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STEERING THROUGH THE STORM: AN EMPIRICAL ANALYSIS OF COVID-19'S IMPACT ON BANK EFFICIENCY IN BANGLADESH

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ABSTRACT

The study evaluates the efficiency levels of Bangladeshi banks spanning 2014 to 2021, with a particular emphasis on 2020 and 2021, when the COVID-19 pandemic caused unexpected global disruption and economic devastation. Utilizing Data Envelopment Analysis (DEA), the study first measures the efficiency of 25 commercial banks in Bangladesh over the specified period. The overall bank efficiency levels in Bangladesh declined substantially during the COVID-19 pandemic compared to the pre-pandemic period. This finding of study has corroborated by paired t-tests and Wilcoxon Signed-rank tests. The study also reveals that both conventional PCBs and Islami PCBs were severely impacted in the initial phase of the pandemic in 2020, but most demonstrated remarkable recovery by 2021. In contrast, SCBs exhibited resilience throughout the pandemic period, with the exception of two banks. The study used Tobit regression model to identify key bank-specific and macroeconomic factors influencing bank efficiency. The regression results indicate that bank size, ROA and diversification have a significant positive influence on bank efficiency levels whereas credit risk, overhead expenses and asset quality have a significant negative effect, as expected. In case of macroeconomic factors, GDP growth contributes positively to bank efficiency levels, while the influence of real interest rate is found to be insignificant. The primary objective of this study is to determine whether the Covid-19 have significant impact on bank efficiency and the findings from the study confirm that COVID-19 had a significant adverse impact on the bank efficiency levels. Academics and policy-makers will also benefit from the results of the study. Certainly, the present study can be extended in many aspects in the future research to come in terms of data variety, including more commercial banks or the choice of performance metrics such as economic efficiency (Cost, revenue and profit) and Malmquist Total Factor Productivity Index (TFP).

KEYWORDS: Bangladeshi banks, bank efficiency, COVID-19, DEA, Tobit regression model

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1. INTRODUCTION

The banking sector, very often seen the backbone of ever-evolving financial systems (Czechowska & Florczak, 2022; Istaiteyeh et al., 2024), found itself at a crossroads, grappling with unprecedented challenges caused by the disruption induced by COVID-19. The banking sector has always been the primary provider of financing for long-term investments while being the foundation of economic expansion for any economy (Schumpeter, 1934). In the case of Bangladesh, banking companies has solidified its role as the most important component within the scope of the country's financial and economic structure since the early 1970s (Kamarudin et al., 2016). Therefore, the banking companies has become the cornerstone of the economy, driving growth and maintaining stability (Deb et al., 2019). Nevertheless, banking companies remain particularly vulnerable to economic turmoil, political unrest, and natural crises (Gazi et al., 2022; Rekha & Hossain, 2022). Such adverse events profoundly affect banking companies' operational mechanisms, triggering regulatory reforms and prompting an overhaul of the prevailing financial framework worldwide.

COVID-19 is a 21st Century global phenomenon (Woodward et al., 2021), raging across all nations of the world, "posing enormous health, economic, environmental and social challenges to the entire human population" (Chakraborty & Maity, 2020 p. 1). It was easily transmissible and spread with remarkable speed. The first case of COVID-19 was reported in Wuhan, China, in late December 2019 (Cheng et al., 2020) and within just a few months, COVID-19 had rapidly spread across the continent. Due to its extraordinary social and economic upheaval, as well as the immense loss of human life, the World Health Organization (WHO) declared a global public health emergency, recognizing COVID-19 officially as a pandemic in early 2020 (Gautam et al., 2022; Golubeva, 2021; Vianna Franco et al., 2022). Several drastic and restrictive measures were imposed in response to the escalating COVID-19 crisis, including lockdowns, restrictions on movement, and partial or complete shutdowns of offices and factories (Gazi et al., 2022). While necessary to contain the spread of COVID-19, the strict enforcement of these measures disrupted livelihoods and communities in ways never seen before, delivering a severe blow to the global economy, particularly within the banking sector (Elnahass et al., 2021; Shabir et al., 2023). In fact, empirical evidence suggest that the effects of the pandemic were substantially worse than those of the Global Financial Crisis (Berger & Demirgüç-Kunt, 2021; Hanif et al., 2021).

COVID-19 had also dealt a severe blow to the economy and livelihoods in Bangladesh, much like in the rest of the world. At the peak of the COVID-19 crisis., important macroeconomic indicators got worsened, such as GDP growth rate, consumer price index, exchange rate, and unemployment rate (Gazi et al., 2022). More specifically, Bangladesh's GDP growth rate experienced a significant decline from 7.9% in 2019 to 3.4% in 2020 as reported by the World Bank, largely due to the economic contraction caused by the pandemic. However, the performance of the banking sector is closely tied to these aforementioned macroeconomic factors, and shifts in these factors have an impact on the profitability and financial performance of banks accordingly (Gazi et al., 2022). Undoubtedly, the COVID-19 pandemic triggered significant economic downturn, affecting the

banking sector of Bangladesh grievously (Rekha & Hossain, 2022). Even before the outbreak of COVID-19, the banking sector of Bangladesh has been long plagued by many anomalies (Karim et al., 2023). Non-performing loans (NPLs) at certain banks accounted for over 30% of their total disbursed loans (Robin et al., 2019). The effects of COVID-19 further exacerbated the dire scenarios of banks in Bangladesh. According to Bangladesh Bank Quarterly report, NPLs in the country's banking sector surged to 8.07% in the first quarter of 2021 from 7.66% at the end of 2020, indicating rising poor asset quality due to COVID-19. To alleviate the economic stress caused by COVID-19, the Bangladesh Bank instructed banks not to classify borrowers as defaulters for failing to pay interest. While this provided relief to borrowers, it significantly hurt the banks' profitability by hindering their ability to recover loans and interest (Begum et al., 2023). On the other hand, banks' liquidity status also deteriorated. It is apparent that the banking sector's overall financial health significantly worsened and was in the red zone during the COVID-19 pandemic period (Karim et al., 2021). Therefore, evaluating the impact of COVID-19 on the banking sector is pivotal from the viewpoint of Bangladesh.

Following the widespread disruptions of the COVID-19 pandemic on financial institutions, assessing the efficiency of banks during COVID-19 has emerged as a prominent area of research. Several authors, such as Boubaker et al. (2023); Gulati et al. (2023); Ikhwan & Riani (2022); Lee & Yang (2024); Mai et al. (2023); Nguyen et al. (2023) and Sang (2022) have offered significant insights regarding the impact of COVID-19 on the operational efficiency of banks at cross-country and regional levels. Numerous studies (Barua & Barua, 2021; Begum et al., 2023; Chowdhury et al., 2023; Gazi et al., 2022; R. Ghosh & Saima, 2021; Karim et al., 2023; Rekha & Hossain, 2022) have been conducted to evaluate the effects of COVID-19 on financial performance, profitability, sustainability, resilience and corporate governance within the banking sector of Bangladesh. Few researchers, Chowdhury et al. (2023) and Kundu et al. (2024) have only focused on the performance of banks in terms of efficiency. In order to address this research gap, this study attempts to measure the technical efficiency of banks in Bangladesh during both the pre-pandemic and pandemic periods using the Data Envelopment Analysis (DEA) method. In addition, the study adopts the panel data Tobit regression as suggested by James Tobin (1958) to identify the determinants of the efficiency of banks with particular emphasis on COVID-19. So, the study necessitates a thorough examination of the following research questions: Q1. Did COVID-19 have any impacts on the efficiency of banks? Q2: What factors caused the shift in efficiency of these banks?

The study makes three significant contributions. Firstly, the study evaluates the efficiency of 25 banks in Bangladesh, categorizing the periods 2014–2019 as pre-COVID-19 and 2020–2021 as the COVID-19 era. To the best of the author's knowledge, the study encompasses the largest sample of banks assessed to date. Secondly, the study adopts the parametric and non-parametric test to find out whether the variances in efficiency scores of banks before and during COVID- 19 are statistically significant. Finally, the study will add valuable insights to the existing literature on the determinants of bank efficiency by incorporating the impact of COVID-19 and employing Tobit regression model.

Tobit regression model is more suitable than fixed and random effects models used in most prior research in Bangladesh due to the censored nature of the efficiency scores (dependent variable), which ranges from 0 to 1 (Bhatia & Mahendru, 2019; Gunes & Yilmaz, 2016; Ikhwan & Riani, 2022; Vuong, 2024).

The remainder of the study is organized as follows: The next section reviews the existing literature on COVID-19's impact on bank efficiency, followed by the description of methods and data used in the study. The results and analysis section contains findings and a brief discussion of their interpretation. In the final section, conclusions, policy implications as well as limitations, and suggestions for future research are provided.

2. LITERATURE REVIEW

Over the course of the past three decades, copious amount of research has been undertaken on bank efficiency across developed and developing nations (Dagnaw Dinberu & Wang, 2018; Vidyarthi & Tiwari, 2020). Koopmans (1951) laid the foundation for the concept of efficiency and different industries, including the banking sector have been leveraging this concept for diverse aspects (Mahbub, 2016; Mester, 1997). The study of bank efficiency is key to fostering the progress of banks, ensuring sustainable operations and formulating important policies for the banking sector (Chen et al., 2021; S. Ghosh et al., 1994; Mester, 1997; Ramly et al., 2017). As a result, substantial growth has been seen in the number of research works on bank efficiency literature (Abreu et al., 2019; Akdeniz et al., 2023; Aliyu et al., 2017; Bhatia & Mahendru, 2019; Nan et al., 2020). Most researchers prefer to adopt non-parametric DEA and parametric stochastic frontier analysis (SFA) methods (Daraio et al., 2019; Hammami et al., 2022; Liu et al., 2013; Ngo & Le, 2019; Sáez-Fernández et al., 2021; Shyu et al., 2015; Ngo & Tripe, 2017; Wasiaturrahma et al., 2020) as traditional financial ratios (such as ROA and ROE) are comparatively less effective in analyzing efficiency and overall bank performance (Dong, 2010; Ngo & Le, 2019). Inspired by the early work of Sherman & Gold (1985), researchers and policymakers across various disciplines have promptly recognized DEA as an effective non-parametric method (Berger & Humphrey, 1997; Charnes et al., 1994; Liu et al., 2013), originating from the framework of Farrell (1957) and later expanded by Charnes et al. (1978) and Banker et al. (1984).

Inarguably, COVID-19 clobbered the world economy with "the most unanticipated large and widespread exogenous economic shock of all time" (Berger & Demirgüç-Kunt 2021, p. 1). Economic shocks have always garnered scholarly interest and as a consequence, researchers have now conducted numerous studies on the impact of COVID-19 on bank efficiency, although the scope of these studies remains limited as of now (Aldomy et al., 2022; Mai et al., 2023; Rekha & Hossain, 2022).

Many researchers have frequently employed DEA method and Tobit regression in the literature for assessing efficiency and uncovering its determinants (Czechowska & Florczak, 2022; Haralayya &

Aithal, 2021; Ikhwan & Riani, 2022; Istaiteyeh et al., 2024; Vuong, 2024). In an effort to measure efficiency, Istaiteyeh et al. (2024) conducted a study on 15 Jordanian banks over the span of 2006 to 2021 utilizing DEA and Tobit regression. They observed that Islamic banks were likely to be more efficient than the conventional banks as corroborated by earlier studies (Bader et al., 2008; Beck et al., 2013; Ben Mohamed et al., 2021; Iqbal, 2001) and that the efficiency level was significantly determined by return on assets, return on equity as well as GDP growth. Notwithstanding the study covered the period of the pandemic, it did not take into account the impact of the pandemic. In a corresponding study by Vuong (2024) adopted Tobit regression to investigate the drivers of efficiency in 30 joint-stock commercial banks over the period between 2016 and 2022 in Vietnam. It was found that ROA and ROE showed positive a correlation with efficiency, whereas the Expense-to-Income Ratio, Asset Size and NPL were negatively linked to efficiency. Following an examination of 78 banks in 15 countries over the period from 2005 to 2020, Nguyen et al. (2023) reported that Islamic banks weathered the storm brought about by the pandemic by demonstrating resilience and moderate performance. The study identified bank size and inflation as key determinants of operational efficiency by applying truncated regression. In a similar context of studying Islamic banks, the findings of Mai et al. (2023) echoed the same as Nguyen et al. (2023) based on a sample of 79 Islamic banks across 16 countries between 2005 and 2020. The study detected that GDP growth influenced bank efficiency level positively. After the outbreak of COVID-19, Ikhwan & Riani (2022) studied Indonesian banks in the years 2015 to 2020, reaching the conclusion that the COVID-19 pandemic negatively affected banks, which in turn decreased their efficiency. The study utilized Tobit regression and identified total financing, ROA and LDR/FDR as key factors influencing bank efficiency. Soeparno et al. (2022) also revealed that bank efficiency notably decreased in Indonesia amid the COVID-19 crisis. Another study by Khoirunnisa & Aliludin (2021) found no negative impact of COVID-19 on the bank efficiency level in Indonesia, contradicting the findings of Ikhwan & Riani (2022) and Soeparno et al. (2022). In light of COVID-19, Sakouvogui & Guilavogui (2022) undertook research on U.S. banks over a 10-year period from 2010 to 2020 and found that COVID-19 had an adverse effect on bank economic efficiency. The research concluded that solvency and liquidity metrics showed evidence of being negatively affected over the course of the pandemic following the utilization of Tobit regression and fixed effects model. Sang (2022) employed the DEA method to analyze the ramifications of COVID-19 and reported that the banks exhibited enhanced operational efficiency in 2020 during the pandemic, relative to 2019 in Vietnam. There are several other studies conducted to assess the effects of COVID-19 on bank efficiency (Boubaker et al., 2023; Čiković et al., 2023; Czechowska & Florczak, 2022; Gulati et al., 2023; Ikhwan et al., 2023; Lee & Yang, 2024; Yagli, 2023).

However, there has been a dearth of empirical studies, particularly those exploring the nuanced impact of economic turmoil and global maelstrom on the efficacy of Bangladesh's banking sector (Jahan, 2019; Samad, 2019). On the occasion of Global Financial Crisis, only a handful of studies have been carried out to explore the repercussion of GFC on efficiency of banks in Bangladesh (Banna et al., 2017; Kamarudin et al., 2016) using DEA & regression analysis. This similar trend

persists even after the never-before-seen disruptions caused by COVID-19. Against this backdrop, Kundu et al. (2024) examined the efficiency level of 43 commercial banks operating in Bangladesh amid the public health crisis of 2020 by means of slack-based DEA. The findings inferred mixed performance of sampled banks with efficiency levels varying from optimal to moderate or minimal at the height of the pandemic. Acknowledging the detrimental effect of COVID-19, Chowdhury et al. (2023) attempted to analyze the implication of bank-specific and macroeconomic variables on the bank efficiency utilizing the DEA method along with fixed and random effects panel regression model. Ten (10) private conventional banks were chosen for the study within the timeframe of 2016 to 2021. The study confirmed that bank efficiency is adversely impacted by the COVID-19 pandemic. In fixed effects regression, the study identified bank size, ROE, capitalization, GDP as statistically significant factors which are positively related to bank efficiency. On the flip side, GDP is the only factor found to be statistically relevant in random effects regression.

Upon reviewing the literature presented above, no empirical evidence was found regarding the determinants, including both bank-specific and macroeconomic factors of bank efficiency using DEA in conjunction with Tobit regression during the pandemic-driven challenges in Bangladesh. Hence, the contribution of the research is addressing the void within the scope of existing research literature on bank efficiency and its determinants in the wake of COVID-19.

3. METHODS AND DATA

3.1 Methods

3.1.1 Data Envelopment Analysis

The study used DEA (Data Envelopment Analysis) approach for the purpose of efficiency measurement of banks in Bangladesh. The basic DEA approach measures efficiency in a way that closely resembles microeconomic concepts. However, unlike traditional methods that rely on a fixed mathematical formula, the DEA frontier is constructed using actual data from the organizations being evaluated. Essentially, the DEA frontier is formed by a linear combination of the data points, creating a convex Production Possibility Set (PPS). Consequently, the efficiency score for any given Decision-Making Unit (DMU) is not an absolute measure but is determined relative to the performance of other DMUs within the same dataset (Casu & Molyneux, 2003). Variable returns to scale (VRS) were chosen over constant return to scale (CRS) to evaluate efficiency levels since not all DMUs operate at an optimal scale because of factors such as imperfect competition and financial limitations (Barry et al., 2011; Khoirunnisa & Aliludin, 2021). The study took an input-oriented approach because, for a bank, it is more practical to minimize inputs rather than maximize outputs, especially within the competitive environment and adverse effects of COVID-19 (Ngo & Le, 2019; Nguyen et al., 2023). In this study, banks are considered financial intermediaries that deliver financial and payment services to various entities within the economy (Holod & Lewis, 2011; Luo, 2003; Sealey & Lindley, 1977; Staub et al., 2010; Sufian, 2009). To measure bank efficiency level, the study employed DEAP 2.1.

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3.1.2 Tobit Regression Model

To identify factors affecting bank performance. Regression analysis was performed on the panel data using Tobit regression model because the DEA efficiency score ranges from 0 to 1 ($0 \leq$ Efficiency ≤ 1), where efficiency represents the efficiency score. Therefore, it was classified as a censored dependent variable. Tobit regression model is particularly suitable in this case. Because it refers to the truncated nature of Dependent variables including explanatory variables. The general structure of Tobit regression model is as follows:

$$\boldsymbol{\gamma_i}^* = \boldsymbol{\beta x_i} + \boldsymbol{\varepsilon_i}$$

$$\boldsymbol{\gamma_i} = \begin{cases} 1 \ if \ \gamma_i^* > 1 \\ \gamma_i^* \ if \ 0 \leq \gamma_i^* \leq 1 \\ 0 \ if \ \gamma_i^* < 0 \end{cases}$$

Where, $\boldsymbol{x_i}$ is a vector of explanatory variables and $\boldsymbol{\beta}$ is the set of parameters to estimate. $\boldsymbol{\gamma_i}$ is the efficiency score found by the DEA in the first stage and $\boldsymbol{\gamma_i}^*$ is the latent variable. $\boldsymbol{\varepsilon_{it}}$ represents the error terms. The upper and lower limits of the dependent variable, $\boldsymbol{\gamma_i}^*$ are set to 1 and 0, respectively.

The study developed three Tobit regression models were developed. In Model 1, the study investigated the effects of bank-specific characteristics on bank efficiency levels. Model 2 extended this investigation by incorporating macroeconomic variables in addition to the bank- specific variables. Lastly, in Model 3, the study included COVID-19 variable to examine its impact on bank efficiency levels in Bangladesh.

Model 1:

$$\boldsymbol{\theta_{it} = \beta_0 + \beta_1 LNTA + \beta_2 ROA + \beta_3 LOAN/TA + \beta_4 NII/TA + \beta_5 NIE/TA + \beta_6 NPL + \varepsilon_{it}}$$

Model 2:

$$\boldsymbol{\theta_{it} = \beta_0 + \beta_1 LNTA + \beta_2 ROA + \beta_3 LOAN/TA + \beta_4 NII/TA + \beta_5 NIE/TA + \beta_6 NPL + \beta_7 GDP\_gth + \beta_8 Real\_INR + \varepsilon_{it}}$$

Model 3:

$$\boldsymbol{\theta_{it} = \beta_0 + \beta_1 LNTA + \beta_2 ROA + \beta_3 LOAN/TA + \beta_4 NII/TA + \beta_5 NIE/TA + \beta_6 NPL + \beta_7 GDP\_gth + \beta_8 Real\_INR + \beta_9 DUM\_COVID + \varepsilon_{it}}$$

Where, θ means the efficiency score as a dependent variable, while β_0 is constant, ($\beta_1 - \beta_9$) are the coefficients of independent variables and ε represents the disturbance term.

Nonetheless, heteroscedasticity may arise when estimated parameters serve as dependent variables in the second stage of analysis (Saxonhouse, 1976). Consequently, following Ismail et al. (2013); Sufian (2009) and Hauner (2005) Quasi Maximum Likelihood (QML Huber/White) standard errors and

covariates are computed, as facilitated by EViews 12 software. Quasi Maximum Likelihood also does not rely on the assumption that error terms are normally distributed. As a result, Quasi Maximum Likelihood is suitable for data with non- normal distributions.

Table 1: Description of dependent and explanatory variables used in Tobit regression model

Description of Variables					
		Variable	Description	Proxy	Hypothesized Relationship
Dependent Variable		Efficiency	Bank Efficiency	DEA	N/A
Explanatory Variables	***Bank Specific***	LNTA	Natural Log of Total Assets	Bank Size	+/-
		ROA	Net Income/Total Asset	Profitability	+
		LOAN/TA	Loans & advances/Total Assets	Credit Risk	-
		NII/TA	Non-interest Income/Total Assets	Diversification	+
		NIE/TA	Non-interest Expense /Total Assets	Overhead Expenses	-
		NPL	Non-performing Loans as a percentage of Loans & Advances	Asset quality	-
	Macroeconomic	GDP_gth	GDP Growth rate of per year	Economic Growth	+
		Real_INR	Real interest rate per year	Real Interest Rate	+/-
		DUM_COVID	Dummy Binary variables, value of 1 if COVID-19 exists, 0 otherwise	COVID-19 Pandemic	-

3.2 Data

The study used financial data from the annual reports of 25 commercial banks in Bangladesh, covering the years 2014 to 2021. The analysis is divided into two periods: 2014–2019 as pre- COVID-19 period and 2020–2021 as COVID-19 period. To ensure consistency and comparability, only state-owned commercial banks (SCBs) and private commercial banks (PCBs) were included in the analysis.

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Additionally, Macroeconomic data used in Tobit regression analysis were sourced from the World Bank DataBank.

3.2.1 Selection of Input and Output Variables for DEA Approach

The study selected Operating Incomes and Other Earning Assets as inputs, while Operating Expenses and Total Deposits were chosen as outputs. This selection aligns with previous research on bank efficiency, including studies by Avkiran (2011); Fujii et al. (2014); Lozano- Vivas et al. (2002); and Nguyen et al. (2023).

Table 2: Brief Description of Variables

Character of Variable	Variables	Elements of the variables
Output	Operating Income	Net interest income Investment income Non-interest income
	Other Earning Assets	Total assets less total loans and advances and fixed assets (Hassan & Hassan, 2018; Robin et al., 2019)
Input	Operating Expenses	Non-interest expenses Personnel expenses
	Total Deposits	Total deposits, money market and short-term funding (Islam & Kassim, 2015)

Table 3: List of Selected Decision-Making Units (DMUs):

No.	DMUs	Abbr.
State-owned Commercial Banks (SCBs)		
1	Agrani Bank PLC	Agrani
2	Janata Bank PLC	Janata
3	Rupali Bank PLC	Rupali
4	Sonali Bank PLC	Sonali
Conventional Private Commercial Banks (PCBs)		
5	Bank Asia PLC.	Bank Asia
6	BRAC Bank PLC	BRAC

7	City Bank PLC	City
8	Dhaka Bank PLC	Dhaka
9	Dutch-Bangla Bank PLC	DBBL
10	Eastern Bank PLC	EBL
11	IFIC Bank PLC	IFIC
12	Mercantile Bank PLC	Mercantile
13	Mutual Trust Bank PLC	MTB
14	NRBC Bank PLC.	NRBC
15	Premier Bank PLC	Premier
16	Prime Bank PLC	Prime
17	Pubali Bank PLC	Pubali
18	UCB PLC	UCB
19	Uttara Bank PLC	Uttara
Islami Sharia Based PCBs		
20	Al-Arafah Islami Bank PLC	AIBL
21	EXIM Bank of Bangladesh PLC	EXIM
22	Islami Bank Bangladesh PLC	IBBL
23	Shahjalal Islami Bank PLC	Shahjalal
24	Social Islami Bank Limited	SIBL
25	Standard Bank PLC	Standard

4. RESULTS & DISCUSSION

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4.1 Descriptive Statistics

Table 4: Summary Statistics for the DEA input and output variables (Figures in BDT Million)

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Input:					
Total Deposits	200	18779.97	1449520.67	333654.73	261732.01
Operating Expenses	200	659.80	26772.37	7837.86	4918.85
Output:					
Other Earning Assets	200	10092.97	982330.17	143210.26	170039.49
Operating Income	200	990.98	43326.78	14497.70	8250.90

4.2 Efficiency of Bangladeshi Banks

Table 5: Input Oriented VRS Efficiency Levels of Banks (Computed by DEAP Version 2.1)

DMUs	Pre COVID-19 Period						COVID-19 Period		Mean	
	2014	2015	2016	2017	2018	2019	2020	2021		
State-owned Commercial Banks:										
Agrani	1.000	0.963	0.955	0.907	0.840	0.771	0.777	0.762	**0.872**	
Janata	0.929	0.893	0.823	0.840	0.798	0.699	0.770	0.802	**0.819**	**0.848**
Rupali	0.860	0.772	0.687	0.788	0.699	0.596	0.688	0.615	**0.713**	
Sonali	0.961	1.000	0.985	0.975	1.000	0.995	1.000	1.000	**0.990**	
Conventional PCBs:										
Bank Asia	1.000	0.970	0.896	0.890	0.934	0.975	0.790	0.923	**0.922**	
BRAC	1.000	0.998	1.000	0.948	0.903	0.940	0.853	0.951	**0.949**	
City	0.925	0.952	0.923	0.834	0.777	0.836	0.763	0.963	**0.872**	
Dhaka	0.903	0.837	0.969	0.874	0.949	0.874	0.800	0.903	**0.889**	
DBBL	0.940	0.911	0.862	0.859	0.939	1.000	0.968	0.947	**0.928**	
EBL	0.993	0.892	0.946	0.902	0.884	0.908	0.885	1.000	**0.926**	
IFIC	0.802	0.785	0.741	0.747	0.690	0.734	0.613	0.790	**0.738**	
Mercantile	0.897	0.823	0.790	0.886	0.834	0.882	0.638	0.745	**0.812**	**0.869**
MTB	0.807	0.773	0.780	0.746	0.778	0.761	0.633	0.706	**0.748**	
NRBC	1.000	1.000	0.979	1.000	0.957	0.964	0.932	0.908	**0.968**	
Premier	0.772	0.711	0.782	0.814	0.894	0.927	0.839	0.909	**0.831**	
Prime	0.918	0.896	0.839	0.787	0.793	0.859	0.783	0.905	**0.848**	
Pubali	0.979	0.948	0.860	0.885	0.886	0.899	0.836	0.824	**0.890**	
UCB	1.000	0.939	0.824	0.808	0.770	0.799	0.720	0.847	**0.838**	

Uttara	0.985	1.000	0.940	0.818	0.826	0.866	0.820	0.822	**0.885**	
Islami Shariah Based PCBs:										
AIBL	1.000	0.960	0.980	0.862	0.777	0.858	0.771	0.798	**0.877**	
EXIM	0.919	0.902	0.818	0.795	0.854	0.806	0.729	0.709	**0.817**	
IBBL	1.000	0.917	0.903	0.936	1.000	1.000	0.773	1.000	**0.941**	**0.836**
Shahjalal	0.825	0.785	0.775	0.721	0.777	0.856	0.753	0.844	**0.792**	
SIBL	0.930	0.932	0.909	0.863	0.810	0.785	0.634	0.648	**0.814**	
Standard	1.000	0.873	0.835	0.777	0.747	0.712	0.686	0.598	**0.779**	
Mean	**0.934**	**0.897**	**0.872**	**0.850**	**0.845**	**0.852**	**0.778**	**0.837**	**0.858**	

A bank is deemed fully efficient when its efficiency level reaches 100%; otherwise, it is considered as inefficient. Higher efficiency levels correspond to reduced inefficiency. Table 5 demonstrates the input oriented VRS efficiency levels of the SCBs, conventional PCBs and Islami PCBs over the period 2014-2021. The overall efficiency levels of the banking sector reached historically poor levels during this study period, specifically 77.8%, and improved to 83.7% respectively in 2020 and 2021 from 85.2% in 2019 prior to the pandemic. The notable finding of this study is that most banking institutions remained inefficient throughout the period between 2014 and 2021. In comparison among SCBs, conventional PCBs and Islami PCBs, conventional PCBs outperformed it's both peers with a mean efficiency level of 86.9%. Meanwhile, SCBs surprisingly exhibited higher mean efficiency scores than Islami PCBs, requiring further investigations. All SCBs performed better even in the time of COVID-19. Their efficiency levels increased, defying the unprecedented challenges caused by the pandemic. However, Rupali and Agrani Bank faced setbacks in 2021. In case of conventional PCBs, the efficiency levels of banks decreased substantially and almost all of them except Dutch-Bangla & Pubali bank rebounded from COVID shock extraordinarily in the subsequent year, showing resilience and excellent management efficiency to navigate the tough times of the pandemic. On the other hand, COVID-19 affected the Islami PCBs banks grievously. The efficiency of these Islamic banks gradually declined over time and reached the lowest level during the worst phase of the pandemic. The state-managed Sonali Bank led the rankings with the highest efficiency level of 99% among the 25 banks in this study, while another state- owned, Rupali Bank, found itself at the bottom of the list with a score of 71.3% on an individual basis.

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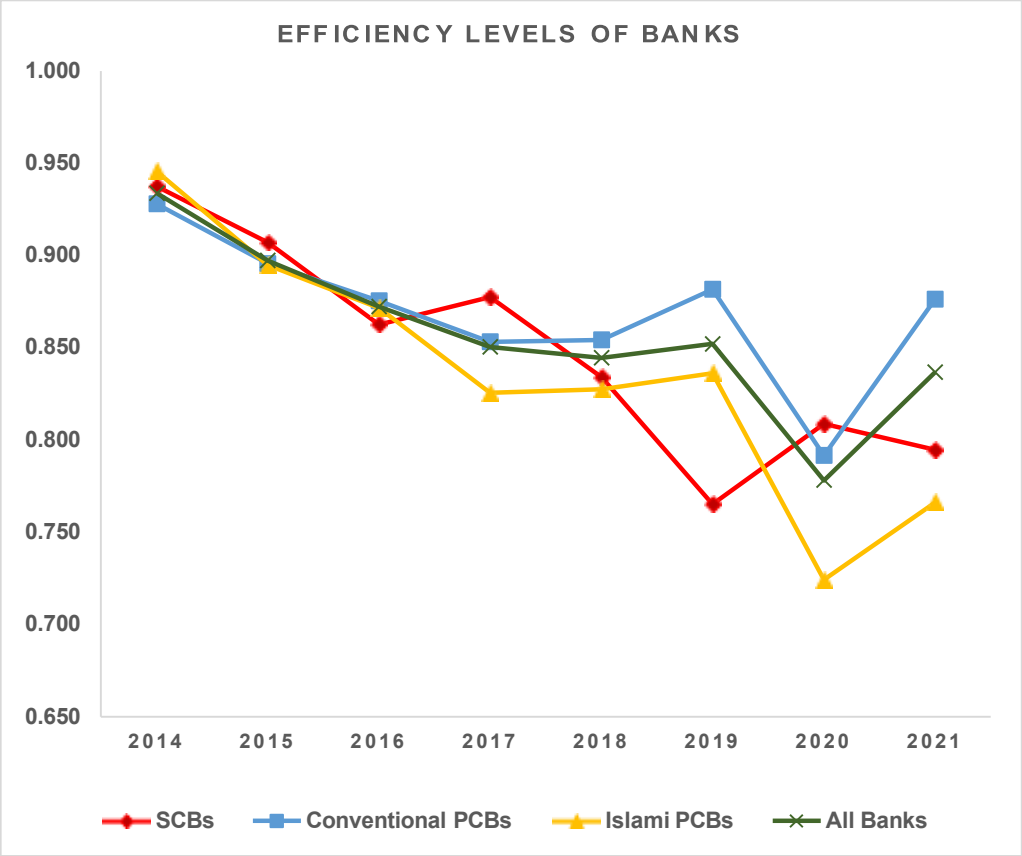

Figure 1

4.3.1 Normality Test

The table below presents the results of the Shapiro-Wilk normality test conducted on the average efficiency scores of 25 banks prior to and throughout the COVID-19 pandemic:

Table 6: Normality Test Result

	Shapiro-Wilk		
	Statistic	**Df**	**Sig.**
Before_COVID_Avg	.970	25	.643
During_COVID_Avg	.964	25	.495

The results suggest that the data approximately follows a normal distribution, as evidenced by a significance value (Sig.) > 0.05. Therefore, the paired test was chosen to find out if there was a statistically significant difference between the average efficiency scores of the studied banks before

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and during COVID, alongside the non-parametric Wilcoxon Signed Ranks test to achieve more robust results.

4.3.2 Robustness Check: Parametric and Non-parametric 4.3.2.1 Tests Paired Test

The results of the paired test of the average efficiency scores of the banks before and during COVID are shown in the table below:

Table 7: Paired Test Result

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Before_COVID_Avg-During_COVID_Avg	.067653	.070200	.014040	.038676	.096630	4.819	24	.000

The derived significance value is 0.000. This indicates that the difference in average efficiency scores before and during COVID-19 is statistically significant. The positive mean difference of 0.067653 shows that the average efficiency scores during COVID-19 were lower than those before the pandemic. This finding is supported by the 95% confidence interval, which does not cross zero, and the results of the t-test.

4.3.2.2 Wilcoxon Signed Ranks Test

The next table presents the Wilcoxon test results for the average efficiency scores of the banks before and during the COVID-19 pandemic:

Table 8: Wilcoxon Test Result

Ranks				
		N	Mean Rank	Sum of Ranks
During_COVID_Avg - Before_COVID_Avg	Negative Ranks	20[a]	14.90	298.00
	Positive Ranks	5[b]	5.40	27.00
	Ties	0[c]		
	Total	25		
a. During_COVID_Avg < Before_COVID_Avg				
b. During_COVID_Avg > Before_COVID_Avg				
c. During_COVID_Avg = Before_COVID_Avg				

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The result suggests a significant trend of decreased efficiency in most banks during the COVID-19 period compared to their pre-COVID-19 performance. The majority of banks (20 out of 25) experienced a decline in average efficiency during COVID-19 compared to before COVID-19, as shown by the higher sum and mean rank of negative ranks. Only 5 banks showed an improvement in efficiency during the pandemic, and none remained unchanged.

Test Statistics[a]	
	During_COVID_Avg - Before_COVID_Avg
Z	-3.646[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

The statistical analysis reveals an Asymp. Sig. (2-tailed) of 0.000, which is below the accepted threshold of 0.05. This confirms a significant difference in average efficiency levels between the periods before and during the COVID-19 outbreak.

In conclusion, parametric and non-parametric tests conducted throughout the study period showed that the sampled banks' efficiency was worse after COVID-19 than it had been before the pandemic. Indeed, the banking sector in Bangladesh was severely affected by COVID-19.

4.4 Correlational Analysis

Table 9: The correlation coefficients matrix of independent variables

Variables	ROA	LNTA	LOANS/TA	NII/TA	NIE/TA	NPL	GDP_gth	Real_INR	DUM_COVID
ROA	1.000								
LNTA	-0.550**	1.000							
LOANS/TA	0.379**	-0.366**	1.000						
NII/TA	0.491**	-0.277**	0.188**	1.000					
NIE/TA	0.492**	-0.400**	0.044	0.470**	1.000				
NPL	-0.588**	0.552**	-0.736**	-0.328**	-0.300**	1.000			
GDP_gth	0.067	-0.064	0.080	0.142*	0.073	0.087	1.000		
Real_INR	0.014	0.041	-0.003	0.023	-0.079	-0.026	-0.173*	1.000	
DUM_COVID	-0.165*	0.309**	0.012	-0.285**	-0.207**	-0.094	-0.608**	0.113	1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Pearson's correlation coefficient was used to assess the relationships between explanatory variables in the regression analysis. Following (Abdelsalam et al., 2008), multicollinearity is a concern when a correlation coefficient exceeds 0.80. Results indicated that no variables surpassed this threshold, aligning with (Kennedy, 2008) standards, suggesting multicollinearity was not an issue.

4.5 Key Determinants of Bangladeshi Banks' Efficiency

To identify the factors influencing the efficiency of Bangladeshi banks, we calculated efficiency scores using DEA (Data Envelopment Analysis) and applied three panel data Tobit regression models to examine their relationship with explanatory variables. Model 3 specifically focuses on the impact of COVID-19 on the determinants of bank efficiency in Bangladesh. The results of the Tobit regressions are presented in table 7.

In Model 1, the Tobit regression model includes all six basic bank-characteristics factors including bank size (LNTA), profitability (ROA), credit risk (LOANS/TA), diversification (NII/TA), management quality (NIE/TA) and asset quality (NPL/LOANS). On the other hand, Model 2 integrates macroeconomic variables like the GDP Growth Rate and Real Interest Rate, while retaining bank-specific variables within the regression model. In Regression Model 3, we use a binary dummy variable for COVID-19 to assess its effect on bank efficiency.

According to the results of regression analysis, the coefficient of bank size indicates that larger banks tend to be more efficient, consistent with the findings of previous studies (Ahmad Mokhtar et al., 2007; Abdul Majid et al., 2010; Gunes & Yilmaz, 2016; Ismail et al., 2013). However, this relationship is only statistically significant in Model 3. The profitability measure, represented by return on assets (ROA), has a statistically significant positive impact on bank efficiency across all three models. This result aligns with prior research findings, highlighting the critical role of profitability in

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Table 10: Panel Data Tobit Regression Results

Dependent Variable	Explanatory Variables	Model 1	Model 2	Model 3
Efficiency	**Bank-specific**			
	Size	0.025752 (0.018298)	0.030221* (0.017394)	0.045575** (0.018219)
	Profitability	0.132383*** (0.028853)	0.127494*** (0.027482)	0.126815*** (0.027684)
	Credit Risk	-0.007006*** (0.001023)	-0.007916*** (0.001013)	-0.007958*** (0.001013)
	Diversification	0.081082*** (0.019005)	0.068411*** (0.018647)	0.052169*** (0.018197)
	Overhead Expenses	-0.026530** (0.011037)	-0.028661*** (0.010180)	-0.029374*** (0.010127)
	Asset Quality	-0.004454** (0.001864)	-0.006684*** (0.002024)	-0.008212*** (0.002177)
	Macroeconomic-specific			
	GDP Growth		0.020398*** (0.004106)	0.009690* (0.004972)
	Real Interest Rate		0.000161 (0.000916)	0.000165 (0.000895)
	Dummy Variable:			
	COVID-19			-0.060286*** (0.018460)
	_cons	0.908179*** (0.279638)	0.815536*** (0.265748)	0.737621*** (0.263212)
	Observations	200	200	200
	Log-likelihood	173.4008	182.8182	188.3054

***, **, * represent 1%, 5% and 10% significance level respectively, standard errors are in the parentheses

enhancing efficiency levels (Dagnaw Dinberu &Wang, 2018; Gunes & Yilmaz, 2016; Ikhwan & Riani, 2022; Istaiteyeh et al., 2024; Samad, 2019; Vuong, 2024). These studies consistently emphasize that higher ROA reflects effective utilization of assets and enhanced financial performance, contributing to improved operational efficiency. On the other hand, all models suggest that credit risk negatively impacts bank efficiency. This evidence is in line with Ariff and Can's (2008) argument that loan portfolio composition significantly influences bank efficiency. Higher credit risk reduces efficiency, as a higher ratio of loans to total assets increases the likelihood of loans becoming non-performing. It

also adds to the costs of managing large loan portfolios and addressing associated risks. Another bank-specific characteristic, diversification, is observed to have a positive relationship with bank efficiency. This is attributed to the stable and less volatile nature of non-interest income compared to interest income, which contributes to an enhancement in the efficiency levels of banks. This relation echoes the results of Sufian (2009), Gulati & Kumar (2011), and Raphael (2013) who found that Non-Interest Income had a positive effect on the efficiency of banks. The above regression result table demonstrates a significant negative impact of management quality, as measured by the ratio of non-interest expense to total assets. This observation supports the findings of previous studies (Berger & DeYoung, 1997; Sufian, 2009; Ally & Patel, 2013; Samad, 2019;). Asset quality has a negative and significant effect on bank efficiency, indicating that inefficiencies arise from high operational costs and poor asset performance. These findings align with those of Vuong (2024), who also highlights the detrimental impact of lower asset quality on banking operations.

In Model 2, macroeconomic factors like GDP growth and real interest rates are included alongside bank-specific variables. GDP growth shows a strong positive impact, suggesting it plays an important role in enhancing bank performance. On the other hand, while real interest rates align with expected sign, their effect is statistically insignificant. Interestingly, both findings differ from earlier studies (Banna et al., 2017), which reported contrasting results for these variables. In model 3, COVID-19 is found to have a significant negative impact on bank efficiency, likely due to operational disruptions and increased credit risks during the pandemic. This indicates that the decline in bank efficiency can be attributed to the challenges posed by the COVID-19 crisis as supported by the earlier study of Chowdhury et al., (2023).

5. CONCLUSION

So far, numerous studies have been conducted on bank efficiency. However, most of these have focused on the banking sectors of developed countries. In contrast, developing countries such as Bangladesh have limited empirical evidence, and research on the effects of economic shocks on bank efficiency is even more scarce. This study aims to address this gap by offering new empirical evidence regarding the impact of COVID-19 on bank efficiency in Bangladesh. The study used Data Envelopment Analysis to evaluate the efficiency scores of 25 commercial banks of Bangladesh over the period of 2014 to 2021, while considering 2014 to 2019 and 2021 & 2022 as pre-Covid-19 and COVID-19 period respectively. The results reveal that bank efficiency levels during COVID-19 period were lower than those of the pre-COVID-19 levels. Among the 25 sample banks, SCBs demonstrated resilience amidst the COVID-19 shocks, while Islami PCBs suffered the most. On the other hand, conventional PCBs faced significant setbacks at the onset of COVID-19, the majority of them quickly recovered in the following year 2021, through effective management and enhanced performance, reaching an improved level of operational efficiency. Using Tobit regression model, the study identifies that bank- specific factors namely ROA, bank size, diversifications and macroeconomics factor, GDP growth have a statistically significant impact on bank efficiency level. Meanwhile, other characteristic factors including credit risks, overhead expenses and asset quality negatively influence

the efficiency level of banks. Most importantly, COVID-19 variable explains the declining bank efficiency levels in Bangladesh during the COVID-19, which is found to have significant adverse impact on bank efficiency in Tobit regression analysis.

This study is an effort to explore the impact of COVID-19 on bank efficiency in Bangladesh and ultimately bank efficiency levels are adversely affected by COVID-19 based on the findings of the study. It provides a comprehensive picture of economic conditions and bank performance in terms of efficiency both before and during COVID-19 in Bangladesh. As a result, the findings of the study will help policymakers in developing better policies to anticipate contextual reactions and optimize banking efficiency in the event of an unexpected crisis. With the provided information and insights in the study, they can gain a clearer understanding of how efficiency affects the performance of their banks in Bangladesh.

Acknowledging its limitations, the study opens avenues for further explorations in various directions. Future research could incorporate additional input/output variables and other approaches such as value-added or production approach, to measure the efficiency of banks. Besides, the sampled data could include more Bangladeshi commercial banks to enhance robustness and provide diverse insights. The present study could also be extended by utilizing alternative non-parametric method, Malmquist Productivity Index approach, which analyzes productivity changes over time while accounting for the effects of technological progress or regression. Future research work could also focus on the efficiency of bank levels in the context of post-COVID-19 effects.

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