Association Between Cost Efficiency and Profitability of US Small Banks: Evidence from 2008 Global Financial Crisis

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Abstract

This paper examines the relative cost efficiency, profitability, and the association between cost efficiency and profitability of U.S. small banks pre-during-post 2008 global financial crisis in three steps. In step 1, using financial information from 15,183 of the same small banks operating from 2010 to 2021, we examine the cost efficiency of U.S. small banks pre-during post-2008 GFC using Data Envelopment Analysis (DEA). The results indicate that the overall efficiency of small banks operating in the U.S. pre-during-post 2008 Global Financial Crisis has been continuously low, and the sources of the low level of overall efficiency have been the low level of technical efficiency rather than allocative efficiency. In turn, the basis of the low level of technical efficiency has been Pure-technical rather than scale efficiency. In step 2, the profitability of U.S. small banks is examined using the same data. The results indicate that the 2008 GFC had a significant negative impact on the profitability of U.S. small banks: The small U.S. banks had high profitability scores pre-2008 GFC, a declining trend that started three years before the 2008 GFC, a sharp decline during the 2008 GFC, and profitability recovery began in 2010 and continues until 2021. In step 3, the association between cost efficiency and profitability is examined. We concluded that the ROA is the best profitability ratio that can be associated with efficiency measures, and there is a strong positive association between overall efficiency and technical efficiency measures with the ROA.

Keywords: U.S. small banks, efficiency, Profitability, 2008 Global financial crisis, efficiency, and profitability association

JEL Classification: G21, G29, C61, G01, F65

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I. Introduction

The financial system of any developed country plays a crucial role in sustaining the country's economic growth. One of the major players in the financial system is the depository financial institutions, of which commercial banking organizations are the largest in size and number. Commercial banks act as financial intermediaries by converting deposits into productive investments and thus accelerating economic development.

The U.S. banking industry has undergone intense changes and transformations over the last twenty years. From 2001 to 2023, the banking industry witnessed 563 bank failures with total assets of $1.05 trillion, many small banks. The industry also suffered from several crises, the major one being the 2008 global financial crisis (2008 GFC) meltdown followed by a wave of bank failures. Most recently, the industry witnessed the collapse of the Silicon Valley Bank and Signature Bank. The financial management strategies of the banking industry have also transformed during the last two decades, as the banks increased their appetite to level their leverage and loaded their asset portfolios with risky mortgage loans based on subprime lending. These managerial strategies of bank management to expand their leverage were justified based on the corporate finance theory related to the magnification of return on assets and equity and the tax effect of borrowing. However, regarding these strategies, some analysts argue that the causes of the 2008 GFC could be that households upsurged their appetite for borrowing, particularly risky borrowing to purchase houses. Disregarding the cause of the 2008 GFC, we believe that the 2008 GFC impacted both the assets and liability sides of the banks' balance sheet and their productivity and profitability. The impact may be more pronounced in the case of small banks because of their peculiar nature of assets and liabilities and their limited access to the financial market.

Although all commercial banks perform a similar function, the activities may vary depending on their size. Small banks generally concentrate on the retail side of the business by attracting deposits from individuals and small businesses and making consumer and business loans to individuals and small businesses operating in their communities. Small banks play an essential role in the growth of the regional economy and are the major fund providers to small regional businesses. Berger et al. (2004) argue that healthy community banks improve Small and Medium Enterprises (SMEs) financing. DeYoung et al. (2012) find that SMEs rely on community banks for financing. They also argue that small banks exacerbate economic downturns during the recession due to low diversification and limited access to the government safety net. Hendrik et al. (2015) also show theoretically and empirically that small regional banks are necessary funding providers in regions with low access to financing. During the financial crisis, In the absence of government agencies' intervention, the role played by the small banks became even more critical to regional economic growth because many small businesses were denied access to funds provided by larger financial institutions. Therefore, for the policymakers responsible for providing liquidity in the financial markets and the regional economic architects concerned about the sustainability of their regional economic well-being, it is important to examine the profitability of small banks and the change in profitability in response to an unexpected event because of their essential role in providing liquidity and financing regional economic growth. Due to the importance of the banking industry in the overall economy and the importance

of small banks in the growth of the regional economy, the banking regulatory and supervisory agencies such as the Federal Reserve System, the Federal Deposit Insurance Corporation, and the Office of Comptroller of the Currency, as well as state banking regulatory agencies, pay special attention to the safety and soundness of the banking industry. The strength and effectiveness of banks are generally measured by their profitability, productivity, and efficiency. It has been argued that more profitable, productive, and efficient banks are less prone to economic downturns. In line with the regulatory and supervisory agencies' attention, an extensive body of literature has been developed in academia to examine banking firms' cost and profit efficiency, productivity growth, and financial performance. The following section briefly reviews the literature on the efficiency and profitability of banks with a focus on small banks.

II. Review of Literature

Sherman and Gold (1985) did the first banking efficiency frontier study. Since then, there have been numerous studies on banking efficiency using different methodologies, input, and output definitions to address efficiency questions in the banking industry. The study by Berger and Humphrey (1997) comprehensively reviews 130 papers on the banking efficiency frontier techniques study up to 1995. However, since then, there have been numerous advances in banking efficiency literature, both in terms of the advancement of efficient frontier techniques and the factors considered essential to investigate their influence on banking efficiency. This motivated researchers to continue their study of banking efficiency. The survey of the most recent studies can be found in Ashton and Hardwick (2000), Casu and Molyneux (2001), Berger (2007), Fethi and Pasiouras (2010), Paradi and Zhu (2013), Kumar and Gulati (2011), and Bhatia et al. (2018). The experience of the recent financial crisis has also motivated researchers to investigate the impact of the financial crisis on the financial system and macroeconomics.

The most recent GFC began in 2007 the United States and lasted more than two years. Almost all sectors of the economy were impacted; however, the banking sector was significantly impacted because banks increased their appetite to level their leverage and loaded their asset portfolios with risky loans based on subprime lending. However, falling real estate prices, highly leveraged balance sheets, and regulatory mistakes set the stage for the arrival of the 2008 financial crisis, considered the most severe financial crisis since the 1929 Depression. The 2008 global financial meltdown impacted the behavior of the commercial banks' management significantly, as many faced mortgage defaults and suffered losses due to the high number of foreclosures. The 2008 financial crisis started in the U.S. and expanded globally quickly, impacting different economies.

To combat the crisis, policymakers from various developed economies responsible for financial system stability implemented aggressive fiscal and monetary policies. They provided an expanded safety net to both depository and non-depository financial institutions. On the monetary policy side, it took an aggressive monetary expansion policy in the framework of interest rate reduction to stimulate the economy. Necessitated by the global financial meltdown, the U.S. fiscal public policymakers initiated policies and initiatives such as TARP in the USA. Conversely, banking sector managers also used strategies to restructure and reposition their portfolio holdings to diminish their portfolio's potential riskiness and increase their banks' performance. Caprio and Honohan (2002 and 2010) show that the spillover from the crisis in the financial system, of which the banking industry is the central part, can push the whole economy into recession. This issue, in turn, drew researchers' attention to investigating the impact of the financial

crisis on banking efficiency pre- and post-financial crisis. Except for a few, the existing studies on the impact of the financial crisis on banking are focused on the 1997 Asian financial crisis. Park and Weber (2006) found that Korean banks were less efficient before the Asian financial crisis. The nature of the 1997 Asian financial crisis differs from that of the 2007 GFC. Surprisingly, only a few published papers are available on the impact of the 2008 GFC on the banking industry. Moradi-Motlagh and Babacan reported that the 2008 GFC harmed the efficiency of banks in Australia, but the effect was more severe on small banks. Gulati, R., and Kumar (2016) study concluded that the impact of the 2008 GFC on Indian banks has been mild, and recovery has been fast. Mehdian et al. (2019) report that there has been a negative impact of the 2008 GFC on the efficiency of large U.S. banks.

While there is a significant number of studies on measuring banking performance using cost and profit efficiency measures, only limited studies use financial statements and ratios analysis to evaluate the financial position of banks. Most of the financial statement and ratio analysis studies focus on the operation of banks outside the U.S. and use panel data consisting of cross-sectional and time series data. The earlier studies on bank profitability using profitability ratios were by Short (1979) and Smirlock (1985), who examined the relationship between banking industry profitability and concentration in Canada, Western Europe, Japan, and the U.S., respectively. One of the earlier studies on U.S. small bank profitability is by Bassell and Brady (2001), who examined the profitability of U.S. small banks (with total assets of less than $331 million) from 1985 to 2000. They report that the expansion of deposits and assets at small banks has consistently exceeded the growth of larger banks, and their profitability has risen to a high level during their study period. They also report that the reason for small banks' high profitability during this period was that their portfolio was devoted to loans. Nal and Cai (2020) investigate the effects of the 2008 GFC on the four largest U.S. banks using data from 2002 to 2020. Using ROA to measure profitability ratios, they show that profit ratios were relatively higher before the crisis, dropped during it, and have since picked up back to pre-crisis levels. Nippani and Ling (2021) examine the relationship between U.S. banks' size and financial performance before and after the 2008 financial crisis using accounting ratios such as return on equity and assets. They report that the financial position of the banks deteriorated after the crisis. The decline in the financial position is more pronounced in the case of small banks compared to larger banks.

The banking industry's profitability outside the U.S. and its response to the 2008 GFC has also been the focus of many recent studies. For example, Alper and Anbar (2011) examined banks' profitability in Turkey from 2002 to 2010. Using panel data, they report that non-interest income to asset ratio and banks' asset size positively and significantly affect banks' profitability in Turkey. Widyastuti et al. (2017) studied the profitability of Indonesian banks from 2010 to 2015. They reported that net interest margin, loan-to-deposit ratio, and operating efficiency significantly impact banks' profitability in Indonesia. These two studies neither focus on small banks nor the effect of the 2008 GFC on banks' profitability. Verma (2021) examines the financial positions of two Indian banks, HDFC Bank Limited and State Bank of India, using financial ratios. The author provides evidence to suggest that the financial performance of HDFC Bank, with total assets of $280 billion in 2022, is superior to that of the State Bank of India, with $ 624 billion in 2022. Chaki et al. (2019) also study the responsiveness of private and public banks in India during and after the 2008 GFC. They show that before the 2008 GFC, India's banking sector's financial performance was stable. During and after the 2008 GFC, the stability and financial performance of the banks declined and reached rock bottom by 2014-15. They claim that the concern for the stability and profitability of banks in India caused the Reserve Bank of India to intervene by introducing massive corrective measures in 2016.

The banks, post-2016, were able to contain the steep fall in financial and soundness parameters. Banerjee (2018) study examines the degree of the predictivity power of financial ratios to forecast the financial performance of banks in the United Arab Emirates. The author proposes several financial ratios that may be used in predicting the future of banks' performance. Contrary to this finding, the study by CFA (2014) concludes that profitability, as measured by ROE and ROA has a positive relationship with the Price/Book ratio and the stock price. However, this relationship weakened during the crisis because, during a recession, the cost of equity becomes higher than ROE. This implies that ROE does not have predictive power for the future ROE, and lower ROE during a recession brings a low P/B ratio and lower stock price. Molyneux and Thorton (1992) and Staikouras and Wood (2004) examine the profitability of European banks in a multi-country setting. The first study reports a significant positive impact of interest rates, bank concentration, and government ownership on bank profitability measured by the return on equity. The second study reports that bank profitability is positively related to equity to asset and negatively related to loan to asset ratio.

As it is evident from the review of the current literature, the existing literature doesn't provide adequate information on the impact of the 2008 GFC on the production performance, profitability, and the correlation between the production performance and profitability of small banks in the U.S. It is to these issues that this study contributes. Specifically, this study aims to examine the impact of the 2008 GFC on the cost efficiency, profitability, and association between cost efficiency and Profitability of U.S. small banks in three following steps:

Step 1: The impact of the 2008 GFC on the productivity performance of small banks is proxied by cost efficiency measures.

Step 2: The impact of the 2008 GFC on the profitability of U.S. small banks is proxied by three profitability ratios: ROE, ROA, and PM.

Step 3: The association between productivity performance and profitability of U.S. small banks.

The remainder of this paper is organized as follows: Section III presents the data and methodology used in the study. Section IV provides the results of the study. Summary and conclusions are discussed in section V.

III. Data and Methodology

a. Data

This study investigates the cost efficiency and profitability of small banks in the United States between 2001 and 2021, with special attention given to the impact of the 2008 Global Financial. The study also examines the correlation between small banks' cost efficiency and profitability, again with special attention given to the impact of the 2008 GFC on this relationship. The data was collected from the consolidated Report of Condition (balance sheet) and Report of Income (income statement) published by the Federal Deposit Insurance Corporation (FDIC) website. Using the FDIC Call Report, we selected a group of small FDIC-insured banks from the 2010 data with total assets of less than $200,000,000. We limited our sample to small banks at least for two reasons: (1) the portfolio of assets and liabilities of small banks are different

than the medium and large size banks, and (2) because of that, we believe that small banks should respond to financial crisis differently than medium and large banks. We also deleted very small banks, banks with TA<$70,000,000 because, in addition to the reasons given above, we believe that these are very small banks located in isolated and rural areas with different portfolios of assets and liabilities than their counterpart and may be less prone to the global financial crisis. Because of their different operating environment, they may respond differently to the global financial crisis during and after it. We did not consider the structure of the banking corporation or its geographic location.
Our analysis period in this study is 21 years, from 2001 to 2021. To have a homogeneous banking sample throughout the study, we further refined our 2001 small bank sample by keeping only the same banks that have been in operation through 2021. We further refined our samples by deleting banks with missing values. Our sample consisted of 732 of the same small banks per year for 21 years from 2010 to 2021, with a total observation of 15,185 small banks. Two sets of data are collected: small banks' outputs, inputs, and input prices that are used in the calculation of small banks' efficiency measures and a set of financial variables to calculate small banks' profitability measures.

Small Bank's outputs, inputs, and price of inputs used in measuring cost Efficiency

Due to the complexity of financial transactions, there are different schools of thought on defining input and output for bank efficiency and productivity studies. Two widely used definitions of output and input variables are used in banking efficiency studies: the intermediation approach and the production approach. Based on the Intermediation approach introduced by Sealy and Lindley (1977), banks are considered an intermediary of services, utilizing inputs such as deposits, fixed assets, and employees to produce earning assets such as loans and investments. A production approach assumes that banks are producers of services, utilizing inputs such as fixed assets and employees to produce services such as deposits and earning assets such as loans and investments. In this study, we applied the Intermediation approach. Based on this approach, small banks provide intermediation services by collecting savers' deposits (interest and non-interest paying deposits and other liabilities) and intermediate these funds to deficit units of the economy by providing loans (Real Estate Loans, Commercial and Industrial Loans, and other loans), and by investing in various investments securities (Das 2001). Under this approach, the outputs (Ys), inputs (Xs), price of inputs (Ps), Total Cost (TC), and Total Assets (TA) are defined as follows:

Y1 = Commercial and industrial loans.
Y2 = Real estate loans.
Y3 = Other loans.
Y4 = Total investment securities.

X1 = Total Liabilities.
X2 = Number of full-time equivalent employees.
X3 = Premises and fixed assets.

P1 = Unit price of interest = Total interest expenses / Total interest-bearing liabilities.
P2 = Unit price of labor = Wages & benefits expenses / # of full-time equivalent employees.
P3 = Unit price of fixed assets = Total expenses of fixed assets / Total fixed assets.

TC = Total cost, the sum of total interest and non-interest expenses.
TA = Total assets, as a measure of bank size, as included in the bank's balance sheet.

Table 1 provides the means and standard deviation of outputs, inputs, and price of inputs for the pooled sample of 15,185 (723 of the same banks for 21 years) small banks operating between 2010 and 2021[1,2].

Table 1: Mean and STD of outputs, Inputs, Price of inputs, ROE, ROA, and PM for the overall, pre-during, and post-pooled samples (2001-2021)

Periods	Y1	Y2	Y3	Y4	X1	X2	X3	P1	P2	P3	ROE	ROA	PM
Overall (n=15,18	18,395	3,725	2,618	2,251	43,601	14.40	700	0.014	59.27	0.684	7.09 (2.13)	0.86 (0.09)	16.32 (3.24)
Pre (n=4,338	13,622	3,074	2,743	2,595	33,462	14.55	570	0.024	47.84	0.526	8.82 (0.74)	1.03 (0.04)	16.02 (1.01)
During (2,892)	17,622	3,589	2,713	2,109	39.920	14.73	693	0.021	55.41	0.669	6.24 (1.46)	0.77 (0.10)	12.36 (3.44)
Post (7,953)	21,280	4,129	2,515	2,048	50,469	14.19	774	0.006	66.90	0.776	6.46 (2.52)	0.86 (0.09)	17.92 (1.66)

Variables used in Calculating Small Banks' Profitability measures

We believe that financial ratio analysis is a useful and straightforward diagnostic tool that can be used to assess the performance of banks on a cross-sectional and a time series basis. Therefore, in the present paper, we employ financial ratio analysis on a time series basis to measure the profitability performance of small banks. There are three widely used measures of bank profitability ratios in the banking literature: Profit Margin (PM), Return on Assets (ROA), and Return on Equity (ROE). We use the above commonly used financial ratios and their components, as discussed in the methodology section, to gauge the profitability performance of the small banks during our sample periods. Table 1 presents the mean and standard deviation of the three profitability measures and their components[3].

Methodology

Step 1 Methodology: Cost Efficiency Measures

In simple terms, efficiency is comparing the actual set of outputs produced by the actual set of inputs with the optimal set of outputs that the same set of inputs could have (Coelli et al., 2005). Therefore, the frontier efficiency methodology can be used to compare the actual output/input values with the optimal output/input values. The frontier efficiency methodology includes parametric and non-parametric techniques. Although both methods build an efficient frontier from which each bank's efficiency is calculated, the underlying assumption of the two techniques differs. In the case of the parametric approach, the efficient frontier is constructed based on a specific production or cost function. In contrast, the non-parametric techniques do not have a restrictive functional form. Further, the parametric approach allows for random error. In

[1] The yearly summary statistics of outputs, inputs, and price of inputs are also available. However, to save space, they are not provided in Table 1A but are available upon request.
[2] Although the yearly samples consisted of the same banks, the mix and size of the portfolio of earning assets held by banks and the size of the banks change from year to year.
[3] The yearly summary statistics of the three profitability measures and their components are also available, but for the sake of saving space, they are not provided in Table 1B but are available upon request.

contrast, in the case of the non-parametric approach, there is no random error, and any deviation from the frontier is considered an inefficiency. Lastly, both methods can be input or output-oriented and are flexible enough to accommodate a return to scale (scale efficiency). We use a non-parametric approach introduced by Farrell (1957), operationalized by Charnes (1978), and extended by Färe, et al. (1985). We construct input-oriented efficient frontiers by solving several Linear Programming (LP) from which the efficiency of each bank is calculated. Overall, the solutions to the set of LPs provide us with five measures of efficiency: Overall Efficiency (OE), Overall Technical Efficiency (OTE), Allocative Efficiency (AE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE). More specifically, for a given bank, i, we first solve the following linear programming model to obtain the potential minimum total cost; we then compute the OE for bank i each year as:

$$
\begin{aligned}
& C_i^* = \min \; p \times x \\
& y_i \leq zY \\
& x_i \geq zX \\
& z \geq 0
\end{aligned}
\qquad \text{LP1}
$$

Where,

C_i^* is the potential minimum total cost of production of bank i,
P is a vector of input prices,
y_i is a vector of outputs produced by bank i of dimension (1, m)
x_i is a vector of inputs utilized by bank i of dimension (1, n)
Y is a matrix of observed outputs of all companies in the sample of dimension (m, N)
X is a matrix of observed inputs of all companies in the sample of dimension (n, N)
z is an intensity vector
N is the number of firms in the sample.

Having the potential minimum total cost of production of bank i calculated (C_i*), we then, the overall efficiency (OE) of bank i as $OE_i = C_i / C^*_i$.

Decomposing the OE into Pure Technical Efficiency (PTE) and Allocative Efficiency (AE) allows an insight into the source (s) of inefficiency. To estimate the OTE of bank i in year t (t= 2010….2021), we solve the following linear programming problem for each bank, each year in the sample:

$$
\begin{aligned}
& \min \; \lambda_i \\
& y_i \leq zY \\
& \lambda_i x_i \geq zX \\
& z \geq 0 \\
& i = 1, \ldots\ldots, N
\end{aligned}
\qquad \text{(LP2)}
$$

Where all variables are as defined earlier.

λ_i is the measure of efficiency (overall technical efficiency, OTE) estimated for bank i relative to a frontier that exhibits constant returns to scale (CRS).

We decomposed this measure into two more efficiency measures to further realize the sources of overall technical inefficiency. The first one is Pure Technical Efficiency (PTE), which determines the bank's efficiency relative to a frontier that exhibits constant and variable returns to scale. The other efficiency measure, the scale efficiency measure (SE), provides indications of whether the bank operates at constant returns to scale (optimal scale) or at increasing or decreasing returns to scale (sub-optimal scale). Formally, the technical efficiency of bank i can be written as:

$OTE_i = PTE_i \times SE_i$, Where SE is ratio of OTE_i to PTE_i.

To compute PTE, denoted by ψ_i, for bank i, LP2 is solved with an additional constraint that is

$\sum_{i=1}^{N} z_i = 1$. From there, we have $SE_i = \lambda_i/\psi_i$,

Bank i is called scale efficient if $SE_i = 1$. It follows that if $0 \leq SE_i < 1$, bank i is called inefficient.

To sort the source of scale inefficiency of bank i, we resolve LP3 after replacing $\sum_{i=1}^{N} z_i = 1$,

by $\sum_{i=1}^{N} z_i \leq 1$, and obtaining an efficiency measure denoted by ω.

Following Färe, et al. (1985) and Turk-Ariss, et al. (2007), if bank i is not scale-efficient and $\omega = \psi$, the source of scale inefficiency bank i is decreasing returns to scale (DRS). On the other hand, if bank i is not scale-efficient and $\omega \neq \psi$, the source of scale inefficiency of this bank is because of increasing returns to scale (IRS). Finally, we compute allocative efficiency (AE), which is an indication of the deviation of the operation from the optimal input mix of resources as: $AE_t = OE_t / OTE_t$.

We summarize the efficiency measures defined above as follows:

$$OE_i = OTE_i \times AE_i$$

then

$$OTE_i = PTE_i \times SE_i$$

and then

$$OE_i = PTE_i \times SE_i \times AE_i$$

Step 2 Methodology: Profitability Measures

We use the three commonly used financial ratios (PM, ROA, and ROE) to gauge the profitability performance of the small banks during our sample periods. Profit Margin (PM) is defined as the ratio of net income available to common stockholders divided by total operating income (sum of interest income

and non-interest income)[4]. PM reflects the percentage of each dollar of income from the operation remaining, after all costs and expenses (interest and non-interest expenses, and taxes). This ratio is also used to measure cost efficiency and expense management and control.

Return on Assets (ROA) is defined as the ratio of net income available to common stockholders to total assets. This ratio shows the dollar amount of operating income generated by each dollar of assets and an indication of how well the assets of a bank are utilized in generating net income. The link between the PM and ROA ratios is the Asset Utilization (AU) ratio, which is the ratio of total operating income to total assets. The AU ratio provides information on productivity and efficient utilization of assets. This ratio is a sign of managerial efficiency and provides information on the success of management in generating income per dollar of assets. Therefore, more efficient banks are expected to generate higher operating income per dollar of assets and to generate high net income per dollar of operating income through cost efficiency.

The calculation of PM, ROA, and AU can be summarized as follow:

PM = Net Income/Total Assets
AU = Total Operating Income/Total Assets
ROA= (PM) (AU) = (Net income/Total Operating Income) (Total Operating Income/Total Assets) = Net Income/Total Assets.

The third profitability ratio used in the banking literature is the return on equity (ROE), defined as the ratio of net income available to common stockholders divided by the book value of common equity. ROE is the most comprehensive indicator of profitability because it is the outcome of all the bank's activities and decisions made during the year. ROE conveys information on how equity capital is used to generate net income. ROE reflects a bank's operating and investment decisions as well as the bank's financing and tax-related decisions. Cole (1972) decomposes the ROE into its components as follows:

ROE = ROA (EM) = (PM) (AU) (EM), or
ROE = (Net Income Available to Common Stockholders / Total Operating Income) (Total Operating Income / Total Assets) (Total Assets / Common Equity)
ROE = Net Income Available to Common Stockholders / Common Equity.

Where, EM stands for equity multiplier and is defined as the ratio of Total Assets to Common Equity. This ratio is a measure of the capital structure of a bank. The benefit of using the extended form of ROE ratio is that it allows financial analysts to explain the source (s) of volatility in ROE. Although ROA and ROE are used extensively as a measure of the profitability of banks, they represent different measures of profitability; ROE represents the net return of capital invested by shareholders, but the ROA is the net return of all assets financed by both debt and equity which, is also a good measure of managerial efficiency. Athanasoglou et al. (2005) argue that ROA is a better measure of profitability because it considers the risks derived from the leverage. However, Goddard et al. (2004) argue that using ROE is a better measure of bank profitability because the calculation of ROA does not include off-balance-sheet items. This argument may not be relevant in this study since small banks have very few off-balance sheet items.

[4] In recent years, banks have increased the non-interest income portion of their total operating income by offering more diversified fee-generating services. However, since this study focuses on small banks, the non-interest income portion of total operating income is still small, about 9.5% on average.

Step 3 Methodology: Association Model of Cost Efficiency and Profitability Ratios

This section investigates the information content of the profitability ratios about the efficiency performance of small banks. We hypothesize that the small bank's profitability ratios contain significant information about the production efficiency of small banks. Assuming a linear relationship between financial ratios and efficiency measures, the efficiency measures are regressed on three commonly used profitability ratios to test the above hypothesis. The following equation is used:

$$E_{ki} = A_0 + \sum^{3}_{j=1} A_{kji} R_{ji} + e_{kji} \qquad (1)$$

Where E_{ik} is the k^{th} type efficiency measure (k = OE, AE, OTE) in period i (i = pre (obs= 4,338), during (obs = 2,892), post (obs = 7,953, and overall (obs = 15,183), respectively). A_0 is the intercept, and A_{kji} is the coefficients to be estimated, R_{ji} is the j^{th} ratio (ROE, ROA, and PM) for each i and k, and e_{kji} is the zero mean stochastic term independent of R_{ji}. Applying the Ordinary Least Square (OLS) technique and the above equation, we estimate coefficient A_{kji}. We hypothesize that the more profitable banks are more efficient, implying that the estimated coefficient sign of the R_{kji} (A_{kji}) to be positive and statistically significant.

IV. Empirical Results

Step1: Impact of 2008 GFC on the Small Banks Efficiency Masseurs

Using the data and methodology presented in section III, we calculate the efficiency measures of small banks using three scenarios: In scenario 1, the yearly efficiency measures of small banks for each year (2001-2021) are calculated from the annual corresponding efficient frontier. Table 2 presents the mean and standard deviation for the whole period (2001-2021) and the mean and standard deviation of efficiency measures for the three distinctive periods of pre-, during, and post-2008 GFC[5].

Table 2: Yearly efficiency measures from the corresponding yearly efficient frontiers (2001-2021)

Year	Statistics	OE	AE	OTE	PTE	Scale E	TN
2001-2021	Mean (STD)	0.3722 (0.1490)	0.7963 (0.1379)	0.4688 (0.1717)	0.5625 0.1682)	0.6597 (0.1546)	15,183
Pre 2008 GFC	Mean	0.4063 (0.1415)	0.8469 0.1080	0.4821 (01639)	0.5758 (0.1652)	0.7057 (0.1508)	4338
During 2008 GFC	Mean	0.405 (0.1440)	0.8090 (0.1173)	0.5061 (0.1728)	0.5935 (0.1683)	0.6873 (0.1479)	2,892
Post 2008 GFC	Mean	0.3050 (0.1580)	0.7330 (0.1453)	0.4183 (0.1785)	0.5182 (0.1801)	0.5860 (0.1651)	7,953

OE = Overall Efficiency AE= Allocative Efficiency TE = Technical Efficiency
PTE = Pure Technical Efficiency Scale E = Scale Efficiency TN=Total Number of observations

As is evidenced by Table 2, the average OE of 15,185 small banks operating in the US between 2001 and 2021 has been very low (37.22%). The primary sources of the low OE efficiency have been mostly low levels of OTE (46.88%) rather than AE (79.63%) efficiency. Decomposing the Technical efficiency to its components of PTE and SE reveals that the primary cause of low OTE has been low PTE (56.25%) and

[5] The yearly summary statistics of the efficiency measure are also available upon request, but for the sake of saving space, they are not provided in Table 2.

SE (65.97%). Putting these together, the principal cause of small banks' low overall efficiency during this study period has been a high level of pure technical inefficiency. A breakdown of the whole period into the three distinctive periods of pre-, during, and post-2008 GFC reveals similar results. The major cause of low OE is the low level of PTE. One of the objectives of this study is to shed light on the impact of the 2008 GFC on the efficiency of small banks. The efficiency measures calculated in scenario 1 may not give us reliable information on the impact of the 2008 GFC on bank efficiency. This is because the efficiency data presented in Table 2 are simply the average of efficiency measures from the corresponding yearly efficient frontier, and the frontiers themselves may have shifted because of the 2008 GFC. To better understand the impact of the 2008 GFC on small bank efficiency, we further investigate our analysis by recalculating the efficiency measures using pooled data efficient frontiers (scenarios 2 and 3). We utilize scenario 2, where the small bank sample is divided into three distinct pooled samples of pre (2001-2006), during (2007-2010), and post (2011-2021) 2008 GFC, and an efficient frontier for each of the subgroups is constructed. The efficiency measures for each bank/year are recalculated from the corresponding common efficiency. Table 3 presents the mean and standard deviation of efficiency measures for the three distinctive periods of pre-, during, and post-2008 GFC from their corresponding frontiers and for the whole period (2001-2021)[6].

Table 3: Efficiency measures from the corresponding efficient frontiers (2001-2021)

Year	Statistics	OE	AE	OTE	PTE	Scale E	TN
2001-2021	Mean (STD)	0.3759 (0.0879)	0.7800 (0.1269)	0.4829 (0.1056)	0.5804 (0.1413)	0.6194 (0.1068)	15,183
Pre 2008 GFC (2001-06)	Mean (STD)	0.4629 (0.1638)	0.8363 (0.0881)	0.5636 (0.1863)	0.6476 (0.1753)	0.7137 (0.1518)	4,338
During 2008 GFC (2007-10)	Mean (STD)	0.4481 (0.1579)	0.8122 (0.1163)	0.5550 (0.1841)	0.6717 (0.1789)	0.5573 (0.1495)	2,892
Post 2008 GFC (2011-21)	Mean (STD)	0.3022 (0.0210)	0.7374 (0.1520)	0.4127 (0.0330)	0.5106 (0.1090)	0.5906 (0.0667)	7,953

OE = Overall Efficiency AE= Allocative Efficiency TE = Technical Efficiency
PTE = Pure Technical Efficiency Scale E = Scale Efficiency TN = Total Number of observations

As is evident from Table 3, again, the overall efficiency of small banks for the period under this study has been low (37.59%), and the major source of overall inefficiency is the low efficiency of technical efficiency and its component pure technical efficiency. Finally, we follow scenario 3, where all small bank data is pooled, and a single common efficient frontier is constructed from which the efficiency measures for each bank for each year were calculated. We believe this approach is the more reliable way to examine the impact and response of small banks to the 2008 GFC. Table 4 presents the year-by-year mean and standard deviation of the efficiency measures from the common efficient frontier. The mean and standard deviation of the efficiency measure for each of the pre-, during, and post-2008 GFC periods and the mean and standard deviation of all small banks are also given in the lower part of Table 4.

Table 4: Yearly efficiency measures from the pooled data efficient frontier 2001-2021

Year	Statistics	OE	AE	TE	PTE	Scale E
2001	Mean	0.3041	0.8093	0.3772	0.4894	0.6290

[6] The yearly summary statistics of the efficiency measure are also available upon request, but for the sake of saving space they are not provided in Table 3.

	(STD)	(0.1192)	(0.0915)	(0.1427)	(0.1572)	(0.1606
2002	Mean (STD)	0.2874 (0.1186)	0.7659 (0.1094)	0.3770 (0.1465)	0.4850 (0.1497)	0.5974 (0.1594)
2003	Mean (STD)	0.2730 (0.1168)	0.7314 (0.1277)	0.3756 (0.1476)	0.4812 (0.1492)	0.5704 (0.1586)
2004	Mean (STD)	0.2733 (0.1215)	0.7071 (0.1313)	0.3880 (0.1503)	0.4886 (0.1521)	0.5603 (0.1536)
2005	Mean (STD)	0.2863 (0.1207)	0.7292 (0.1260)	0.3946 (0.1490)	0.4925 (01511)	0.5836 (01532)
2006	Mean (STD)	0.3045 (0.1172)	0.7732 (0.1146)	0.3967 (0.1458)	0.4924 (0.1575)	0.6243 (0.1535)
2007	Mean (STD)	0.3135 (0.1158)	0.7978 (0.1086)	0.3956 (0.1419)	0.4884 (0.1446)	0.6475 (0.1539)
2008	Mean (STD)	0.3044 (0.1143)	0.7840 (0.1163)	0.3912 (0.1399)	0.4818 (0.1433)	0.6362 (0.1505)
2009	Mean (STD)	0.2876 (0.1132)	0.7592 (0.1264)	0.3821 (0.1399)	0.4714 (0.1431)	0.6145 (0.1520)
2010	Mean (STD)	0.2768 (0.1164)	0.7422 (0.1316)	0.3762 (0.1467)	0.4638 (0.1462)	0.5997 (0.1505)
2011	Mean (STD)	0.2623 (0.1168)	0.7283 (0.1384)	0.3637 (0.1459)	0.4526 (0.1506)	0.5817 (0.1497)
2012	Mean (STD)	0.2511 (0.1159)	0.7206 (0.1452)	0.3515 (0.1414)	0.4396 (0.1447)	0.5718 (0.1523)
2013	Mean (STD)	0.2516 (0.1167)	0.7082 (0.1513)	0.3593 (0.1430)	0.4445 (0.1471)	0.5660 (01521)
2014	Mean (STD)	0.2541 (0.1177)	0.7056 (0.1530)	0.3636 (0.1427)	0.4483 (0.1461)	0.5666 (0.1516)
2015	Mean (STD)	0.2582 (0.1132)	0.7043 (0.1543)	0.3715 (0.1420)	0.4546 (0.1483)	0.5698 (0.1501)
2016	Mean (STD)	0.3313 (0.1500)	0.7096 (0.1446)	0.4691 (0.1794)	0.5462 (0.1737)	0.6017 (0.1563)
2017	Mean (STD)	0.3435 (0.1568)	0.7191 (0.1461)	0.4803 (0.1836)	0.5565 (0.1789)	0.6129 (0.1590)
2018	Mean (STD)	0.3612 (0.1606)	0.7415 (0.1465)	0.4895 (0.1840)	0.5658 (0.1800)	0.6346 (0.1617)
2019	Mean (STD)	0.3786 (0.1659)	0.7723 (0.1404)	0.4875 (0.1892)	0.5645 (0.1857)	0.6599 (0.1619)
2020	Mean (STD)	0.3014 (0.1366)	0.7911 (0.1403)	0.3834 (0.1572)	0.4593 (0.1622)	0.6565 (0.1590)
2021	Mean (STD)	0.3014 (0.1479)	0.8074 (0.1379)	0.3742 (0.1658)	0.4527 (0.1783)	0.6651 (0.1643)
2001-2021	**Mean (STD)**	**0.2953 (0.1329)**	**0.7368 (0.1380)**	**0.4084 (0.1600)**	**0.4895 (0.1614)**	**0.6075 (0.1591)**
Pre 2008 GFC	**Mean (STD)**	**0.2881 (0.1197)**	**0.7527 (0.1223)**	**0.3849 (0.1472)**	**0.4882 (0.1509)**	**0.5942 (0.1586)**
During 2008 GFC	**Mean (STD)**	**0.2956 (0.1158)**	**0.7708 (0.1230)**	**0.3863 (0.1418)**	**0.4764 (0.1446**	**0.6245 (0.1528)**
Post 2008 GFC	**Mean (STD)**	**0.2989 (0.1445)**	**0.7368 ().1495)**	**0.4084 (0.1716)**	**0.4895 (0.1720)**	**0.6075 (0.1608)**

OE = Overall Efficiency AE= Allocative Efficiency TE = Technical Efficiency
PTE = Pure Technical Efficiency Scale E = Scale Efficiency TN = Total Number of observations

A review of efficiency measures given for the whole period of 2001-2021 reaffirms our previous observation from the efficiency measures of scenarios 1 and 2 that the primary source of low overall efficiency of small banks is high technical inefficiency, which in turn is the result of high pure technical inefficiency. Comparing the efficiency measures of the pre-2008 GFC with those of during and post-2008 GFC indicates that the 2008 GFC did not hurt small banks' efficiency measures except for pure technical efficiency. Comparing the efficiency measures given in Table 2 (based on Scenario 1) and Table 3 (based on Scenario 2) with that of the lower section of Table 4 (based on Scenario 3) reveals a necessary but not surprising observation: Every value of the efficiency measures of scenario 3 is lower than the corresponding values in scenario 1 and 2. As we add more observations to the sample, the efficient frontier seems more likely to shift upward and lower the average efficiency measures. Three primary findings can be made from this section: 1. The major source of inefficiency in US small banks is the low level of technical inefficiency caused by the low level of pure technical efficiency. In estimating banks' profit efficiency, Berger, Hancock, and Humphrey (1993) also warn that technical inefficiency is more prevalent than allocative inefficiency amongst banks. 2. The 2008 GFC did not hurt US small bank efficiencies except pure technical efficiency. 3. In studies like this one, where the impact of an unexpected event is under examination using linear programming, a more extensive data set will provide more reliable results.

Step 2: Impact of 2008 GFC on the Small Banks Profitability Ratios

In this section, we will examine the trend of small banks' profitability ratios from 2001 to 2021 and discuss the impact of the 2008 GFC on small bank profitability. Using the three profitability ratios and the data presented in section 2, we calculated the profitability ratios for each bank/year. Table 5 shows the mean and standard deviation of profitability ratios and the mean and standard deviation for the overall sample and the pre-, during, and post-2008 GFC periods.

Table 5: Mean and standard deviation of the profitability ratios (2001-2021)

Year		**ROE**	**ROA**	**PM**
2001	Mean (STD)	8.66 (6.77)	0.97 (0.69)	12.82 (8.75)
2002	Mean (STD)	8.9 (6.75)	1.03 (0.68)	15.42 (9.82)
2003	Mean (STD)	8.46 (6.82)	0.99 (0.70)	16.41 (10.73)
2005	Mean (STD)	9.07 (6.99)	1.08 (0.79)	17.64 (11.96)
2006	Mean (STD)	8.69 (8.58)	1.06 (0.77)	15.60 (11.12)
2007	Mean (STD)	8.41 (6.88)	1.02 (0.74)	14.50 (9.71)
2008	Mean (STD)	6.82 (9.16)	0.82 (088)	12.86 (13.34
2009	Mean (STD)	4.58 (10.68)	0.58 (1.01)	10.09 (17.82)
2010	Mean (STD)	5.14 (10.17)	0.65 (0.94)	12.00 (18.01)
2011	Mean (STD)	5.80 (13.72)	0.73 (0.92)	14.69 (19.28)
2012	Mean (STD)	6.42 (9.23)	0.76 (0.83)	16.61 (17.39)
2013	Mean (STD)	6.40 (6.93)	0.76 (0.73)	17.65 (16.07)
2014	Mean (STD)	6.41 (7.26)	0.77 (0.72)	18.02 (15.48)
2015	Mean (STD)	6.33 (6.28)	0.78 (0.68)	18.10 (14.85)
2016	Mean (STD)	6.33 (6.79)	0.80 (0.67)	18.34 (14.15)
2017	Mean (STD)	6.25 (5.89)	0.78 (0.71)	17.78 (15.03)
2018	Mean (STD)	6.71 (7.57)	0.87 (0.77)	19.39 (14.65)
2019	Mean (STD)	6.28 (12.92)	0.86 (0.84)	18.23 (17.12)
2020	Mean (STD)	6.25 (9.56)	0.74 (0.79)	17.61 (17.63)

2021	Mean (STD)	7.88 (7.07)	0.85 (0.77)	20.71 (18.76)
2001-21	**Mean (STD)**	**7.09 (2.13)**	**0.86 (0.09)**	**16.32 (3.24)**
Pre 2008 GFC	**Mean (STD)**	**8.82 (0.74)**	**1.03 (0.04)**	**16.02 (1.01)**
During 2008 GFC	**Mean (STD)**	**6.24 (1.46)**	**0.77 (010)**	**12.36 (3.44)**
Post 2008 GFC	**Mean (STD)**	**6.46 (2.52)**	**0.79 (0.07)**	**17.92 (1.66)**

ROE = Return on Equity = Net Income/Total Equity Capital
ROA = Return on Assets = Net Income/Total Assets
PM = Profit Margin = Net Income/Total Operating Income

It is apparent from Table 5 that the small banks have been profitable during the period of this study. Comparing the profitability ratios during the distinct pre-, during, and post-2008 GFCs reveals that small banks were profitable pre-2008 GFC, became less profitable during the 2008 GFC, and recovered after the 2008 GFC. More detailed information on the impact of the 2008 GFC on small bank profitability becomes more revealing when we review the profitability data on a time series year by year. The three measures of profitability ratios increased from 2001 to 2004 but started to decline in 2005, two years before the 2008 GFC. This declining trend continued into the 2008 GFC period until 2009, and then the trend was reversed upward, beginning in 2010. The upward trend that started in 2010 continued until 2020 when the upward trend accelerated. The recovery from the declined profitability of the 2008 GFC era began in 2010 and reached the pre-2008 GFC level in 2020. The decline in profitability began before the 2008 GFC, and an increase in profitability started before the 2008 GFC ended.

Step 3: Impact of 2008 GFC on the correlation Between Efficiency measures and profitability

This section examines the association between profitability ratios (ROE, ROA, and PM) as independent variables and the efficiency measures (OE, AE, and OTE) as independent variables. We first examine the correlation between efficiency measures and profitability ratios and the cross-correlation between efficiency measures and profitability ratios. Table 6 provides the correlation among dependent and independent variables and across the dependent and independent variables.

Table 6: Correlations between efficiency measures and financial ratios (2001-2021)

VARIABLES	OE	AE	OTE	ROE	ROA	PM
OE	1					
AE	0.352	1				
OTE	0.884	0.091	1			
ROE	0.017	0.071	0.014	1		
ROA	0.053	0.089	0.018	0.872	1	
PM	0.032	0.099	0.002	0.799	0.899	1

OE = Overall Efficiency; OTE = Overall Technical Efficiency; AE = Allocative Efficiency PTE = Pure Technical Efficiency; SE = Scale Efficiency; ROE = Return on Equity; ROA = Return of Assets; PM = Profit Margin

As is evident from Table 6, there is a high correction (0.884) between OE and OTE. The high correlation between OE and OTE reaffirmed our previous findings that the major cause of low OE of small banks is the low level of OTE. There is also a relatively high correlation between

AE and OE. However, there is not much correlation between AE and OTE. A review of the correlation among profitability ratios indicates a strong correlation among the profitability ratios. Interestingly, the cross-correlation between the efficiency measures and profitability ratios is very small[7]. To further investigate the association between efficiency measures and profitability ratios, we utilized equation 1. We applied the OLS technique to regress the efficiency measures (OE, AE, and OTE) on the three profitability ratios. We run the regression for the overall pooled sample as well as the three distinct pooled samples of pre-, during, and post-2008 GFC[8]. Table 7 presents the regression coefficients and corresponding t-ratios in panels A to C.

Table 7: Regression Coefficient of Independent Variable (t-ratios in parenthesis)

Efficiency Measures/ Profitability Ratios	ROE	ROA	PM
Panel A: OE			
Pre 2008 GFC (2001-06)	-0.034 (0.741)	4.662 (6.052) *	-0.231 (5.224) *
During 2008 GFC (2007-10)	-0.238 (3.891) *	9.267 (9.273) *	-0.399 (7.840) *
Post 2008 GFC (2011-21)	-0.202 (5.980) *	4.499 (7.670) *	-0.085 (3.529) *
Overall (2001-2021)	-0.180 (7.010) *	3.639 (9.608) *	-0.064 (3.871) *
Panel B: AE			
Pre 2008 GFC (2001-06)	0.041 (0.714)	-6.451 (7.272) *	0.609 (12.410) *
During 2008 GFC (2007-10)	0.026 (1.462)	-4.675 (4.978) *	0.413 (7.554) *
Post 2008 GFC (2011-21)	0.001 (0.029)	-2.316 (4.354) *	0.164 (6.650) *
Overall (2001-2021)	0.004 (0.477)	-0.030 (0.093)	0.092 (5.400) *
Panel C: OTE			
Pre 2008 GFC (2001-2006)	-0.076 (1.346) *	9.310 (9.915) *	-0.591 (10.982) *
During 2008 GFC (2007-10)	-0.265 (3.581) *	13.606 (11.235)*	-0.704 (11.417) *
Post 2008 GFC (2011-21)	-0.238 (-5.932) *	6.528 (9.395) *	-0.180 (6.347) *
Overall (2001-2021)	-0.2137 (0.921) *	4.313 (9.449) *	-0.115 (5.839) *

t-statistic in parentheses; * Significant a 1 % level.
OE = Overall Efficiency; AE = Allocative Efficiency; TE = Technical Efficiency;
ROE = Return on Equity; ROA = Return on Assets; PM = Profit Margin

Table 7 shows a statistically significant strong positive association between OE and OTE with ROA. Although the association between AE and ROA is strong and statistically significant, the direction of the association is inverse. The associations between PM and efficiency measures are statistically significant, however the degree of association is much looser. The degree and direction of association between efficiency measures and ROE are mixed: There is a low degree of negative association, but it is statistically significant with OE and OTE, but there is an insignificant association with AE. This association pattern (both degree and direction) exists with disregarding the sample used (overall, pre-, during, and post-2008 GFC). Among the three profitability ratios, we believe the association between ROA and efficiency

[7] We also tested for correlation among variables for the pre-, during, and post-2008 GFC periods. Again, the results indicated similar results. Due to space constraints, we decided not to report, but results are available upon request.
[8] The correlation results from Table 6 may indicate a multicollinearity problem in estimating Equation 1. However, these correlations can be ignored to some extent as the classical linear regression model (CLRM) assumptions are not violated and, therefore, the estimators are the best linear unbiased estimators.

measures to be more reliable. The direction and degree of association between ROE and efficiency measures may not provide an accurate and reliable relationship. This is because ROE represents the net income of capital invested by shareholders and ignores the capital raised through debt, the most significant portion of capital raised by banks to invest. Contrary to ROE, ROA is the net income available to all capital providers (debt and equity). The PM also should provide complete information on the association between efficiency and profitability. PM shows the percentage of each dollar of income from the operation remaining after all costs and expenses and is considered a measure of cost efficiency and expense management, ignoring managerial efficiency. As explained in the methodology section, ROA is the combined results of PM and Asset Utilization (AU). AU, the ratio of total operating income to total assets and, provides information on productivity and efficient utilization of assets that is considered a sign of managerial efficiency. Therefore, the ROA captures the combined effects of cost and managerial efficiency. This implies that more efficient banks are expected to generate higher operating income per dollar of assets and, due to cost efficiency, generate high net income per dollar of operating income.

V. Summary and Conclusion

This paper examines the cost efficiency, profitability, and the association between cost efficiency and profitability of U.S. small banks pre-during-post 2008 global financial crisis. This was accomplished in three steps: Step 1 examined the cost efficiency, step 2 examined profitability ratios, and Step 3 examined the association between cost efficiency and profitability ratios. Using financial data from the FDIC website, we collected data for 723 of the same small banks from 2001 to 2021, with a total observation of 15,183 banks. In step 1, we examined the cost efficiency of U.S. small banks pre-during, and post-2008 GFC using Data Envelopment Analysis (DEA) under three scenarios: In scenario 1, the yearly efficiency measures of small banks for each year (2001-2021) were calculated from the annual corresponding efficient frontier. In scenario 2, the small bank sample was divided into three distinct pooled samples of pre- (2001-2006), during (2007-2010), and post (2011-2021) 2008 GFC, and an efficient frontier for each of the subgroups was constructed. The efficiency measures for each bank/year were recalculated from the corresponding common efficiency. In scenario 3, all small bank data was pooled, and a single common efficient frontier was constructed from which the efficiency measures for each bank for each year were calculated.

The results indicate that the overall efficiency of small banks operating in the U.S. pre-during-post 2008 Global Financial Crisis has been continuously low, and the sources of the low level of overall efficiency have been the low level of technical efficiency rather than allocative efficiency. In turn, the basis of the low level of technical efficiency has been Pure-technical rather than scale efficiency. In step 2, the profitability of U.S. small banks was examined using the same data and utilizing the three well-recognized profitability ratios. The results indicate that the 2008 GFC had a significant negative impact on the profitability of U.S. small banks: The small U.S. banks had high profitability scores pre-2008 GFC, a declining trend that started three years before the 2008 GFC, a sharp decline during the 2008 GFC, and profitability recovery began in 2010 and continues until 2021. In step 3, utilizing the Ordinary Least Square technique and the results from steps 1 and 2, the association between cost efficiency and profitability ratios was examined. The results indicate a strong positive and statistically significant association between OE and OTE with ROA. We also concluded that among the three profitability ratios, the association between ROA and efficiency measures is more reliable than the association between efficiency measures and ROE and PM.

The following conclusions emerge from the above three steps in this study.

Step 1: The primary source of inefficiency in U.S. small banks is the low level of technical efficiency caused by the low level of pure technical efficiency. The 2008 GFC only hurt U.S. small banks' pure technical efficiency. We also conclude that the more extensive data set in banking efficiency studies using DEA will provide more reliable results.

Step 2: An unexpected adverse event, such as the 2008 GFC, have negatively impacts on small banks' profitability. Therefore, policy intervention may be necessary to support the safety and soundness of small banking operations during the financial crisis. Further, we noticed that the negative impact of the 2008 GFC on small bank profitability was felt three years before the actual crisis, and the recovery in profitability happened two years before the end of the crisis. This may indicate that the profitability of small banks may have a predictive value.

Step 3: A strong positive and statistically significant association exists between OE and OTE with ROA. This association persists even during the major global financial crisis, such as the 2008 GFC. Therefore, in assessing the profitability of small banks to promote safety and soundness, policymakers should rely on changes in profitability proxied by ROA and changes in efficiency proxied by the OE or OTE.

References:

Alper, D. and Anbar A. (2011). "Bank Specific and Macroeconomic Determinants of Commercial Bank Profitability: Empirical Evidence from Turkey." *Business and Economics Research Journal* 2(2), 139-152.

Ashton, J.K. and Hardwick P. (2000). "Estimating inefficiencies in banking." *Journal of Interdisciplinary Economics* 11 (1), 1-33.

Athanasoglou, P. P., Briss, S. N. and Delis, M. D. (2005). "Bank-Specific, Industry-Specific and Macroeconomics Determinants of Bank Profitability." *Bank of Greece,* Working Paper #25.

Banerjee, A. (2018). "Can ratios predict the financial performance in banks: A case of national banks in United Arab Emirates (UAE)." *International Journal of Accounting and Financial Reporting 8*(4), 2162-3082.

Bassett, W. and Zakrajsek, E. (2001). "Profits and Balance Sheet Developments at U.S. Commercial Banks in 2000." *Federal Reserve Bulletin*, 88, 367-93.

Berger, A.N. & Humphrey, D.B. (1997). "Efficiency of Financial Institutions: International Survey and Directions for Future Research." *European Journal of Operation Research* 98 (2), 175–212.

Berger, A.N. (2007). "International Comparisons of Banking Efficiency." *Financial Market, Institution, and Instruments* 16(3), 119–144.

Berger, A.N., Hancock, D., and Humphrey, D.B. (1993). "Bank Efficiency Derived from the Profit Function." *Journal of Banking and Finance*, 17, 317-347.

Bhatia, V., Basu, S., Mitra, S.K. and Dash p. (2018). "A Review of Bank Efficiency and Productivity." *OPSEARCH* 55, 557-600.

Casu, B., & Molyneux. P. (2001). "Efficiency in European banking, European Banking: Efficiency, Technology and Growth." J.A. Goddard, P. Molyneux, J.O.S. Wilson (Eds.), John Wiley and Sons Ltd., England, 99-139.

Chaki, S., Chauhau, K and Daryal, A. (2019). "Financial Performance of Banks in India: Are Banks Sound Enough to be Banked Upon?" *International Journal of Innovative Technology and Exploring Engineering* 8(9S), 1004-1010.

Charnes, A., Cooper, W.W., and Rhodes, E. (1978). "Measuring the Efficiency of Decision-Making Units." *European Journal of Operation Research* 2(6), 429-444.

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J., Battese, G.E. (2005). An Introduction to Efficiency and Productivity Analysis. Springer, Berlin.

Cole, D. W. (1972). "Return of equity model for banks." *The Bankers Magazine,* 155 (3), 40-47.

Das, A., and S. Ghosh. (2006). "Financial Deregulation and Efficiency: An Empirical Analysis of Indian Banks During the Post Reform Period." *Review of Financial Economics* 15(3), PP 193-221.

Drake, L. (2001). "Efficiency and Productivity Change in UK Banking." *Applied Financial Economics* 11(5), 557-571.

Elyasiani, E., Mehdian, S. and Rezvanian, R. (1994). "Empirical tests of association between production and financial performance: The case of commercial banking industry." *Applied Financial Economics* 4, 55-59.

Färe, R., S. Grosskopf, and C. A. K. Lovell. (1985). *The Measurement of Efficiency of Production (Studies in Productivity Analysis)*. Springer.

Fethi, M.D. and Pasiouras, F. (2010). "Assessing Bank Efficiency and Performance with Operational Research and Artificial Intelligence Techniques: A Survey". *European Journal of Operation Research* 204 (2),189-98.

Financial Crisis Insights on Bank Performance Reporting (Part 1), Assessing the Key Factors Influencing Price-to-Book Ratios, CFA Institute 2014.

Goddard, J., Molyneux, P. and Wilson, J. (2004). "Dynamics of Growth and Profitability in Banking." *Journal of Money, Credit and Banking* 63 (3), 1069-1090.

Molyneux, P. and Thornton, J. (1992). "Determinants of European Banks Profitability: A note". *Journal of Banking and Finance* 16, 1173-1178.

Nal, O. and Cai, A. (2020). "Analyzing Impact of a Crisis on Bank Financial Ratios". *Accounting and Finance Research* 9(4), 1-17.

Nippani, S. and Ling, R. (2021). "Bank size and performance: An analysis of the industry in the United States in the post-financial-crisis era". *Journal of Financial Research 44*(3), 587-606.

Paradi, J.C. and Zhu, H. (2013). "A Survey on Bank Branch Efficiency and Performance Research with Data Envelopment Analysis". *Omega*, 41(1), 61-79.

Rezvanian, R., Mehdian, S., and Jaklin, K. (2023). "Profitability of US Small Banks pre-during-post 2008 Global Financial Crisis: Evidence from Ratio Analysis." Working paper.

Sathye, M. (2001). "X-Efficiency in Australian Banking: An Empirical Investigation." *Journal of Baking and Finance* 25(3), 613-630.

Staikouras, C. and Wood, G. (2004). "The Determinants of European Bank Profitability". *International Journal of Economics and Business Research,* 3 (6), 57-68.

Short, B. (1979). "The Relationship Between Commercial Bank Profit Rates and Banking Concentration in Canada, Western Europe and Japan". *Journal of Banking and Finance,* 3, 209-219.

Smirlock, M. (1985)."Evidence on the (Non) Relationship Between Concentration and Profitability in Banking". *Journal of Money, Credit and Banking*, 17, 69-83.

Turk Ariss, R., R. Rezvanian, and S. M. Mehdian. (2007). "Cost Efficiency, Technological Progress and Productivity Growth of Banks in GCC Countries." *International Journal of Business* 12 (4), 471-91.

Verma, R. (2021). "Comparative analysis of financial performance of HDFC and SBI bank on the basis of ratio analysis". *Asian Journal of Management, 12*(2), 111-114.

Widyastuti, U., Purwana, D. and Zulaihati, S. (2017). "Internal Determinants of Commercial Bank Profitability in Indonesia". *Mediterranean Journal of Social Sciences* 8 (3), 219-223.