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Managerial Efficiency and Bank Profitability

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We study the relationship between managerial efficiency and bank profitability in the context of the U.S. banking sector. We utilize Stochastic Frontier Analysis based on a dataset of 4081 U.S. banks, spanning from 2009 to 2021. Two key findings emerge: firstly, geographical disparities exist in operating cost efficiency, with banks in more developed states demonstrating higher efficiency compared to those in less developed regions. Secondly, we document a significant positive relationship between managerial efficiency and profitability. Our findings are robust to alternative definitions of key variables and additional model specifications. The implications of these findings extend to policymakers, who should prioritize tailored interventions to enhance bank efficiency while considering geographical specificities.

1.0 Introduction

Banks serve as important financial intermediaries by providing the necessary capital to sustain economic operations (Rajan and Zingales, 2003; Levine, 1997, 1998). The collapse of the banking sector, as evidenced by the Global Financial Crisis (GFC) of 2007-2009, can precipitate unimaginable consequences for a country and interconnected economies. The endurance and stability of the banking sector hinge on the efficiency and profitability of banks (Golin and Delhaise, 2013). In the face of intense competition, banks must maintain efficiency and profitability to survive. Particularly, the stability of the entire sector is at risk if systematically important banks falter.

Managerial efficiency stands out as a critical determinant among various factors affecting banks, whether at the level of individual institutions or within the broader macroeconomic context. The competence and effectiveness of bank management play a pivotal role in shaping the overall health and success of these financial entities. Without proficient management, banks cannot sustain profitability, given the intricate nature of their operations and the necessity for astute decision-making. Banks operate within well-defined frameworks and protocols, deviation from which can result in financial losses. For instance, the evaluation of loan applications demands a specialized skill set; failure to meticulously assess these applications can lead to loan defaults and subsequent financial setbacks.

Recent research by Assaf et al. (2019) highlights the significance of bank efficiency, particularly during periods of economic turbulence such as the Global Financial Crisis (GFC), where efficient banks in the USA demonstrated greater resilience. Over the past decade, the U.S. banking sector has undergone significant transformations, spurred by both the aftermath of the GFC and advancements in technology (Barth et al., 2010). Issues of bank efficiency and profitability have been central to these changes, as the profitability of banks plummeted in the wake of the crisis. In response, policymakers implemented various regulations aimed at enhancing the resilience and efficiency of the banking sector, often at the expense of profitability and risk-taking. Thus, examining the nexus between managerial efficiency and bank profitability assumes high importance, particularly within an economy like the USA, which exerts considerable influence over the global banking landscape, as evidenced during the GFC.

In this study, we utilize a Stochastic Frontier Analysis method, as proposed by Aigner et al. (1977), to estimate the levels of operating cost efficiency among commercial banks in the United States. We then employ these estimated efficiency levels as a proxy for managerial efficiency to examine their influence on bank profitability. Our analysis is based on an extensive dataset comprising 47,108 observations from 4,081 banks, covering the period from 2009 to 2021. Our investigation yields two main findings. Firstly, we observe significant geographical disparities in the managerial efficiency of U.S. banks. Specifically, banks located in more developed states demonstrate higher levels of efficiency, whereas those situated in less developed states exhibit lower efficiency levels. Secondly, we find a positive and highly significant relationship between managerial efficiency and commercial bank profitability, as measured by 'return on average equity' (ROAE). This implies that enhanced managerial efficiency translates into improved financial performance by effectively managing a bank's operational activities. Our findings remain robust across various tests, including the use of alternative dependent variables (such as ROAA) and independent variables (such as the inverse of the cost-to-income ratio), as well as the inclusion of time-fixed effects in our models. This helps mitigate potential biases stemming from omitted variables, as the inclusion of time effects accounts for macroeconomic and technological changes throughout the study period.

Early studies, such as those by Berger and Humphrey (1997), explored efficiency metrics and highlighted their role in shaping bank performance across various financial systems. Similarly, Molyneux and Thornton (1992) demonstrated a positive link between cost efficiency and profitability in European banks, emphasizing the managerial capacity to minimize costs as a determinant of financial success. However, much of the existing literature relies on aggregate or national-level analyses, leaving regional variations and their implications underexplored. The interplay between managerial efficiency and regional factors, such as economic, social, and technological developments remain a critical yet overlooked dimension in this domain. A notable gap in the literature is the limited exploration of geographic disparities in managerial efficiency within the United States. While some studies (e.g., Elyasiani and Mehdian, 1990; Tsionas et al., 2018) have benchmarked efficiency levels across banks, they have largely treated U.S. banks as a homogeneous group. Luo (2003) highlighted that banks in resource-rich states, such as those in the Northeast, tend to achieve higher efficiency levels, but this finding has not been consistently linked to profitability outcomes. Our study addresses this gap by providing a state-wise analysis of managerial efficiency and examining its influence on profitability metrics.

Additionally, the existing body of work often risks conflating managerial efficiency with direct profitability improvements due to mechanical associations. This conflation reduces the explanatory power of such analyses, leaving key questions about causality unanswered. To address this, we employ robust methodological frameworks, including Stochastic Frontier Analysis (SFA), to disentangle managerial efficiency from random noise and explore its true impact on profitability. Furthermore, we complement our approach with alternative efficiency measures, such as Data Envelopment Analysis (DEA), and conduct robustness checks incorporating crisis period and bank risk as moderating variables.

Another critical research gap lies in the evolving dynamics of the banking industry, particularly in the wake of technological advancements and shifting regulatory landscapes following the global financial crisis. Studies like those by Barth et al. (2010) and Berger et al. (2010) have underscored the importance of technological adoption in enhancing bank efficiency, yet few have connected these advancements to regional or managerial disparities within a single country. Moreover, the long-term effects of crisis periods on managerial decision-making and efficiency, as documented by Assaf et al. (2019), remain insufficiently studied. By analyzing data spanning 2009–2021, our research captures the post-global financial crisis period, offering fresh insights into how managerial efficiency interacts with profitability in a dynamic and evolving banking landscape.

In summary, this study contributes to the literature by bridging three critical gaps: the lack of regional analysis in managerial efficiency research, the need to separate mechanical associations from true managerial effects, and the limited integration of technological and regulatory changes into efficiency-performance frameworks. Our findings not only advance theoretical understanding but also provide actionable insights for policymakers aiming to address regional disparities and improve banking sector resilience.

The implications of our study findings extend to policymaking. Recognizing potential geographical disparities in operating cost efficiency is relevance for policymakers. Given the significant impact of bank location, as evidenced in the existing literature and our analysis, policymakers need to exercise caution in crafting national banking policies and regulations to prevent undue disadvantage to banks operating in less developed regions. Moreover, policymakers should prioritize efforts to enhance bank efficiency and proactively identify problematic banks to safeguard the profitability and stability of the U.S. banking sector. This proactive approach is crucial in mitigating elevated credit risk and the potential for bank failures, as highlighted in studies by Badunenko et al. (2021) and Assaf et al. (2019).

The remainder of this research is structured as follows: Section 2 presents a review of pertinent literature; Section 3 outlines the methodological framework and details of the data; Section 4 provides an in-depth analysis of the findings; and finally, Section 5 concludes the study.

2.0 Literature review

Accounting-based analyses of bank performance often rely on financial statement data to identify the factors influencing bank profitability, as evidenced by measures such as return on assets (ROA) or return on equity (ROE) (Olson and Zoubi, 2011). Factors such as size, revenue growth, risk, and expense management are commonly explored in studies focusing on individual nations (e.g., Kosmidou et al., 2007; Ben Naceur and Goaied, 2008) or specific geographic regions (e.g., Kwan, 2003; Bonin et al., 2005). Research encompassing multiple countries (e.g., Hassan and Bashir, 2003; Ben Naceur and Omran, 2011) typically considers both internal profitability aspects and external factors such as inflation, concentration, unemployment, and GDP growth.

Nonetheless, the importance of efficient management and bank expenditure as determinants of profitability cannot be understated. The inclusion of an expense-related variable as a determinant of bank profitability has been extensively discussed in the literature. Bourke (1989) and Molyneux and Thornton (1992), for instance, assert a positive correlation between profitability and better management. Accordingly, the X-efficiency hypothesis posits that more efficient banks tend to be more profitable due to their lower costs (Tregenna, 2009). However, studies examining the impact of cost efficiency primarily rely on the cost-to-income ratio, which may not fully capture the managerial efficiency of banks in practice.

2.1 Efficiency of the U.S. banking sector

Elyasiani and Mehdian (1990) employ Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) techniques to estimate the average cost efficiency of U.S. banks at 88%. Conversely, Berger et al. (1993) determine the average cost efficiency of U.S. banks to be 52%. However, several studies focusing on U.S. banks (e.g., Akhigbe and McNulty, 2003) have indicated that smaller banks exhibit greater efficiency. Similarly, Fan and Shaffer (2004) observe significant inefficiency among large commercial banks in the US, primarily attributed to under-revenues rather than excessive costs. Al Sharkas et al. (2008) investigate bank mergers in the U.S. and conclude that they enhance efficiency, bringing large banks closer to the efficiency frontier. Tsionas et al. (2018) employ a consistent approach to explore market power and efficiency, concluding that U.S. banks, on average, operate at 82.30% cost efficiency. On the other hand, Ding and Sickles (2018) analyze the relationship between efficiency, capital structure, and portfolio risk from 2001 to 2016, finding that U.S. banks exhibit an average cost efficiency of 62%.

Geographic variations in bank efficiency have also been studied (e.g., Luo, 2003). It is commonly posited that banks in the Northeast are capable of achieving higher efficiency levels compared to those in other regions due to superior markets with abundant resources, advanced technology, and affluent clientele (Luo, 2003). For instance, Hamid and Verma (1994) highlight that banks in the Southwest experienced the least technological advancements, resulting in significant disparities across different regions of the United States. Furthermore, bank location influences equity injections (Dahl and Shrieves, 1990), regional economic performance (Samolyk, 1994), and interstate banking regulation (Goldberg et al., 1992), thereby emphasizing the importance of bank location in measuring bank performance.

2.2 Managerial efficiency and profitability of banks

The concept of managerial efficiency pertains to a bank's capacity to either maximize profits or minimize costs within a given context. Banks can achieve greater profitability by effectively managing their costs. The relationship between efficiency and profitability has been studied in numerous studies conducted within individual countries as well as across different nations. For instance, Yılmaz et al. (2013) document the significant impacts of managing operating expenses, capitalization, credit risk, bank size, and inflation on profitability across nine emerging countries, including Turkey. Similarly, research on Jordanian banks highlights the association of high profitability with efficient cost management, robust capitalization, low credit risk, and substantial lending activities (Ramadan, Kilani, and Kaddumi, 2011). Almumani (2013), examining 13 Jordanian banks over the period 2005-2011, arrives at similar conclusions, demonstrating that the cost-to-income ratio exerts a significant negative influence on bank profitability. Berger (1995) expands upon this body of literature by examining concentration, market share, cost efficiency, and scale efficiency, concluding a positive correlation between cost efficiency and bank profitability.

Regarding U.S. banks, Tregenna (2009) investigates profitability trends during 1994-2005, exploring the effects of concentration, market power, bank size, and operational efficiency. However, efficiency does not emerge as a strong determinant of profitability. Despite mixed evidence, we anticipate that managerial efficiency will exert a positive influence on commercial bank profitability in the US. Hence, we formulate the following alternative hypothesis:

H_1: Managerial efficiency has a positive impact on commercial banks' profitability.

2.3 Firm-specific and macroeconomic determinants of bank profitability

Bank size emerges as a pivotal factor among the control variables influencing bank profitability. According to Demirguc-Kunt and Maksimovic (1998), the size of a bank directly influences how various financial, legal, and contextual factors, such as corruption, affect its profitability. Furthermore, size directly correlates with a bank's capital adequacy, as larger banks are more inclined to raise capital at lower costs, thereby appearing more profitable (Short, 1979). Capital ratios exhibit a positive relationship with bank size, suggesting that as banks increase in size, their profitability tends to rise, particularly for small to medium-sized banks (e.g., Short, 1979; Bourke, 1989; Molyneux and Thornton, 1992; Goddard et al., 2004; Bikker and Hu, 2002). Larger banks can leverage economies of scale to reduce costs associated with information gathering and processing (Boyd and Runkle, 1993). However, the existing literature presents varied findings regarding the nature of the relationship between size and profitability (Kosmidou, 2008). Research by Berger and Humphrey (1997) and Altunbas et al. (2001) suggests that large banks benefit from economies of scale. Conversely, other experts argue that expanding a bank's size does not notably reduce costs (Berger et al., 1987), raising the prospect of potential scale inefficiencies in very large banks. According to Gracia-Herrero et al. (2009), the association between capital and bank profitability can be justified on two fronts. Firstly, well-capitalized banks engage in cautious lending during favorable market conditions, thereby enhancing profitability. Secondly, banks with sufficient capital and a track record of creditworthiness can lower their funding costs due to market discipline exerted by depositors and the reduced borrowing requirements of well-capitalized banks.

The banking sector inherently emphasizes the importance of risk management due to its operational dynamics. Poor asset quality and inadequate liquidity stand out as the primary causes of bank failures, thus delineating credit risk and liquidity risk as two pivotal risk categories in this context (Olson and Zoubi, 2011). Financial institutions may opt to diversify their portfolios or increase their holdings of liquid assets during periods of heightened uncertainty to mitigate risk. However, heightened liquidity levels entail a higher proportion of idle funds and fewer loans. Consequently, profitability tends to decrease with increased liquidity (e.g., Pasiouras and Kosmidou, 2007; Kosmidou, 2008; Molyneux and Thornton 1992). The adverse impact of credit risk on profitability is evident, as supported by Bourke (1989) and Miller and Noulas (1997). Non-performing loans (NPLs) constrain lending resources, thereby exerting a detrimental effect on profitability (Garcia-Herrero et al., 2009). This finding can be explained by considering the link between the accumulation of unpaid loans and the exposure of financial institutions to high-risk loans, suggesting that such loan losses have led to diminished returns for numerous commercial banks.

Bank profitability is influenced by macroeconomic conditions in various ways. Economic growth, as indicated by the Gross Domestic Product (GDP) growth rate, impacts banks' credit risk, borrowers' repayment capabilities, and collateral values, subsequently affecting profitability. Additionally, higher interest rates can bolster profitability due to increased interest income (Gracia-Herrero et al., 2009). However, elevated interest rates may lead to reduced demand for bank credit and diminished profitability. Demirgüç and Huizinga (1999) identify a correlation between economic growth, real interest rates, and enhanced profitability.

Moreover, stable and low inflation can stimulate demand for bank credit by lowering interest rates and enhancing economic productivity, thereby impacting profitability. Several studies document a positive relationship between inflation and profitability (e.g., Athanasoglou et al., 2008; Demirgüç and Huizinga, 1999; Bourke, 1989), although Kosmidou (2008) concludes a negative correlation between these variables. According to Kosmidou (2008), profitability may increase with accurate inflation predictions and prompt revenue adjustments, but the opposite may occur otherwise.

The quantity theory of money posits that the money supply directly influences price levels and nominal GDP. A growing money supply may stimulate significant demand for bank loans from businesses, driving down interest rates. Mamatzakis and Remoundos (2003) identify a significant positive relationship between profitability and money supply. However, an increased money supply may dampen demand for bank loans and diminish banks' profit prospects. Kosmidou (2008) finds no substantial relationship between profitability and money supply.

Despite several studies on the profitability and efficiency of U.S. banks, certain issues remain less explored in the existing literature. Firstly, the extensive analysis of the impact of cost-efficiency, as a proxy of managerial efficiency, on profitability using estimated X-efficiency levels of banks is lacking. Most studies have relied on the cost-to-income ratio as a measure of efficiency to assess its influence on profitability. Secondly, there is a scarcity of studies investigating potential associations between state-wise bank efficiency and profitability. In this connection, the contributions of this paper to regional bank efficiency literature are twofold. Firstly, it quantifies the state-wise managerial efficiency of U.S. banks using Stochastic Frontier Analysis. Understanding the potential implications of geographic differences in efficiency on bank profitability holds significance for policymakers. If bank location indeed impacts profitability, as suggested by existing literature and our analysis, policymakers need to exercise caution in formulating national banking policies and regulations to prevent the exploitation of banks in disadvantaged regions. Secondly, this study contributes to the literature by examining the impact of operating cost efficiency on bank profitability while controlling for other firm-specific and macroeconomic determinants, firm specific unobservable heterogeneity, and state differences.

3.0 Methodological framework and data

3.1 Econometric models

To estimate the impact of managerial efficiency on bank profitability, we estimate the following Eq. (1) and Eq. (2).

$$roae_{i,c,t} = a_0 + a_1\, cost_{efficiency}{}_{i,c,t} + a_{2j}X_{i,c,t} + T_t + f_i \quad (1)$$

$$roae_{i,c,t} = a_0 + a_1\, cost_{efficiency}{}_{i,c,t} + a_{2j}X_{i,c,t} + a_{3k}Z_{c,t} + f_i \quad (2)$$

Here, roae is the profitability measure which stands for return on average equity, our main dependent variable. *cost_efficiency* is the measure of cost efficiency, serving as a proxy for managerial efficiency and standing as our primary independent variable. *X* is the *j* vector of bank-specific determinants of bank profitability which includes total equity capital ratio, bank size, loan growth, NPL ratio, liquidity, deposit-assets ratio, and asset diversity. *Z* is the *k* vector of macroeconomic determinants of bank profitability which includes inflation, GDP growth rate, and unemployment rate. T_t is the time effect and f_i is the bank-fixed effect.

Table 1 contains descriptions of all the variables and their expected relationships with the dependent variable. We estimate Eq. (1) and Eq. (2) using fixed-effects estimators since we find individual effects in our dataset by using the LM test. Additionally, based on the Hausman test of overidentification, we decide utilizing the fixed-effects model as we find correlations between individual effects and the independent variables to be systematic.

3.2 Explanatory variables

3.2.1 Operating cost efficiency

To estimate the level of *cost_efficiency*, following Pasiouras et al. (2009) and Aigner et al. (1977) model, we employ the SFA approach because of its ability to separate the inefficiency term from the random error term of the cost function. SFA is a widely used parametric technique that separates inefficiency from random noise, offering a distinct advantage over non-parametric methods, for example, Data Envelopment Analysis (DEA). By incorporating a stochastic error term, SFA accounts for measurement errors, random shocks, and other external factors that may influence a bank's cost structure but are beyond its managerial control (Aigner et al., 1977; Kumbhakar & Lovell, 2000). This feature is particularly relevant in the banking sector, where external economic conditions, regulatory changes, and market volatility can significantly influence operational outcomes (Berger & Humphrey, 1997). Moreover, SFA enables hypothesis testing about efficiency determinants, facilitating a robust and statistically grounded analysis of the relationship between managerial efficiency and bank profitability (Greene, 2005). These strengths make SFA a suitable choice for our study, where accurately isolating managerial inefficiency from other noise is critical for examining its impact on profitability.

In contrast, DEA, a non-parametric technique, constructs a deterministic efficiency frontier based on observed data, assuming that all deviations from the frontier are due to inefficiency. While DEA offers flexibility and does not require specific functional form assumptions, it is sensitive to outliers and does not account for statistical noise, which can lead to biased efficiency scores in datasets with heterogeneity or external shocks (Coelli et al., 2005). Given the dynamic and complex nature of the U.S. banking sector, DEA's deterministic framework may oversimplify the efficiency estimation process. To ensure the robustness of our findings, however, we employ DEA to reconstruct the efficiency variable and rerun our baseline model. This additional robustness test confirms the validity of our SFA-based results and demonstrates consistency across different efficiency estimation methods. The DEA findings are discussed in section 4.3 (Table 8), further supporting the methodological rigor of our study.

The specification of the cost-efficiency function based on SFA is as follows:

$$lnTC_{i,c,t} = f(y_{i,c,t}, p_{i,c,t}, \theta) + v_{i,c,t} + u_{i,c,t}$$

Following Pasiouras et al. (2009), we specifically estimate the following Translog cost function:

$$\begin{aligned} lnTC_{i,c,t} = \alpha_0 + \sum_{i=1}^{3} \alpha_i lny_{it} + \sum_{j=1}^{2} \beta_j lnp_{jt} \\ + \frac{1}{2}\sum_{i}^{3}\sum_{k}^{3} \sigma_{ik}\, lny_{it}\, lny_{kt} + \frac{1}{2}\sum_{j}^{2}\sum_{\mathrm{h}}^{2} \gamma_{j\mathrm{h}}\, lnp_{jt} lnp_{ht} \\ + \sum_{i}^{3}\sum_{j}^{2} \delta_{ij} lny_{it} lnp_{jt} + r_1 \mathrm{t} + r_2(\mathrm{t} * \mathrm{t}) + d_1 \mathrm{lnEquity}_{i,c,t} \\ + d_2 \frac{1}{2}(\mathrm{lnEquity} * \mathrm{lnEquity}) + v_{i,c,t} + u_{i,c,t} \end{aligned} \quad (4)$$

Where, $lnTC_{i,c,t}$ is the natural logarithm of total operating costs of bank *i* in *c* state for year t. $y_{i,c,t}$ is a vector of outputs. $p_{i,c,t}$ is a vector of input prices. θ is a vector of technology parameters to be estimated. $v_{i,c,t}$ is the stochastic error term and $u_{i,c,t}$ is the term capturing time-varying inefficiency. Following Sealey and Lindley (1977), we define our inputs and outputs based on the intermediation approach. According to this approach, we use gross loans, other earning assets, and off-balance sheet items as outputs. We use labor expenses, total interest expenses, and other operating expenses as three inputs and their prices as input prices. We use a Translog functional form instead of the Cobb-Douglas functional form as the Translog functional form is more flexible, can accommodate multiple inputs and outputs in frontier-based efficiency analysis, and can allow the imposition of linear homogeneity restrictions. Finally, we impose linear homogeneity by normalizing the total cost and the prices by the third price (the price of other earning assets).

3.2.2 Bank-specific and macroeconomic control variables

Our initial control variable specific to banks is *capital*, which evaluates the influence of a bank's capital level on its profitability. We anticipate an inverse correlation between capital level and bank profitability because an increase in capital level ties up funds and diminishes the pool of available funds for loans, ultimately reducing the profitability of banks. Additionally, we incorporate *size*, represented by the natural logarithm of a bank's total assets, to examine the impact of bank size on profitability. We anticipate a positive correlation between size and profitability since larger banks are more capable of diversifying their portfolio and benefiting from economies of scale, which may result in decreased losses and increased profitability. This expectation aligns with the findings of Hassan and Bashir (2003), who observe that larger banks tend to offer a diversified range of services, leading to greater profitability.

We incorporate *loan growth* to control for the influence of lending expansion on bank profitability, and we anticipate a positive correlation between loan growth and profitability. This expectation arises from the fact that higher loan volumes translate to increased business and profitability for banks. Additionally, we include the *non-performing loan (NPL)* ratio to evaluate how loan losses or credit risk influence profitability. We expect a negative impact of NPLs on profitability, as higher NPLs result in a reduction in net profit due to losses deducted from revenues. Moreover, higher NPLs necessitate banks to allocate more resources towards managing and recovering bad loans. This phenomenon is described as the 'Bad Luck' concept by Berger and DeYoung (1997).

We consider *liquidity* to capture how the cash held as liquidity in banks may potentially influence profitability due to excess liquidity tying up loanable funds. Additionally, we examine the *deposits-assets ratio* to acknowledge how the level of funds received as deposits influences bank profitability. It can be argued that increases in deposits raise the cost of funds and reduce the bank's profitability. Conversely, increased deposits present the opportunity for greater loanable funds, which, if invested effectively, can generate more business and profits for banks. Therefore, the impact of the deposits-assets ratio remains inconclusive. Lastly, we analyze *asset diversity* to capture how diversifying the portfolio of bank assets may influence profitability by potentially reducing risks and losses. Consequently, we anticipate a positive association between asset diversity and bank profitability.

Regarding macroeconomic determinants, we consider inflation, as lower and stable *inflation* can potentially enhance bank profitability by influencing the demand for bank credit, as well as the interest rate and net interest margin of banks (Athanasoglou et al., 2008; Kosmidou et al., 2008). However, the positive impact of inflation on profitability relies on the accurate anticipation of inflation and timely adjustment of interest rates by banks (Kosmidou et al., 2008). Consequently, the effect of inflation on bank profitability remains unpredictable. Next, we include the *GDP growth rate*, as fluctuations in economic activities can influence bank profitability by decreasing the likelihood and actual occurrence of loan defaults. Additionally, increased economic activities boost the demand for bank loans, thereby augmenting bank revenues and profitability. Lastly, we include *unemployment*, as it affects bank profitability by influencing loan repayment by individual borrowers. With rising unemployment levels, borrowers' capacity to service loans diminishes due to reduced income, ultimately leading to decreased bank profitability through increased loan losses. Therefore, we anticipate a negative association between unemployment and bank profitability.

3.3 Data

The dataset comprises an unbalanced panel dataset with 47,108 observations from 4,081 commercial banks spanning the period from 2009 to 2021. We utilize data from commercial banks to maintain homogeneity within the dataset. Bank-specific data are sourced from the BankFocus Database, while state-wise data for macroeconomic determinants are obtained from the Bureau of Economic Analysis and the Bureau of Labor Statistics. Table 1 presents summary statistics and descriptions of both bank-specific and macroeconomic determinants of profitability. To address concerns regarding extreme values, we apply Winsorization at the 1st and 99th percentiles. Overall, the data exhibit consistency and are not significantly impacted by extreme values. Table 2 displays the correlation matrix among the variables, revealing no indications of multicollinearity issues (further confirmed by Variance Inflation Factor (VIF) analysis in Table A1 in Appendix A).

Table 1: Summary statistics of the main variables

variables	Description of the variables	Expected sign	No.of Obs.	Mean	SD	Min	Median	Max
roae	Ratio of profit after tax to average total equity	n/a	47108	0.0860	0.0746	-0.2596	0.0881	0.2923
roaa	Ratio of profit after tax to average total assets	n/a	47108	0.0093	0.0074	-0.0229	0.0096	0.0294
cost_efficiency	Estimated level of cost efficiency	+	47108	0.8816	0.0570	0.6593	0.8946	0.9598
1/(cost to income)	Inverse of cost to income ratio	+	47108	1.5310	0.4040	0.0937	1.4829	16.2987
capital	Ratio of total equity to total assets	-	47108	0.1101	0.0282	0.0598	0.1045	0.2249
size	Natural logarithm of total assets	+	47108	5.5353	1.2911	2.8904	5.3775	9.9786
loan_growth	Growth rate of gross loans	+	47108	0.0577	0.1283	-0.1912	0.0416	0.7487
npl ratio	Ratio of non-performing loans to gross loans	-	47108	0.0153	0.0187	0.0001	0.0088	0.1026
liquidity	Ratio of liquid assets to total assets	-	47108	0.3037	0.1515	0.0414	0.2814	0.7142
deposit/asset	Ratio of deposits to total assets	+/-	47108	0.8668	0.0402	0.7033	0.8754	0.9295

asset_diversity	Ratio of net loans to total assets	+	47108	0.6211	0.1476	0.2180	0.6394	0.8890
inflation	Rate of inflation in different states	+/-	47108	0.0121	0.0268	-0.0740	0.0110	0.1220
gdpgr	Growth rate of GDP of different states	+	47108	0.0334	0.0373	-0.1534	0.0354	0.2463
unemployment	Rate of unemployment in different states	-	47108	0.0565	0.0221	0.0190	0.0500	0.1380

Source: Authors' Calculation

This table reports the summary statistics and the description of the variables utilized in different analyses.

Table 2: Correlation matrix of all variables

	roae	roaa	cost_ efficiency	1/(cost to income)	capital	size	loan_ growth	NPL ratio	liquidity	deposit/ assets	asset_ diversity	inflation	gdpgr	unemployment
roae	1													
roaa	0.934***	1												
cost_efficiency	0.243***	0.231***	1											
1/(cost to income)	0.585***	0.670***	0.159***	1										
capital	-0.100***	0.163***	-0.032***	0.184***	1									
size	0.105***	0.089***	-0.054***	0.227***	-0.075***	1								
loan_growth	0.137***	0.097***	0.035***	0.067***	-0.049***	0.120***	1							
npl ratio	-0.425***	-0.397***	-0.221***	-0.186***	0.006*	-0.055***	-0.230***	1						
liquidity	-0.038***	-0.012***	-0.003	-0.060***	0.113***	-0.171***	-0.205***	0.009**	1					
deposit/asset	0.053***	-0.098***	0.006*	-0.169***	-0.597***	-0.079***	-0.016***	-0.009**	0.055***	1				
asset_diversity	0.088***	0.048***	0.040***	0.073***	-0.176***	0.160***	0.233***	-0.038***	-0.875***	-0.016***	1			
inflation	0.123***	0.122***	-0.017***	0.046***	0.006	0.092***	-0.016***	-0.129***	0.070***	0.062***	-0.059***	1		
gdpgr	0.159***	0.145***	0.033***	0.070***	-0.023***	-0.022***	0.024***	-0.123***	0.057***	0.033***	-0.060***	0.688***	1	
unemployment	-0.253***	-0.263***	-0.132***	-0.113***	-0.052***	0.008**	-0.102***	0.295***	0.008**	-0.006*	-0.038***	-0.417***	-0.375***	1

Source: Authors' Calculation

This table reports the Spearman correlation coefficients of the variables included in the regression models.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.0 Results and discussion

4.1 Efficiency estimation

4.1.1 Overall cost efficiency

A summary of the overall cost efficiency of U.S. banks from 2009 to 2021 is shown in Table 3. The mean cost efficiency score falls between 66.66% and 95.98%, with a mean ranging from 87.60% to 89.52%. The overall mean cost efficiency is 88.42%, which is in line with the findings of Tsionas et al. (2018) and Elyasiani and Mehdian (1990).

Table 3: Summary statistics of year-wise overall cost efficiency

	No. of Obs.	Mean	SD	Min	Median	Max
2009	2844	0.8761	0.0605	0.6660	0.8908	0.9598
2010	2852	0.8760	0.0651	0.6660	0.8933	0.9598
2011	2879	0.8782	0.0614	0.6660	0.8932	0.9598
2012	2969	0.8843	0.0579	0.6660	0.8991	0.9598
2013	2971	0.8877	0.0552	0.6660	0.9015	0.9598
2014	2941	0.8848	0.0542	0.6660	0.8979	0.9598
2015	2894	0.8866	0.0516	0.6660	0.8976	0.9598

2016	2954	0.8861	0.0514	0.6660	0.8967	0.9598
2017	2989	0.8867	0.0516	0.6660	0.8971	0.9598
2018	3010	0.8854	0.0510	0.6660	0.8960	0.9598
2019	2976	0.8831	0.0507	0.6660	0.8920	0.9598
2020	3008	0.8952	0.0498	0.6660	0.9066	0.9598
2021	2963	0.8845	0.0526	0.6660	0.8960	0.9598

Source: Authors' Calculation

This table reports the year-wise summary statistics of the cost efficiency estimates.

4.1.2 State-wise cost efficiency

We examine the state-wise bank cost efficiency of U.S. banks, which contributes to the existing literature as no prior studies have attempted to assess cost efficiency in this manner. Table 4 illustrates that banks in Rhode Island achieve the highest mean cost efficiency at 92.18%, while those in Delaware exhibit the lowest, with a mean cost efficiency of 82.79%. Despite the common perception that banks in the Northeast region are typically more efficient due to operating in superior markets with greater resources, advanced technology, and affluent clientele (Luo, 2003), our study yields a different finding. Delaware, located in the Northeast, demonstrates the lowest mean efficiency compared to other states, whereas Rhode Island, despite being the smallest among the 50 states of the USA, exhibits greater bank cost efficiency.

Table 4: State-wise summary statistics of cost efficiency

	No.Obs.	Mean	SD	Min	Median	Max
Alabama	1073	0.8677	0.0557	0.6593	0.8794	0.9598
Alaska	61	0.9063	0.0183	0.8571	0.9083	0.9489
Arizona	105	0.8407	0.0821	0.6593	0.8575	0.9598
Arkansas	966	0.8731	0.0524	0.6593	0.8822	0.9598
California	1161	0.8964	0.0559	0.6593	0.9106	0.9598
Colorado	640	0.8630	0.0690	0.6593	0.8841	0.9598
Connecticut	277	0.8981	0.0431	0.7007	0.9064	0.9598
Delaware	129	0.8279	0.0792	0.6593	0.8601	0.9546
Florida	880	0.8674	0.0686	0.6593	0.8818	0.9598
Georgia	1519	0.8577	0.0656	0.6593	0.8737	0.9598
Hawaii	63	0.8669	0.0548	0.7453	0.8869	0.9317
Idaho	127	0.9061	0.0412	0.7074	0.9174	0.9598
Illinois	4016	0.8784	0.0594	0.6593	0.8936	0.9598
Indiana	846	0.8863	0.0401	0.6718	0.8933	0.9598
Iowa	2632	0.9105	0.0398	0.6593	0.9200	0.9598
Kansas	2206	0.8930	0.0515	0.6593	0.9039	0.9598
Kentucky	1390	0.8492	0.0527	0.6593	0.8557	0.9598
Louisiana	1183	0.8797	0.0512	0.6593	0.8917	0.9555
Maine	208	0.8795	0.0576	0.6593	0.8915	0.9537
Maryland	251	0.8856	0.0574	0.6593	0.8986	0.9559
Massachusetts	1073	0.8933	0.0351	0.7020	0.8998	0.9598
Michigan	835	0.8755	0.0490	0.6593	0.8858	0.9516
Minnesota	2669	0.8965	0.0584	0.6593	0.9139	0.9598
Mississippi	761	0.8898	0.0410	0.6593	0.8960	0.9598
Missouri	2255	0.8833	0.0527	0.6593	0.8934	0.9598

Montana	425	0.8847	0.0548	0.6593	0.8948	0.9598
Nebraska	1405	0.9070	0.0459	0.6593	0.9189	0.9598
Nevada	65	0.8917	0.0540	0.7577	0.8962	0.9598
New Hampshire	143	0.9017	0.0217	0.8175	0.9047	0.9550
New Jersey	469	0.8781	0.0594	0.6593	0.8929	0.9598
New Mexico	321	0.8484	0.0641	0.6593	0.8636	0.9549
New York	980	0.8824	0.0657	0.6593	0.9021	0.9598
North Carolina	301	0.8599	0.0576	0.6593	0.8720	0.9598
North Dakota	650	0.9137	0.0422	0.6593	0.9263	0.9598
Ohio	1354	0.8602	0.0548	0.6593	0.8714	0.9598
Oklahoma	2000	0.8855	0.0570	0.6593	0.8989	0.9598
Oregon	142	0.9116	0.0306	0.7832	0.9137	0.9598
Pennsylvania	1221	0.8726	0.0508	0.6593	0.8852	0.9598
Rhode Island	78	0.9218	0.0309	0.7745	0.9248	0.9597
South Carolina	371	0.8683	0.0600	0.6593	0.8832	0.9483
South Dakota	495	0.8979	0.0730	0.6593	0.9196	0.9598
Tennessee	1343	0.8717	0.0521	0.6593	0.8799	0.9598
Texas	3957	0.8748	0.0598	0.6593	0.8901	0.9598
Utah	251	0.8491	0.0972	0.6593	0.8893	0.9598
Vermont	104	0.8961	0.0235	0.8337	0.8974	0.9480
Virginia	656	0.8673	0.0482	0.6593	0.8766	0.9568
Washington	377	0.8800	0.0529	0.6593	0.8923	0.9598
West Virginia	523	0.8443	0.0503	0.6593	0.8588	0.9301
Wisconsin	1878	0.8925	0.0459	0.6593	0.9023	0.9598
Wyoming	273	0.8769	0.0688	0.6593	0.8967	0.9583
Total	47108	0.8816	0.0570	0.6593	0.8946	0.9598

Source: Authors' Calculation

This table reports the average operating cost efficiency levels of commercial banks located in different U.S. states

4.2 Managerial efficiency and bank profitability

This section presents the estimation results for Equations (1) and (2), where the dependent variable in the first and second columns is the return on average equity, and in the third and fourth columns, it is the return on average assets.

Table 5: Impact of managerial efficiency on bank profitability

	(1)	(2)	(3)	(4)
	roae	roae	roaa	roaa
cost_efficiency	0.3231***	0.3240***	0.0318***	0.0320***
	(0.0153)	(0.0152)	(0.0014)	(0.0014)
capital	0.1862	0.1751***	0.0647***	0.0651***
	(0.0430)	(0.0413)	(0.0043)	(0.0041)
size	0.0193***	0.0141***	0.0021***	0.0018***
	(0.0027)	(0.0019)	(0.0003)	(0.0002)
loan_growth	0.0227***	0.0228***	-0.0013	0.0013***
	(0.0036)	(0.0035)	(0.0004)	(0.0004)
npl ratio	-1.1412***	-1.0699***	-0.1065***	-0.1000***

	(1)	(2)	(3)	(4)
	roae	roae	roaa	roaa
cost_efficiency	0.3231***	0.3240***	0.0318***	0.0320***
	(0.0153)	(0.0152)	(0.0014)	(0.0014)
capital	0.1862	0.1751***	0.0647***	0.0651***
	(0.0430)	(0.0413)	(0.0043)	(0.0041)
size	0.0193***	0.0141***	0.0021***	0.0018***
	(0.0027)	(0.0019)	(0.0003)	(0.0002)
loan_growth	0.0227***	0.0228***	-0.0013	0.0013***
	(0.0036)	(0.0035)	(0.0004)	(0.0004)
npl ratio	-1.1412***	-1.0699***	-0.1065***	-0.1000***
	(0.0390)	(0.0383)	(0.0036)	(0.0035)
liquidity	0.0318***	0.0270**	0.0030***	0.0029**
	(0.0116)	(0.0113)	(0.0012)	(0.0012)
deposit/assets	-0.0094	-0.0160	0.0011	0.0009
	(0.0213)	(0.0212)	(0.0020)	(0.0020)
asset_diversity	0.0486***	0.0344***	0.0063***	0.0050***
	(0.0125)	(0.0121)	(0.0013)	(0.0012)
inflation		-0.0151		-0.0021*
		(0.0114)		(0.0011)
gdpgr		0.1379***		0.0124***
		(0.0087)		(0.0008)
unemployment		-0.1498***		-0.0190***
		(0.0259)		(0.0025)
constant	-0.3569***	-0.2938***	-0.0434***	-0.0383***
	(0.0306)	(0.0281)	(0.0029)	(0.0026)
WaldTest_year(p-value)	0.0000		0.0000	
Adj. R-Square	0.2511	0.2453	0.2876	0.2799
Number of obs.	47108	47108	47108	47108
Number of banks	4081	4081	4081	4081
Bank fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	No	Yes	No

Source: Authors' Calculation

The table reports the result from our main analysis or estimation of Equation (1) and Equation (2). 'Roae' is the main dependent variable measured as the ratio of profit after tax to total equity. Cost efficiency, the proxy of managerial efficiency (the main independent variable), is estimated using Stochastic Frontier Analysis (SFA) following Aigner et al., (1977) model which assumes the inefficiency error term follows a half-normal distribution. Standard errors are reported in parentheses and are clustered for bank groups. * p<0.10, ** p<0.05, *** p<0.01

Table 5 presents the estimation results, indicating that the inclusion of macroeconomic variables results in slight changes to the coefficients and significance levels of the variables for both dependent variables. However, the inclusion of macroeconomic variables does not necessarily lead to a better explanation of the dependent variable, as evidenced by the slightly decreased adjusted R2 values. Focusing on the primary dependent variable, return on average equity, we observe that managerial efficiency positively influences profitability and is significant at the 1% level. We observe similar findings with the alternative measure of profitability (return on average assets).

This conclusion aligns with our expectations and related literature that associates efficiency aspects with bank profitability, e.g., operating expenses management (Yılmaz et al., 2013), cost management (Ramadan, Kilani, and Kaddumi, 2011), and cost-to-income ratio (Almumani, 2013). However, our results contradict Tregenna (2009) who finds efficiency is not a strong determinant of profitability.

Regarding control variables, capital demonstrates a positive and significant influence on profitability when both macroeconomic variables and bank-specific variables are considered. However, it becomes insignificant when only bank-specific characteristics are taken into account. Although we anticipated a negative relationship between capital and profitability, a positive coefficient may be attributed to an inverse relationship with intermediation cost (Bourke, 1989). Additionally, relying less on debt financing enables banks to withstand external shocks and maintain profitability (Kosmidou, 2008).

Bank size exhibits a significant positive effect on bank profitability, whether considering bank-specific variables alone or not. Therefore, based on our findings, larger U.S. banks can leverage diversification and economies of scale to achieve greater profitability. This result is in line with Berger (1995), who identifies a positive relationship between cost efficiency and bank profitability for U.S. banks. However, it contradicts Tregenna (2009), who suggests that banks' high profits are not necessarily 'earned' through efficient performance and efficiency is not a strong determinant of profitability.

In case of the loan growth results, the relationship with profitability is positive and significant, indicating that higher loan growth creates more profit opportunities for U.S. banks. This finding also aligns with expectations and holds when macroeconomic variables are included in the equation. The relationship between the non-performing loan (NPL) ratio and profitability is significantly negative, consistent with expectations. Therefore, our study supports the 'Bad Luck' concept for U.S. banks. Despite the expectation that liquidity would have a negative impact on profitability, our findings reveal a significant positive association between the two. The final bank-specific variable, asset diversity, demonstrates a significant positive impact on profitability. This result is also consistent with expectations and corroborates the findings of previous literature (e.g., Hughes et al., 1999; Deng et al., 2007; Deng and Elyasiani, 2008). Thus, diversifying U.S. banks' asset portfolios reduces losses and increases profits.

About the macroeconomic variables, aside from inflation, the other two variables—GDP growth and unemployment rate—exhibit a significant impact on profitability. As anticipated, the relationship between GDP growth and unemployment rate with profitability is positive and negative, respectively.

When utilizing return on average assets (roaa) as the dependent variable, capital, bank size, NPL ratio, liquidity, asset diversification, GDP growth rate, and inflation maintain the same relationship with profitability at the same level of significance but with different coefficient values. However, inflation now emerges as significant, presenting a negative association with profitability.

4.3 Managerial efficiency and bank profitability - exploring regional disparity

The regional disparities across economic, social, and technological dimensions in the United States have profound implications for the efficiency of banks operating in these states. Historical factors, policy differences, and resource allocation contribute to uneven development, creating diverse challenges and opportunities for financial institutions. By examining how these disparities influence economic activity, social structures, and technological infrastructure, we can better understand their role in shaping bank efficiency across different regions.

Economic disparities significantly affect bank efficiency. In top-tier states like California and Massachusetts, robust innovation ecosystems, high-value industries, and skilled workforces create favorable conditions for banks, providing access to strong deposit bases, lower credit risks, and opportunities for innovation (Bartik, 2020). Mid-tier states, such as Texas and Colorado, are in a transitional phase, offering both opportunities and risks as their economies diversify and attract knowledge-based industries (Audretsch and Feldman, 2004). Conversely, struggling states like Mississippi and West Virginia face weaker economic structures, limited industrial diversity, and low economic mobility, which increase credit risks and constrain banking operations (Moretti, 2012).

Social disparities also play a critical role in shaping bank efficiency. Top-tier states such as Massachusetts and Minnesota invest heavily in education, healthcare, and social infrastructure, reducing poverty and promoting financial stability (Cutler and Lleras-Muney, 2010). These conditions enhance banks' operational efficiency by reducing default risks and supporting consumer financial inclusion. Mid-tier states like Oregon and New Jersey have made progress but still face challenges in achieving equitable access to social resources. Struggling states, including Louisiana and Alabama, suffer from underfunded education systems, poor healthcare access, and high poverty rates, which limit economic activity and reduce the pool of creditworthy borrowers, hindering bank efficiency (Case and Deaton, 2017).

Technological disparities further influence bank performance across regions. In innovation hubs such as California and Massachusetts, advanced technological infrastructure supports banks' adoption of digital services and operational efficiencies, fostering competitive advantages (Audretsch and Feldman, 2004). Mid-tier states like Virginia and Illinois are making strides in improving digital connectivity and attracting high-tech industries, though they often lack the scale of top-tier states. Struggling states, such as Montana and Alaska, face significant challenges, including inadequate broadband infrastructure and limited STEM education, which hinder banks' ability to implement technological innovations and compete in the digital economy (Forman et al., 2012). Addressing these disparities is crucial for ensuring equitable development and improving bank efficiency nationwide.

Drawing on existing literature and informed judgment, we classify the disparities among U.S. states across three dimensions: economic, social, and technological development. Table A2 in Appendix A provides a classification of the states into three groups (top-tier, mid-tier, and struggling) according to these disparities. We construct three variables, named economy, society, and technology, that rank each state in these respective areas, with higher values reflecting more favorable conditions. To explore how the relationship between managerial efficiency and profitability differs across regional contexts, we repeat the baseline analysis, incorporating interactions between the regional economic, social, and technological characteristics and efficiency scores. The results of this analysis are displayed in Table 6.

Table 6: Managerial efficiency and bank profitability - regional disparity

	(1)	(2)	(3)	(4)
	roae	roae	roaa	roaa
cost_efficiency×economy	0.0783***	0.0752**	0.0073***	0.0069***
	(0.0229)	(0.0296)	(0.0020)	(0.0026)
cost_efficiency×society	0.0798***	0.0681**	0.0073***	0.0056**
	(0.0236)	(0.0294)	(0.0021)	(0.0026)
cost_efficiency×technology	0.0647***	0.0588**	0.0055**	0.0040
	(0.0242)	(0.0298)	(0.0022)	(0.0027)
Moderating variables	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes
Number of obs.	47108	47108	47108	47108
Number of banks	4081	4081	4081	4081
Bank fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	No	Yes	No

Source: Authors' Calculation

The table reports the estimation results of Equation (1) and Equation (2) where the cost_efficiency variable is interacted with economy, society, and technology variables that capture regional disparity. 'Roae' is the main dependent variable measured as the ratio of profit after tax to total equity. Cost efficiency, the proxy of managerial efficiency (the main independent variable), is estimated using Stochastic Frontier Analysis (SFA) following Aigner et al., (1977) model which assumes the inefficiency error term follows a half-normal distribution. Standard errors are reported in parentheses and are clustered for bank groups. * p<0.10, ** p<0.05, *** p<0.01

The results presented in Table 6 reveal how regional disparities in economic, social, and technological conditions influence the relationship between managerial efficiency and bank profitability. The positive and significant interaction terms for cost_efficiency×economy across all models suggest that banks operating in states with better economic conditions experience a stronger positive relationship between managerial efficiency and profitability. This aligns with the idea that economically advanced states provide an environment conducive to operational efficiency translating into higher profits, likely due to greater industrial diversity, higher income levels, and more stable employment opportunities.

Similarly, the significant coefficients for cost_efficiency×society indicate that enhanced social conditions, such as better healthcare access, education, and lower poverty rates, amplify the effect of managerial efficiency on profitability. This suggests that banks in socially advanced states benefit from a more stable and equitable environment, which supports their operational and financial outcomes. Except for column (4), the coefficients for cost_efficiency×technology are also positive and significant, though slightly smaller compared to economic and social contexts. This implies that technological advancements play a critical role in enabling banks to leverage their efficiency for profitability. However, the relatively smaller coefficients suggest that while technological factors are important, their influence may be somewhat secondary to economic and social conditions.

Overall, the findings highlight that regional disparities significantly shape the efficiency-profitability relationship, with stronger effects observed in regions with favorable economic, social, and technological environments. These results underscore the need for banks to consider regional dynamics when strategizing to improve efficiency and profitability.

4.4 Robustness tests

We assess the robustness of our findings by employing the inverse of the cost-to-income ratio as a proxy for managerial efficiency while estimating Equations 1 and 2. Additionally, we utilize a dynamic panel data estimation technique, System GMM (SGMM), on a dynamic profitability model. The dynamic model is one which contains the lag of the dependent variable as an independent variable in the model to account for persistency of the dependent variable. We use the following dynamic model:

$$roae_{i,c,t} = a_0 + a_1 roae_{i,c,t-1} + a_2\, cost\_efficiency_{i,c,t} + a_{3j} X_{i,c,t} + a_{4k} Z_{c,t} + f_i \quad (3)$$

The dependent variable considered is the return on average equity, with the return on average assets included as part of additional analysis. The results are presented in Table 7, demonstrating that our findings remain robust when using the alternative proxy for the independent variable (see columns 1-4 of Table 7) and when employing a different estimation technique that also addresses endogeneity issues (see column 5 of Table 7).

Table 7: Robustness test - inverse of cost-to-income ratio as the proxy of managerial efficiency and SGMM estimation

	(1)	(2)	(3)	(4)	(5)
	roae	roae	roaa	roaa	roae
$roae_{i,t-1}$					0.1586*
					(0.0870)
cost_efficiency					0.2424**
					(0.1140)
1/(cost to income)	0.1571***	0.1572***	0.0162***	0.0161***	
	(0.0030)	(0.0030)	(0.0003)	(0.0003)	
capital	0.0506	0.0563	0.0504***	0.0527***	-0.2571
	(0.0371)	(0.0360)	(0.0036)	(0.0035)	(0.8614)
size	-0.0117***	-0.0141***	-0.0011***	-0.0012***	0.0749***
	(0.0023)	(0.0016)	(0.0002)	(0.0002)	(0.0272)
loan_growth	0.0353***	0.0363***	0.0027***	0.0028***	-0.1666***
	(0.0029)	(0.0029)	(0.0003)	(0.0003)	(0.0611)
npl ratio	-1.0357***	-0.9851***	-0.0947***	-0.0904***	0.2497
	(0.0354)	(0.0348)	(0.0031)	(0.0031)	(1.3097)
liquidity	0.0105	0.0077	0.0007	0.0008	1.0260**
	(0.0095)	(0.0093)	(0.0009)	(0.0009)	(0.4181)
deposit/assets	-0.0150	-0.0117	0.0005	0.0012	0.5969
	(0.0176)	(0.0175)	(0.0016)	(0.0016)	(0.7881)

asset_diversity	-0.0206**	-0.0318***	-0.0010	-0.0019*	1.5757***
	(0.0103)	(0.0101)	(0.0010)	(0.0010)	(0.4483)
inflation		-0.0315***		-0.0037***	-0.0645
		(0.0098)		(0.0009)	(0.1761)
gdpgr		0.0819***		0.0067***	0.2762**
		(0.0073)		(0.0007)	(0.1352)
unemployment		-0.3585***		-0.0407***	0.4194
		(0.0226)		(0.0021)	(0.5377)
constant	-0.0778***	-0.0236	-0.0156***	-0.0114***	-2.3758***
	(0.0230)	(0.0211)	(0.0021)	(0.0019)	(0.8650)
Adj. R-Square	0.4218	0.4188	0. 4769	0.4714	
Number of obs.	47399	47399	47399	47399	33232
Number of banks	4108	4108	4108	4108	3925
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	No	Yes	No	Yes
No. of instruments					40
AR (1)					0.000
AR (2)					0.210
Hansen p-value					0.752

Source: Authors' Calculation

The table reports the results of our robustness analyses using cost-to-income ratio as the proxy of managerial efficiency and SGMM estimation. 'Roae' is the main dependent variable measured as the ratio of profit after tax to total equity. '1/(cost to income)' is the main independent variable measured as the inverse of the cost-to-income ratio, which acts as a proxy of managerial efficiency. Standard errors are reported in parentheses and are clustered for bank groups. * p<0.10, ** p<0.05, *** p<0.01.

To test the robustness of our baseline results using a different efficiency estimation method, we apply a nonparametric approach called Data Envelopment Analysis (DEA), initially introduced by Charnes et al. (1978) and further elaborated by Coelli et al. (2005). DEA evaluates the relative efficiency of decision-making units (DMUs) by constructing a piecewise linear production frontier based on observed input-output combinations. Using this approach, we estimate efficiency levels and rerun the baseline analyses from Table 5 with the reconstructed efficiency scores. The results, presented in Table 8, confirm similar findings, supporting the robustness of our results.

Table 8: Robustness test - DEA approach to estimate efficiency

	(1)	(2)	(3)	(4)
	roae	roae	roaa	roaa
cost_efficiency	0.0324***	0.0184***	0.0032***	0.0021***
	(0.0044)	(0.0040)	(0.0004)	(0.0004)
capital	-0.0721**	0.0920*	0.0532***	0.0596***
	(0.0331)	(0.0504)	(0.0032)	(0.0049)
size	0.0291***	0.0163***	0.0031***	0.0020***
	(0.0020)	(0.0021)	(0.0002)	(0.0002)
loan_growth	0.0177***	0.0332***	0.0001	0.0021***
	(0.0033)	(0.0045)	(0.0003)	(0.0005)

npl ratio	-1.7109***	-1.4682***	-0.1537***	-0.1350***
	(0.0408)	(0.0525)	(0.0036)	(0.0047)
liquidity	0.0734***	0.0629***	0.0064***	0.0061***
	(0.0096)	(0.0149)	(0.0009)	(0.0015)
deposit/assets	-0.0440***	-0.0642**	-0.0008	-0.0031
	(0.0159)	(0.0268)	(0.0014)	(0.0025)
asset_diversity	0.1261***	0.0727***	0.0128***	0.0087***
	(0.0109)	(0.0157)	(0.0010)	(0.0016)
inflation		-0.0522***		-0.0067***
		(0.0143)		(0.0014)
gdpgr		0.1493***		0.0136***
		(0.0099)		(0.0009)
unemployment		-0.0617*		-0.0109***
		(0.0322)		(0.0030)
constant	-0.0761***	-0.0120	-0.0181***	-0.0116***
	(0.0215)	(0.0312)	(0.0019)	(0.0029)
WaldTest_year(p-value)	0.0000		0.0000	
Adj. R-Square	0.2960	0.2283	0.3047	0.2614
Number of obs.	47108	47108	47108	47108
Number of banks	4081	4081	4081	4081
Bank fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	No	Yes	No

Source: Authors' Calculation

The table reports the robustness test of our baseline analyses by using Data Envelopment Analysis (DEA) as an alternative efficiency estimation technique. 'Roae' is the main dependent variable measured as the ratio of profit after tax to total equity. Cost efficiency, the proxy of managerial efficiency (the main independent variable), is estimated using DEA following Charnes et al. (1978) and Coelli et al. (2005). Standard errors are reported in parentheses and are clustered for bank groups. * p<0.10, ** p<0.05, *** p<0.01.

The relationship between managerial efficiency and bank profitability can be influenced by external factors such as crisis periods and a bank's risk profile. To explore these possibilities, we include Covid-19 as a moderating variable to represent the crisis period. Specifically, we construct a dummy variable, Covid Crisis, which is assigned a value of 1 for the year 2020 and 0 otherwise. Additionally, we examine the impact of bank risk by incorporating the z-score as a measure. The results, presented in Table 9, indicate that none of the coefficients are statistically significant.

Table 9: Robustness test – crisis period and bank risk

	(1)	(2)	(3)	(4)
	roae	roae	roaa	roaa
cost_efficiency×covid crisis	-0.0258	0.0019	-0.0003	0.0018
	(0.0247)	(0.0234)	(0.0024)	(0.0022)
cost_efficiency×z-score	-0.0065	-0.0455	-0.0037	-0.0001
	(0.0287)	(0.0397)	(0.0026)	(0.0037)
Moderating variables	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes
Number of obs.	47108	47108	47108	47108
Number of banks	4081	4081	4081	4081
Bank fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	No	Yes	No

Source: Authors' Calculation

The table reports the estimation results of Equation (1) and Equation (2) where the cost_efficiency variable is interacted with covid crisis and z-score that capture the influence of crisis period and bank risk, respectively. 'Roae' is the main dependent variable measured as the ratio of profit after tax to total equity. Cost efficiency, the proxy of managerial efficiency (the main independent variable), is estimated using Stochastic Frontier Analysis (SFA) following Aigner et al., (1977) model which assumes the inefficiency error term follows a half-normal distribution. Standard errors are reported in parentheses and are clustered for bank groups. * p<0.10, ** p<0.05, *** p<0.01

During economic crises, banks face heightened uncertainty, reduced liquidity, and increased default risks, which can diminish the effectiveness of even the most efficient management practices. For example, during the global financial crisis, managerial efficiency often failed to translate into profitability as external shocks overwhelmed operational advantages (Berger & Bouwman, 2013). Similarly, a high-risk profile, characterized by elevated levels of non-performing loans and exposure to volatile markets, can exacerbate vulnerabilities, reducing the profitability benefits typically associated with managerial efficiency (Altunbas et al., 2007). Under such conditions, banks may prioritize risk containment over operational efficiency, diverting resources to manage crises or stabilize their financial positions. Moreover, asymmetric information during crises can hinder banks' ability to leverage efficiency for profit maximization (Diamond & Rajan, 2001). These dynamics suggest that while managerial efficiency is critical, its impact on profitability may weaken or become negligible during periods of elevated risk and systemic shocks, highlighting the need for adaptive strategies that go beyond cost efficiency to include robust risk management practices.

5.0 Conclusion

We explore how managerial efficiency relates to bank profitability within the U.S. banking sector. Using the Stochastic Frontier Analysis method, we estimate the operational cost efficiency levels of commercial banks in the United States. These efficiency levels serve as a proxy for managerial efficiency, allowing us to investigate their impact on bank profitability. We uncover two key findings. Firstly, we identify significant disparities in managerial efficiency among U.S. banks across different geographical regions. Banks located in more developed states tend to demonstrate higher efficiency levels, while those in less developed states show lower efficiency. Secondly, we find a strong positive relationship between managerial efficiency and commercial bank profitability. This suggests that better managerial efficiency leads to improved financial performance by effectively managing a bank's operational activities.

Our study findings have important implications for policymaking, particularly concerning geographical disparities in operating cost efficiency within the banking sector. It is important for policymakers to carefully design national banking policies and regulations to ensure fairness and prevent any unintended consequences for banks operating in less developed regions. Additionally, policymakers should prioritize initiatives aimed at improving bank efficiency and proactively identifying problematic banks. To address regional inefficiencies, policymakers should prioritize investments in economic development, such as fostering industrial diversity and improving infrastructure, alongside enhancing social infrastructure through education and healthcare initiatives. Enhancing technological capabilities is crucial for enabling banks in struggling states to adopt innovative solutions, streamline operations, and improve overall efficiency in a competitive financial environment. Financial literacy campaigns can promote inclusion and expand the customer base, while regulatory incentives for technology adoption can improve operational efficiency. Collaboration between banks and local governments can further drive region-specific solutions, ensuring that banks in underperforming states can thrive while contributing to equitable economic growth.

Regarding limitations, our analysis focuses solely on U.S. banks, limiting the generalizability of our findings to other banking systems or countries. Also, our study period spans from 2009 to 2021, and future research can extend the analysis to include more recent data to capture any evolving trends or patterns in bank efficiency and profitability. One limitation of this study is its focus on cost efficiency as a proxy for managerial performance. While cost efficiency is an important dimension, it does not fully encapsulate other critical aspects of managerial effectiveness, such as strategic decision-making, leadership, or risk management capabilities. These dimensions can also significantly influence bank performance but require alternative datasets or qualitative methods for robust measurement. Future research could explore these broader dimensions to provide a more holistic understanding of managerial performance in the banking sector. We acknowledge the omission of potentially impactful factors such as technological advancements, regulatory changes, and cultural influences, which can shape both managerial efficiency and bank profitability. While these variables were beyond the scope of our current dataset, they represent critical areas for further investigation.

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7.0 Appendices

Table A1: VIF table

Variable	VIF
asset_diversity	4.54
liquidity	4.4
roaa	2.19
1/(cost_to_income)	1.99
capital	1.73
deposit/asset	1.62
npl ratio	1.3
size	1.13
loan_growth	1.12
cost_efficiency	1.1
Mean VIF	2.11

Source: Authors' Calculation

Table A2: Classification of U.S. states based on disparities

Category	Top-Tier States	Mid-Tier States	Struggling States
Economic development **States are classified based on GDP, industrial diversity, income levels, and employment opportunities.**	California, Connecticut, Massachusetts, New York, Washington, Minnesota, Vermont, New Hampshire, Rhode Island, Hawaii	Arizona, Colorado, Florida, Georgia, Illinois, Maryland, Michigan, North Carolina, Oregon, Pennsylvania, Texas, Utah, Virginia, Delaware, New Jersey, Tennessee, Indiana, Missouri, Wisconsin, Ohio, North Dakota	Alabama, Alaska, Arkansas, Idaho, Kentucky, Louisiana, Mississippi, Montana, Nevada, New Mexico, Oklahoma, South Carolina, South Dakota, West Virginia, Wyoming, Maine, Michigan, Pennsylvania, Iowa, Nebraska
Social development **Social indicators such as healthcare access, educational attainment, and poverty rates inform the rankings.**	Connecticut, Massachusetts, Minnesota, New Hampshire, Vermont, New York, California, Colorado, Washington, New Jersey	Florida, Illinois, Michigan, North Carolina, Oregon, Pennsylvania, Texas, Utah, Virginia, Wisconsin, Arizona, Georgia, Ohio, Maryland, Rhode Island, Missouri, Kansas, Tennessee, Michigan, Alabama, Wyoming	Alaska, Arkansas, Idaho, Kentucky, Louisiana, Mississippi, Montana, Nevada, North Dakota, Oklahoma, South Dakota, West Virginia, Maine, Hawaii, South Carolina, New Mexico, Iowa, Nebraska, North Carolina
Technological development **Rankings are based on innovation hubs, broadband access, STEM employment, and research funding.**	California, Maryland, Massachusetts, New York, Washington, Minnesota, Colorado, Virginia, Michigan, Arizona	Texas, Florida, Georgia, Illinois, Oregon, Pennsylvania, Virginia, Utah, Wisconsin, Pennsylvania, Nevada, Ohio, Indiana, Missouri, Illinois, Michigan, Utah, North Carolina, North Dakota, Arizona	Alabama, Alaska, Arkansas, Hawaii, Idaho, Mississippi, Montana, Nevada, North Dakota, South Dakota, West Virginia, Wyoming, Iowa, Nebraska, Maine, South Carolina, Louisiana, New Mexico