0.797	0.216

The trend in the efficiency score, following the passage of the new banking act in 2016 to the end of the study period, suggests that Ghana's bank managers have been able to implement an effective input utilization and cost-management strategies in place. Nevertheless, as the overall average PTE and CE scores, according to this study's findings, are relatively below the benchmark "best-practice" efficiency score of 1, bank managers are advised to continue putting in more effort to effectively minimize input or cost wastage.

mean score in 2015. However, the PTE mean score began to soar immediately after the passage of the new banking act when it recorded a remarkable score of 0.944 in 2016 through 2019 when it recorded an average score of 0.948. The average yearly CE scores also decline before the passage of the new banking act in 2016 when it fell from 0.818 in 2008 to 0.686 in 2015. Similarly, the CE score, however, soared immediately after the passage of the new banking act when it recorded a remarkable score of 0.822 in 2016 through 2019 when it recorded an average score of 0.851.

Comparatively, both the PTE and the CE scores in Ghana, prior to the passage of the new banking act in 2016, exhibited a worrying downward trend, but with the coming into effect the implementation of the recent spate of banking reforms, both scores began to soar. These suggest that the recent spate of banking reforms is showing a positive influence relatively on both the PTE and the CE levels of the banks in Ghana. However, the improvement in the efficiency scores throughout the study period is more pronounced in pure technical efficiency than cost-efficiency. This suggests, therefore, suggests that the executive managers of the universal banks in Ghana are more capable of utilizing input resources than cost-management.

4.2. Determination of bank pure technical efficiency

The first phase of the second stage of this study is to examine the determinants of bank pure technical efficiency in the Ghanaian banking industry during the study period 2008–2019. Table 6 below depicts the p-value of the F-test to be 0.000 which suggests that the explanatory variables used in the static Eq. (3) are jointly relevant in determining Ghana's bank PTE. The analysis of the residual depicts the presence of heteroscedasticity and as such, White/Huber robust standard error and the Windemeijer (2005) corrected robust standard error was used to estimate the coefficients in the static panel model and the dynamic panel model respectively. In terms of the static panel equation, the Hausman test (i.e. p-value = 0.999) confirms the superiority of the random effect estimator over the fixed effect estimator. The Breusch-Pagan Lagrange test (i.e. p-value = 0.000) also confirms the superiority of the random effect GLS estimator over the pooled OLS estimator. On the other hand, the two-step system GMM technique was used in this study to estimate the coefficients in the dynamic panel model. From the table, the test statistic of Arellano-Bond AR1 (i.e. p-value = 0.021) confirms the existence of first-order serial autocorrelation in the error term. However, since the test statistics of the Arellano-Bond AR 2 for the second-order serial autocorrelation in the residual of 0.414 is significantly above 10%, the specification of the error term in this study is not rejected. Further, the number of institutions used (i.e. 21 banks) in the sample are more than the number of valid instruments (i.e. 20 instruments), and that, the Hansen test of over-identification of instruments is p-value = 0.116 (i.e. above 10% level of significance) which confirms the validity of the instruments used in this study. The validity of the instruments used in the system GMM is further strengthened with a test statistics of the difference-in-Hansen test of exogeneity score of 0.116. The significance of this test statistic also confirms the validity of the instruments used for the levels equation in this study. The significance of the Hansen test and the difference-in-Hansen test of exogeneity suggest that the instruments used in the system GMM and the levels equation and the error term are not serially correlated and that the dynamic panel Eq. (4) of this study is correctly specified for the estimation of the coefficients of the dynamic panel. This confirms the superiority of the dynamic panel model over the static panel models. Hence, this study chose the two-step system GMM technique over the random effect GLS technique for the determination of the PTE in Ghana.

The examination of the determinants of bank efficiency based on the two-step system GMM estimations presented in Table 6 below depicts the significance of bank size, GDP growth rate, and inflation in the determination of bank PTE in Ghana. The positive impact of bank size on bank pure technical efficiency in Ghana at the 10 percent level of significance, as shown in Table 6, implies that size matters in the determination of bank pure technical efficiency and that the larger the bank the purer technically efficient. These results also support the ongoing industry consolidation reforms by the regulator and the policymakers. The findings in this study are consistent with the results of Adjei-Frimpong et al. (2014b) on Ghanaian banks and Sufian (2009) on Malaysian banks. The pure technical efficiency of the universal banks in Ghana could as well be attributable to economies of scale. That the large universal banks, unlike the small banks in Ghana are usually present nationwide and are compelled to be technically efficient in input utilization or avoid wastages to remain competitive.

In terms of the macroeconomic factors, the table depicts mixed findings. The GDP growth rate, contrary to the expectation of this study, depicts a negative but significant impact on bank pure technical efficiency in Ghana. This suggests that the overall economic growth rate had rather a negative effect on bank pure technical efficiency during the study period in Ghana. This is consistent with the findings of Adjei-Frimpong et al. (2014b) who reported a negative but insignificant relationship between the GDP growth rate and bank pure technical efficiency in Ghana. Further, Table 6 shows the rate of Inflation in Ghana to be statistically significant at a 10 percent level of significance and has a positive impact on bank pure technical efficiency in Ghana.

Table 6. Determinants of bank pure technical efficiency in Ghana.

Variables/Estimates	OLS Model	FE Model	RE Model	System GMM
$LNPTE_{t-1}$	-	-	-	5.245 (0.11)
LNSIZE	54.400 (0.70)	33.000 (0.05)	16.400 (2.4)	0.007* (2.05)
CAP	0.013* (1.67)	0.014 (1.65)	0.013** (2.48)	0.065 (1.45)
ROA	0.038 (1.45)	0.023 (0.70)	0.031 (1.22)	0.021 (0.49)
LIQ	0.005 (1.13)	0.004 (0.54)	0.004 (0.95)	-0.003 (-0.34)
LLP	-0.002 (-0.28)	-0.002 (-0.32)	-0.001 (-0.35)	-0.004 (-1.75)
GDPG	0.089*** (2.99)	0.081** (2.66)	0.083*** (3.36)	-0.091* (-1.88)
INFL	0.029 (1.25)	0.020 (0.03)	0.023 (1.30)	0.012* (1.76)
CONS	4.624*** (317.49)	4.634*** (457.17)	4.631*** (505.41)	4.338* (1.92)
R-squared	0.094			
F-Statistics (p-value)	0.009	0.018	0.000	0.000
No. of Banks	21	21	21	21
No. of valid instruments	-	-	-	20
No. of Observations	198	198	198	177
Hansen J test (p-value)				0.116
Arellano-Bond tests:				
AR (1) p-value				0.021
AR (2) p-value				0.414
Difference-in-Hansen test (p-value):				
GMM instruments for levels				0.116

The estimates of the static Eq. (3): $LNPTE_{it} = \alpha_1 CAP_{it} + \alpha_2 ROA_{it} + \alpha_3 LNSIZE_{it} + \alpha_4 LIQ_{it} + \alpha_5 LLP_{it} + \alpha_6 INFit + \alpha_7 GDP_{it} + +\eta_i + \mu_{it}$ *and the dynamic Eq. (4):* $LNPTE_{it} = \beta_1 LNPTE_{it-1} + \beta_2 CAP_{it} + \beta_3 ROA_{it} + \beta_4 LNSIZE_{it} + \beta_5 LIQ_{it} + \beta_6 LLP_{it} + \beta_7 INFit + \beta_8 GDP_{it} + +\eta_i + \varepsilon_{it}$ are presented in this table. *The level of significance at 10%, 5% and 1% are denoted by *, ** and *** respectively. T-statistics* are in *parentheses below the estimated coefficients.*

This implies that a high rate of inflation in Ghana leads to an increase in the levels of bank pure technical in Ghana. This is, however, contrary to the expectations of this study. The positive and significant association between the high rate of inflation and bank PTE suggests that the universal banks in Ghana can charge higher rates even in times of higher inflationary trends to compensate for higher returns. The findings of this study are consistent with the study of Adjei-Frimpong et al. (2014b) and Chan and Karim (2010) who also reported that a significant increase in the levels of inflation will impact positively on bank PTE.

4.3. Determination of bank cost-efficiency

The second phase of the second stage of this study is to examine the determinants of bank cost-efficiency in the Ghanaian banking industry during the study period 2008–2019. Table 7 below depicts the p-value of

Table 7. Determinants of bank cost-efficiency in Ghana.

Variables/Estimates	OLS Model	FE Model	RE Model	System GMM
$LNCE_{t-1}$	-	-	-	14.408 (0.50)
LNSIZE	0.003*** (2.68)	-5.100 (-0.04)	8.720 (0.65)	0.012* (2.01)
CAP	0.043***(3.78)	0.037** (2.10)	0.036*** (3.00)	0.011** (2.21)
ROA	0.097** (2.49)	0.070 (0.1.39)	0.085** (2.01)	0.082 (0.90)
LIQ	-59.100 (-0.09)	0.016* (1.76)	0.009 (1.29)	-0.017 (-1.37)
LLP	-0.010 (-1.14)	-0.017** (-2.52)	-0.014*** (-2.68)	-0.008 (-0.72)
GDPG	0.123*** (2.81)	0.055 (1.44)	0.075** (2.14)	-0.096** (-2.66)
INFL	0.089** (2.59)	0.048 (1.46)	0.058** (1.94)	0.196* (2.03)
CONS	4.568***(212.86)	4.616*** (182.88)	4.603*** (202.11)	3.835*** (2.97)
R-squared				0.136
F-Statistics (p-value)	0.001	0.013	0.000	0.000
No. of Banks	21	21	21	21
No. of valid instruments	-	-	-	20
No. of Observations	198	198	198	177
Hansen J test (p-value)				0.480
Arellano-Bond tests:				
AR (1) p-value				0.012
AR (2) p-value				0.422
Difference-in-Hansen test (p-value):				
GMM instruments for levels				0.538

The estimates of the static *Eq. (3)*: $LNCE_{it} = \alpha_1 CAP_{it} + \alpha_2 ROA_{it} + \alpha_3 LNSIZE_{it} + \alpha_4 LIQ_{it} + \alpha_5 LLP_{it} + \alpha_6 INFit + \alpha_7 GDP_{it} + +\eta_i + \mu_{it}$ and the dynamic *Eq. (4)*: $LNCE_{it} = \beta_1 LNCE_{it-1} + \beta_2 CAP_{it} + \beta_3 ROA_{it} + \beta_4 LNSIZE_{it} + \beta_5 LIQ_{it} + \beta_6 LLP_{it} + \beta_7 INFit + \beta_8 GDP_{it} + +\eta_i + \varepsilon_{it}$ are presented in this table. The level of significance at 10%, 5% and 1% are denoted by *, ** and *** respectively. T-statistics are in parentheses below the estimated coefficients.

the F-test to be 0.000 which suggests that the explanatory variables used in the static Eq. (3) are jointly relevant in determining the cost-efficiency scores of the universal banking industry in Ghana. The analysis of the residual depicts the presence of heteroscedasticity and as such, White/Huber robust standard error and the Windemeijer (2005) corrected robust standard error was used to estimate the coefficients in the static panel model and the dynamic panel model respectively. In terms of the static panel equation, the Hausman test (i.e. p-value = 0.741) confirms the superiority of the random effect estimator over the fixed effect estimator. The Breusch-Pagan Lagrange test (i.e. p-value = 0.000) also confirms the superiority of the random effect GLS estimator over the pooled OLS estimator. On the other hand, the two-step system GMM technique was used in this study to estimate the coefficients in the dynamic panel model. From the table, the test statistics of Arellano-Bond AR1 (i.e. p-value = 0.012) confirms the existence of first-order serial autocorrelation in the error term. However, since the test statistics of the Arellano-Bond AR 2 for the second-order serial autocorrelation in the residual of 0.422 is significantly above 10%, the specification of the error term in this study is not rejected. Further, the number of institutions used (i.e. 21 banks) in the sample are more than the number of valid instruments (i.e. 20 instruments), and, the p-value of the Hansen test of over-identification of instruments is 0.480 (i.e. above 10% level of significance) which confirms the validity of the instruments used in this study. The validity of the instruments used is further strengthened with a test statistics of the difference-in-Hansen test of exogeneity score of 0.538. The significance of the test statistics also confirms the validity of the instruments used for the levels equation in this study. The significance of the Hansen test and the difference-in-Hansen test of exogeneity suggest that the instruments used in the system GMM and the levels equation and the error term are not serially correlated and that the dynamic panel Eq. (4) of this study is correctly specified for the estimation of the coefficients of the dynamic panel. This also suggests the superiority of the dynamic panel model over the static panel models. Hence, this study chose the two-step system GMM regression technique over the random effect GLS regression technique for the determination of the bank cost-efficiency in Ghana.

The examination of the factors that account for the changes in the levels of bank cost-efficiency in Ghana based on the two-step system GMM estimations presented in Table 7 below depicts the significance of bank size, bank capital, GDP growth rate, and inflation. The positive impact of bank size on bank cost-efficiency in Ghana at the 10 percent level of significance, as shown in Table 7, implies that size matters in the determination of bank cost-efficiency and that the larger the bank the more cost-efficient the bank might be. This results also support the ongoing industry consolidation reforms by the regulator and the policymakers since the passage of the new banking act in 2016. The findings are consistent with the results of Tecles and Tabak (2010), which conclude that large-size universal banks are the most cost-efficient banking subgroup in the universal banking industry. In contrast, the findings of Altunbas et al. (2007) concluded that the small universal banks are rather the most cost-efficient universal banking subgroup.

Another bank-specific factor that has a positive impact on the cost-efficiency score of the universal banks in Ghana and is statistically insignificant at 5 percent is bank capitalization. The results as shown in Table 7 confirms the significance of the ongoing capital reforms to the cost-efficiency of Ghana's banks. The significant effect of bank capital on the cost-efficiency of the banks may be attributable to the implementation of the ongoing capital requirement directive (CRD) under the Basel II/III capital framework particularly after the coming into effect of the new banking Act in 2016. This could also be attributable to the remarkable improvements in the capital adequacy ratio (CAR) of the Ghanaian banking industry during the study period. Again, the positive impact of bank capital on bank cost-efficiency could be attributable to the appropriate use of the injected funds unlike in other regimes that misuse injected capital as a source of funds for lending rather than the use of cheaper deposit. The findings in this study are, however, not consistent with the results of Adjei-Frimpong et al. (2014b) who reported a statistically significant but negative effect of bank capitalization on bank cost-efficiency. This the authors attributed to the misuse of bank capital for lending activities instead of the use of cheaper deposits for that purpose.

In terms of the macroeconomic factors, the table depicts mixed findings. The GDP growth rate, contrary to the expectation of this study, has a negative but significant impact on bank CE in Ghana. This suggests that the overall GDP growth rate had rather a negative effect on bank CE in Ghana. This is consistent with the findings of Adjei-Frimpong et al. (2014b) who reported a negative and significant relationship between the GDP growth rate and bank cost-efficiency in Ghana. According to the authors, a significant but negative effect of economic growth on the efficiency of banks could be attributable to the relaxation of some of the credit asset acceptance or screening requirements in times of economic boom and thereby negatively affecting the cost of operations. Further, Table 7 shows the rate of Inflation in Ghana to be statistically significant at 10 percent level of significance and has a positive impact on bank cost-efficiency in Ghana.

This implies that a high rate of inflation in Ghana leads to an increase in the levels of bank cost-efficiency in Ghana. This is, however, contrary to the expectations of this study. The positive and significant relationship between the high rate of inflation and bank cost-efficiency suggests that the universal banks in Ghana can charge higher rates even in times of higher inflationary trends to compensate for higher returns. The findings of this study are also confirmed by the study of Adjei-Frimpong et al. (2014b) and Chan and Karim (2010) who reported a significant and positive association between a high rate of inflation and bank CE.

5. Conclusion

This empirical work examines the relative efficiency levels of the universal banking system in Ghana during the period 2008–2019 using a nonparametric DEA technique in the first stage. The overarching objective of this study is to examine the determinants of bank cost-efficiency in Ghana during the study period using both static panel and dynamic panel regression estimators in the second stage. Overall, the findings of this study show relatively low pure technical efficiency and cost-efficiency levels of the entire Ghanaian banking industry during the study period to be below the benchmark "best-practice" efficiency score of 1. The low pure technical efficiency levels are attributed to executive management's inability to utilize input resources efficiently. Similarly, the cost-inefficiency in the Ghanaian banking industry is attributable to the executive management's inability to fully control or manage operational expenses effectively during the study period. However, both the purely technical and cost efficiency levels of the Ghanaian banking industry, after the coming into effect of the new banking Act in 2016 and several other banking reforms after Act 930, demonstrated a remarkable improvement suggesting that the executive management of Ghanaian banks were able to better utilize input resources and management cost more effectively during these periods. Nevertheless, Ghana's banking industry's efficiency levels are still below the "best-practice" score of one (1), and for that matter, the executive management of banks in the country needs to exert more effort in input utilization and cost-management schemes.

The two-step system GMM estimator per the diagnostic analysis proved to be superior and was chosen over the random effect GLS estimator for bank cost-efficiency determination. The empirical findings depict bank size, GDP growth rate and inflation to be the most important factors that must be considered in the determination of bank PTE in Ghana. The study also depicts bank size, bank capitalization, GDP growth rate and inflation to be the most important factors that significantly have a positive influence that must be considered in CE determination in Ghana. In contrast, the findings reveal that bank capital, return on assets (ROA), liquidity and loan loss provision is, however, not important factors that must be considered in the determination of bank PTE. The results also show that the return on assets (ROA), liquidity and loan loss provision are insignificant in the determination of bank CE in Ghana.

As shown, the banking reform in the Ghanaian banking industry is an ongoing process. Following the recommendations of Berger and Humphrey (1997), important implications will be offered by the findings of this study to researchers, policymakers, and bank management. First, as this study extends the study of existing researchers (See Adeabah, Gyeke-Dako and Andoh, 2019; Bokpin, 2013), it will add to the few works of literature on bank pure technical and cost-efficiency studies on Ghana. Second, the remarkable improvement of the efficiency levels of the Ghanaian banking system, particularly after the coming into effect of the new banking Act in 2016, for instance, gives credence to the ongoing bank reforms, and for that matter, the regulator and policymakers should continue to streamline regulations on especially bank capital requirements and other reforms, and to the other subsectors of the Ghanaian banking industry. Last but not the least, the year-on-year remarkable improvements in both PTE and CE in the Ghanaian banking sector indicate bank management benefit more from their investments in technology and other related knowledge transfers. This suggests that investments in technological advancement will go a long way to help the less pure technically efficient or cost-inefficient banks to improve their pure technical or cost-efficiency going forward.

Future studies will focus on the efficiency of the entire universal banking sector by which data on all the 23 universal banks will readily be available. Also, a more deterministic frontier technique, such as stochastic frontier analysis (SFA), would be employed in future research. Further, other efficiency estimates, such as scale or profit efficiencies could be estimated using either parametric or nonparametric techniques in future research. More explanatory variables would have been available such as Herfindahl-Hirschmann Index (HHI) of banking industry market concentration, return on equity (ROE), monetary policy rate (MPC), etc. but for want of parsimony and to avoid instruments proliferation in the dynamic estimator, this study only focused on the variables as employed in both pure technical and cost-efficiency determination in Ghana.

Declarations

Author contribution statement

Nathaniel Blankson: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Ebenezer Bugri Anarfo: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Godfred Amewu: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Louis Doabil: Conceived and designed the experiments; Performed the experiments.

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Data will be made available on request.

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No additional information is available for this paper.

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