An internship report submitted in **Evaluating of Factors Influencing Bank Operating Efficiency in Private Commercial Banking Sector of Bangladesh**
For the Degree of Masters of Business Administration

Supervised By:

Akila Rubaiyath

Lecturer, Department of Finance and Banking

Faculty of Business Studies

Comilla University, Cumilla.

Submitted By:

Ishrat Jahan

Id:22317019

Registration:22317019

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Department of Finance and Banking

Comilla University, Cumilla

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Department of Finance and Banking

Comilla University, Cumilla

Letter of Transmittal

26 May, 2025

Akila Rubaiyath

Lecturer,

Department of Finance and Banking

Faculty of Business Studies

Comilla University, Cumilla

Subject: Submission of an intern report **Evaluating of Factors Influencing Bank Operating Efficiency in Private Commercial Banking Sector of Bangladesh**

Madam,

It is a matter of great pleasure for me that I have finally been able to complete the internship report on **Evaluating of Factors Influencing Bank Operating Efficiency in Private Commercial Banking Sector of Bangladesh** as per the academic requirement for completing the MBA program from Department of Finance and Banking. I am highly grateful to you for as you have assigned me such a great task which has helped me to gain and enriched my knowledge regarding operating efficiency of private commercial banking sector in Bangladesh. I have given my utmost effort to comprehend and translate the knowledge, I have gained from the secondary sources, news, articles and data analysis, in writing this report. Therefore, I hope the study will be able to meet its standard and serve its purpose accordingly.

Sincerely,

Ishrat Jahan

ID:22317019

MBA 6th Batch

Department of Finance and Banking

Comilla University, Cumilla

Letter of Certification

This is to certify that the thesis paper regarding the topic **Evaluating of Factors Influencing Bank Operating Efficiency in Private Commercial Banking Sector of Bangladesh** has been submitted successfully by Ishrat Jahan ID:22317019 MBA 6th Batch Department of Finance and Banking Comilla University, Cumilla.

I found her sincere and hardworking regarding the study under my supervision. I wish her every success in all aspects.

Signature of Supervisor

____

Akila Rubaiyath

Lecturer

Department of Finance and Banking

Faculty of Business Studies

Comilla University, Cumilla

Student Declaration

I, hereby, declare that the work on the topic, **Evaluating of Factors Influencing Bank Operating Efficiency in Private Commercial Banking Sector of Bangladesh** has been completed by me under the supervision of Akila Rubaiyath. Furthermore, I also declare that this study has not been submitted to any other institution or university. There is no breach of copyright protection and quotation from different articles and newspapers have been properly referenced. I further take full responsibility if any copyright is breached or any sort of loss to the third party is done.

Signature of the Student

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Ishrat Jahan

ID:22317019

MBA 6th Batch

Department of Finance and Banking

Comilla University, Cumilla

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SONALI BANK PLC.
WAPDA BUILDING BR, CUMILLA.
'Credible and Smart'

Mobile : +88-01766-693457
E-mail : brwbuilding@sonalibank.com.bd

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TO WHOM IT MAY CONCERN

THIS IS TO CERTIFY THAT **ISHRAT JAHAN, CLASS ID- 22317019, REG NO-22317019** STUDENT OF COMILLA UNIVERSITY, DEPARTMENT OF FINANCE & BANKING UNDER **MBA PROGRAM** IS CONTINUING HER THREE MONTHS LONG INTERNSHIP IN SONALI BANK PLC. WAPDA BUILIDING BRANCH, CUMILLA.

DURING HER ONGOING INTERNSHIP PERIOD SHE UNDERGOES A THOROUGH INTERNSHIP PROGRAM ON **"EVALUATING OF FACTORS INFLUENCING BANK OPERATING EFFICIENCY IN PRIVATE COMMERCIAL BANKING SECTOR OF BANGLADESH"**. SHE MAINTAINED ALL THE RULES & PROVIDED THE SERVICES AS AN EMPLOYEE OF THE ORGANIZATION.

ON THE WAY OF ACCOMPLISHING THE TASK WE FOUND HER VERY SINCERE, HARD WORKING AND CURIOUS TO ACQUIRE BANKING KNOWLEDGE. SHE DEVOTED HERSELF FULLY IN WORK AREA AND PERFORMED ALL THE DUTIES & RESPONSIBILITIES ACCORDINGLY. SHE ALWAYS ENGAGED HERSELF IN WORK INSTRUCTED BY THE PERSONNEL OF THE BRANCH.

WE WISH EVERY SUCCESS IN HER LIFE.

(S. M. SAJJAD ALI KHAN)
SENIOR PRINCIPAL OFFICER & BRANCH MANAGER
SONALI BANK LIMITED
WAPDA BUILIDNG BRANCH
CUMILLA.

Abstract

This study investigates the effect of bank-specific factors on the operational efficiency of private commercial banks in Bangladesh, analyzing data from ten banks over the period 2014 to 2023. Key internal variables considered include bank size, the ratio of non-performing loans (NPLs) to total loans, total NPL ratio, the loan-to-deposit ratio, loan loss provisions to total loans, interest rate spread, and operating expenses as a share of total income. Macroeconomic indicators such as GDP growth and inflation were also included for broader analysis. To ensure robust results, the study utilizes four econometric models: Pooled OLS, Generalized Least Squares (GLS), Fixed Effects, and Random Effects. Several diagnostic tests—covering heteroskedasticity, autocorrelation, cross-sectional dependence, and unit roots—were conducted to verify the reliability and validity of the models. The findings reveal that only a subset of bank-specific variables—namely bank size, NPL-related ratios, loan loss provisions, and operating expenses—have a statistically significant impact on operational efficiency. This indicates that internal bank management and financial policies play a more decisive role in determining efficiency than macroeconomic conditions. The study contributes to the literature by emphasizing the importance of internal financial indicators in influencing bank performance. Based on these insights, it recommends that private commercial banks in Bangladesh focus on improving operational efficiency by managing NPLs, reducing excessive operational expenses, and optimizing bank size. Targeted efforts to strengthen these areas can enhance the competitiveness and sustainability of the banking sector in a dynamic economic environment.

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1.0 Introduction

Privately-owned commercial banks in Bangladesh typically exhibit greater operational efficiency compared to their state-run counterparts, particularly in managing expenditure-to-income metrics and technical effectiveness. Empirical studies reveal that these institutions outperform public sector banks in efficiency assessments. Metrics such as the Bank Operating Profit to Operating Income (BOPO) ratio and the Capital Adequacy Ratio (CAR) often reflect superior values for private banks. Research from sources including the Institute of Chartered Accountants of Bangladesh (ICAB) and Bangladesh Journals Online has shown that private banks achieve an average efficiency rating of approximately 80.84%, whereas public banks tend to struggle with elevated cost-to-income proportions. In the broader economic landscape, commercial banks serve as fundamental intermediaries between savers and borrowers. Their functionality underpins economic growth and sectoral stability, making efficiency in banking operations vital for the nation's economic health (Odunga, 2013). As of 2025, over 40 privately held commercial banks are operating under the oversight of the Bangladesh Bank. These banks are categorized into traditional interest-based institutions and Shariah-compliant Islamic banks. They contribute notably to financial inclusion, job creation, capital mobilization, and overall national economic development.

The operational productivity of these banks has seen consistent enhancement due to increased reliance on automation, digital transformation, and more robust risk governance mechanisms. Investments in modern core banking infrastructure, mobile applications, and agent banking channels have helped reduce operational overheads and extend banking access to previously underserved demographics. High-performing banks like BRAC Bank, Dutch-Bangla Bank, and City Bank display advantageous cost-to-income ratios, highlighting their effective administrative strategies. Despite macroeconomic headwinds and global uncertainties, these institutions have managed to maintain stable profitability indicators such as Return on Assets (ROA) and Return on Equity (ROE). In 2023, many of them reported moderate earnings growth, largely supported by non-interest income streams and prudent cost management. Nevertheless, profitability has been adversely affected by a rise in defaulted loans, growing reserve requirements, and currency fluctuations. Commercial banks continue to face obstacles such as loan delinquencies, tight regulatory standards, and competition from non-bank financial entities (NBFIs).

Looking ahead, the industry is expected to grow, driven by deeper financial inclusion, technological integration, and supportive government initiatives targeting small and medium enterprises (SMEs) and sustainable finance. Recent Developments: Increased collaborations with fintech companies and a strong pivot toward digital banking. Greater emphasis on environmental, social, and governance (ESG) frameworks. Expansion into remote areas via agent banking and mobile platforms

These banks are increasingly seen as pillars of the financial ecosystem. Sustaining long-term profitability and efficiency will depend heavily on continued modernization, good governance, and improved asset management. Digital tools such as mobile apps, ATMs, and online portals significantly reduce manual interventions, improve transaction speeds, and drive down costs. Automation lowers the chance of errors and enhances the customer experience. Cost-effective management of human resources, physical branches, and administrative functions positively impacts the expense-to-income ratio. Delegating non-essential functions like IT services and customer support to third-party vendors also reduces operational burdens.

Large-scale banks often enjoy cost advantages by distributing their fixed expenditures across a broader client base. A well-trained workforce is key to maintaining high service quality and efficient operations. Conversely, an excessive number of branches or ATMs can lead to inflated overheads. Smart network optimization using transaction data and customer behavior analysis helps reduce redundancy. Bundling services—such as loans, savings, insurance, and payment cards—can boost revenue per customer without significantly increasing costs. Internal checks, compliance systems, and proactive risk management are essential in preventing financial setbacks. Efficient institutions maintain low levels of defaulted assets, reducing the need for costly provisions and write-offs. Maintaining high-quality assets enhances interest-based income and mitigates financial risks. Furthermore, robust IT security infrastructure ensures smooth operations and shields the institution from cyber threats.

1.2 Research Questions

- ✓ Which variable influence Operating efficiency most?
- ✓ Do operating efficiency effect profitability through different firm's variable?
- ✓ Do operating efficiency is a noticeable factor for private commercial bank?

1.3 Scope of Further Study

This study investigates the determinants of bank efficiency using operating expense to total asset ratio and cost to income ratio as key indicators. While the analysis provides meaningful insights, several avenues remain open for future research. Incorporating additional qualitative variables such as governance quality, technological adoption, or managerial efficiency may offer a more comprehensive understanding of cost behavior. Expanding the scope to a cross-country or regional comparison could highlight the role of institutional and regulatory environments in shaping bank efficiency. Moreover, future studies may benefit from employing dynamic or non-linear models to capture delayed or threshold effects, particularly regarding variables like bank size or interest rate spread. The inclusion of crisis periods or regulatory reforms can also shed light on how external shocks influence efficiency metrics. A more granular analysis of operating expenses—such as separating administrative, IT, or compliance costs—could further clarify specific areas of inefficiency. Time-varying effects of macroeconomic indicators like GDP growth or interest rate spread may also be explored by segmenting the data across economic cycles. In addition, differentiating between bank types—such as public, private, or cooperative—might reveal structural differences in cost efficiency drivers. Finally, the application of frontier-based techniques like Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA) could validate and complement regression-based findings by providing robust efficiency scores. These directions can enrich the understanding of bank performance and support more targeted policy and managerial interventions.

1.4 Research Objectives

Broad objectives

Investigating influences on banking efficiency in Bangladesh’s private commercial sector.

Some additional objectives of this study are as follows

- ❖ To ascertain the normality of the dataset through descriptive statistics.
- ❖ To assess the relationship between banks some specific factors and Operating efficiency
- ❖ To perform various diagnostic test for measuring validity and reliability of the regression model
- ❖ To figure out the problems that are present with the data set through various diagnostic test and to determine the best model according to that.

2.0 Literature review

Banks play a crucial role in the economy by facilitating financial transactions, providing credit, and influencing monetary policy. They act as intermediaries between savers and borrowers, channeling funds to support investment and economic growth. Banks also contribute to the stability of the financial system and manage the flow of money within and between nations. Lotto (2019) identified that bank branches excelling in service productivity also ranked highest in profitability, indicating a direct link between operational excellence and financial performance. Benthem (2017) posits that financial institutions can boost their earnings by expanding investment in innovative financial solutions and extending branch networks, thus improving market coverage and operational strength.

Hsiao, Chang et al. (2010) emphasized that to remain competitive, banks should enhance efficiency, reduce operating expenses, leverage scale advantages, adopt technological advancements, and diversify service offerings. Sarkar, Sarkar et al. (1998) stress the importance of studying deregulation impacts in developing countries independently, due to distinct institutional frameworks affecting operational performance. Kumbhakar and Sarkar (2003) argue that although deregulation primarily aims to elevate efficiency levels, its results have been inconsistent. Berger and Mester (2003) report that nearly all of this research—about 95%—concentrates on banking institutions in developed markets, especially the United States.

Drake, Hall et al. (2006) observed notable disparities in technical performance among banks, considerable differences based on size and type, and variable impacts of environmental elements across institutions. Talluri, Kim et al. (2013) highlight the research potential in translating industrial production techniques into service environments to boost both efficiency and quality in banking. Sherman and Gold (1985) argue that conventional financial ratios fall short in assessing branch productivity, calling for more analytical methods. Berger (2003) links enhancements in operational and lending efficiency to advancements in back-office systems, while improved front-end technologies have benefitted customers—resulting in broader productivity gains and enriched service options. Kwast and Rose (1982) discovered some evidence that top-performing banks had reduced liability costs, although certain asset-side costs were higher. However, they found no solid proof that highly profitable banks were inherently more efficient than less profitable ones.

Noulas (2001) determined that public banks trailed private ones in efficiency, particularly regarding non-interest and labor-related costs, and the performance gap widened over time. Odunga, Nyangweso et al. (2013) concluded that improving capital adequacy ratios is crucial for enhancing operational efficiency and sustaining competitiveness—a viewpoint echoed by Lotto (2018), who demonstrated that Tanzanian commercial banks operating under stricter capital requirements achieved greater efficiency. This suggests that adequate capital not only ensures financial resilience but also mitigates moral hazard between shareholders and creditors. Kwan and Eisenbeis (1997) found a positive relationship between inefficiency and increased risk-taking, reinforcing the moral hazard argument that underperforming banks are more likely to engage in riskier behaviors. Additionally, they attribute increased capital in inefficient banks to regulatory interventions. Sherman and Gold (1985) advocate for the use of Data Envelopment Analysis (DEA), a mathematical model that evaluates efficiency based on service output and input use, as a valuable supplement to traditional performance metrics.

Eldomiaty, Fikri et al. (2015) note that in fiercely competitive markets such as Egypt, variables like asset quality, adequate capitalization, credit exposure, and liquidity significantly influence efficiency—showcasing the benefits of strong financial governance in high-performing banks. Al-Shammari and Salimi (1998) define operational efficiency as the ability to offer services at reduced costs while maintaining quality, achieved by optimizing the right performance factors to maximize value and minimize routine costs. Pradhan, Shyam et al. (2017) assert that factors like operational productivity, the loan-to-deposit ratio, and provisions for bad loans positively correlate with banks' financial outcomes. Athanasoglou, Brissimis et al. (2008) explain that efficient banks efficiently allocate society's savings toward projects with high social value, carefully supervising them post-lending—thus accelerating economic progress. In contrast, inefficiencies within banks can hinder economic development and diminish public welfare.

Myers and Majluf (1984) argue that in the absence of capital ratio adjustments, banks lack motivation to maintain buffers above regulatory minimums. Moreover, raising equity could signal negative insider information to markets, especially under asymmetric information. Jha and Hui (2012) discovered that return on assets is significantly shaped by capital adequacy, interest cost relative to total loans, and net interest margin, while the capital adequacy ratio also strongly impacts return on equity. Anandarajan, Hasan et al. (2005) warn that ineffective provisioning for loan losses could materially distort reported capital and profitability, raising concerns in financial accounting. Zhu and Wang (2025) observe that Chinese banks display stronger efficiency in capital utilization than in capital profitability, suggesting the need to improve returns on capital to enhance overall operational success.

Benthem (2017) further reveals that improved operational efficiency may lead to a rise in non-performing loans, implying that managerial choices directly influence credit quality. Ikhide (2008) suggests that scaling up operations could significantly enhance the efficiency of Namibian commercial banks. Minh, Thanh et al. (2020) point out that increasing non-interest income, through diversified services, improves bank performance and is often emphasized in research evaluating non-credit activities. Omar, Rahman et al. (2006) find that the overall productivity of the banking sector has slightly improved, with efficiency advancements being the main contributor to this growth rather than technological innovation.

Enhancing efficiency within a country's banking sector significantly boosts both its domestic and international competitiveness, leading to increased income generation and expanded employment prospects. A key aim of such reforms is to explore avenues for improving the operational effectiveness of the banking industry at both institutional and sector-wide levels (Rahman, Nabi et al., 2011). Privately-owned commercial banks tend to incur lower operational expenses compared to state-owned commercial banks (SCBs), indicating that they are more dynamic and operate with higher efficiency (Wu and Chen, 2010).

For any manager operating in a customer-focused environment, maximizing operational effectiveness remains a top priority. Strategies to attain such efficiency include reshaping managerial conduct, streamlining operations, and embracing technological advancements. The integration of mobile credit services has notably strengthened the operational effectiveness of commercial banks, especially in terms of loan recovery and shareholder returns. In this context, performance metrics used to assess efficiency included return on assets, earnings per share, and the ratio of non-performing loans (Kinyanzui, Achoki et al., 2018).

2.1 Literature gap

Although prior research has investigated the determinants of operating efficiency and its effects on bank profitability, there remains a lack of comprehensive analysis on how particular measures of operating efficiency—namely, the operating expense to total asset ratio and the cost to income ratio—are influenced by and interact with a wide range of financial and macroeconomic variables. These include bank size, various non-performing loan metrics, loan-to-deposit ratios, interest spreads, capital adequacy ratios, GDP growth, inflation, and loan loss provisions. This study seeks to address this gap by analyzing the mutual effects among these variables to better understand operating efficiency in private commercial banks.

3.0 Research Methodology

3.1 Research Type

This study is descriptive and is based on insights gained during the internship period. To compile this report, data was gathered from various annual reports of selected private commercial banks as well as information available on their official websites.

3.2 Research Design

This study aims to provide a comprehensive overview of various aspects such as contribution, potential, profitability, operational efficiency, total loan approvals, total deposit approvals, the proportion of non-performing loans (NPL) within sanctioned loans, inflation, GDP growth, and related factors. Consequently, a descriptive research methodology has been adopted.

3.3 Source of Data

For the sake of preparing this report, secondary source is used. Secondary source is:

- Annual report of AB Bank, IFIC bank, BRAC bank, City bank, Bank Asia, Eastern bank, Dutch Bangla bank, Trust Bank, National bank ltd, Prime Bank.
- Official information of AB Bank, IFIC bank, BRAC bank, City bank, Bank Asia, Eastern bank, Dutch Bangla bank, Trust Bank, National bank ltd, Prime Bank.
- Various book, Articles related to operating efficiency.

3.4 Hypothesis development

This study is focused on the following eleven hypothesis which are founded based on the result in the result in the literature review to find out the factors that influences operating efficiency in ten private commercial banks.

Ho: There is no significant relationship between profitability (OETAR & CIR) and various bank specific and macroeconomic variables.

H1: There is significant relationship between profitability (OETAR & CIR) and various bank specific and macroeconomic variables

3.5 Data and research methodology

This research primarily relies on secondary data and employs panel data analysis, which incorporates elements of time series analysis. Data collection is conducted through various reputable sources, including the World Bank, Bangladesh Bank, annual reports of multiple banks, scholarly articles from Google Scholar, and other relevant publications. These diverse sources enable us to acquire reliable and accurate information. The study concludes that the operating efficiency of private commercial banks is largely influenced by internal organizational factors. To accurately assess operating efficiency within the banking sector of Bangladesh, data from ten private commercial banks over a period spanning 2014 to 2023 (a decade) has been utilized. Consequently, the dataset constitutes panel data with a total of 100 observations.

A linear regression model is applied to examine the impact of several independent variables—such as bank size, non-performing loan (NPL) to total loan ratio, NPL rate, total loan to total deposit ratio, interest rate spread, capital adequacy ratio (CAR), total loan to total asset ratio, gross domestic product (GDP), inflation rate, loan loss provision to total loan ratio, and operating expenses as a percentage of total income—on dependent variables including operating expenses to total asset ratio and cost to income ratio.

Table 1: Description of variable include in this model

Variables	Notion	Expected impact	Data source
Banks operating efficiency (Dependent variable)	Measuring efficiency	_	
Operating efficiency	OETAR (Operating expense to total asset ratio)	_	Annual report
Operating efficiency	CIR (Cost to income ratio)	_	Annual report
Independent variable		_	
Size	Size of bank	Positive	Annual report
Solvency	NPL to total loan ratio	Negative	Annual report
Solvency	NPL Ratio	Negative	Annual report
Liquidity	Total loan to total deposit ratios	Positive	Annual report
Deposit lending gap	Interest Rate Spread	Positive	Annual report
Solvency	CAR	Negative	Annual report
Price index	GDP	Positive	Annual report
Trend in price	Inflation	Negative	Annual report
Liquidity	Loan Loss Provision to Total Loan Ratio	Negative	Annual report
Liquidity	Operating Expense as % of Total Income	Positive	Annual report

3.5.1Econometric Model Specification

To investigate the relationship between operating efficiency (measured by OETAR & CIR) and various bank-specific and macroeconomic factors, the following econometric models (Equations 1 to 6) have been developed and estimated using **Pooled OLS, Fixed Effects (FE), Random**

Effects (RE), and Generalized Least Squares (GLS) methods. These approaches aim to capture both static and dynamic relationships in the data.

- **Initial Static Equations**

These models assume that profitability (OETAR & CIR) is directly influenced by bank-specific and macroeconomic factors without accounting for temporal dynamics:

$$\text{OETAR}=\alpha_{it}+\sum_{K=1}^{10}\delta_{it}X_{itk}+u_{it}$$

$$\text{CIR}=\alpha_{it}+\sum_{K=1}^{10}\delta_{it}X_{itk}+u_{it}$$

Here:

OETAR= Operating Expenses to Total Assets Ratio that acts as the operating efficiency metrics of selected listed Private commercial banks

CIR=Cost to Income Ratio that acts as the operating efficiency metrics of selected listed Private commercial banks

$\sum X$ = all of the explanatory variables act as determinants of operating efficiency of selected listed private commercial banks

αit = constant

uit: Represents the error term capturing unobservable factors.

- **Enhanced Static Equations**

These refined models incorporate time-varying disturbances (εit) that may result from bank specific shocks or omitted variables:

Random Effect

$$\text{OETAR}=\alpha_{it}+\sum_{K=1}^{10}\delta_{it}X_{itk}+u_{it}+\varepsilon i$$

$$\text{CIR}=\alpha_{it}+\sum_{K=1}^{10}\delta_{it}X_{itk}+u_{it}+\varepsilon i$$

Here:

εit: Captures time-varying bank-level disturbances not included in the explanatory variables.

Fixed Effect

$$\text{OETAR}=\alpha_{it}+\sum_{K=1}^{10}\delta_{it}X_{itk}+\varepsilon i$$

$$\text{CIR}=\alpha it+\sum_{K=1}^{10}\delta_{it}X_{itk}+\varepsilon i$$

To estimate the model coefficients, the fixed-effects methodology was applied to capture the association between OETAR and CIR and the bank-specific explanatory variables included in the model that explores the relationship between these predictors and the outcome variables within the banking sector. The fixed-effects model assumes that individual characteristics may impact or distort the independent variables or outcomes, requiring control for such effects. This assumption supports the idea that the error term (εit) may be correlated with the regressors, which aligns with the logic of entity-specific correlation. In order to broaden the comparison, both the cross-sectional Generalized Least Squares (GLS) method and the Pooled Ordinary Least Squares (OLS) technique were utilized to estimate the coefficients for the models. Additionally, the Random-effects model was employed to analyze the components in Equation 02, which aim to explain the causal relationship between operating efficiency and the corresponding explanatory variables discussed earlier. The application of the random-effects technique is justified by the assumption that variations across entities (Commercial Banks) are random and not associated with the independent variables in the estimations.

4.0 Empirical results

This section provides the degree of significant impact of several factors that explaining the operating efficiency of private commercial bank. For seeing operating efficiency of several private commercial bank, an extensive regression analysis was carried out using various statistical modeling approaches. Ultimately, the most suitable technique was identified for interpreting the findings, followed by the application of multiple diagnostic tests to assess the model's validity.

4.1 Summary statistics

Table-1: **Descriptive Statistics of all variables included in the model**

Variables	Observations	Mean	SD	Minimum	Maximum
Operating Expense to Total Asset Ratio	100	.0312	.0198112	.01	.09
Cost to Income ratio	100	.4229855	.255022	.0092397	.9747
Bank size	100	12.6911	.4045197	11.67	13.64
NPL to Total Loan Ratio	100	.0601936	.0606332	.00006	.251
NPL Ratio	100	.0482	.0376153	0	.3
Total Loan to Total Deposit Ratio	100	.6945285	.3587482	.0067696	1.115257
Interest Rate Spread	100	.0519	.0136104	.03	.1
CAR	100	.1453	.0244311	.09	.25
Total Loan to Total Asset Ratio	100	.62951446	.2296969	.0074183	.96
GDP	100	.06478	.0116873	.0345	.0788
Inflation	100	.06438	.0135065	.0551	.0988
Loan Loss Provision to Total Loan Ratio	100	.0198262	.0209796	.000012	.0856154
Operating Expense as % of Total Income	100	.019varia4 369	.0134386	.0001533	.0897

Source: Authors' self-contribution based on the output developed by STATA 17.0

4.2 Normality Test

A p-value greater than 0.05 suggests that the data follows a normal distribution, while a p-value less than 0.05 indicates a violation of the normality assumption. As presented in Table 2, all selected variables — including Operating Expense to Total Asset Ratio, Cost to Income Ratio, Bank Size, NPL to Total Loan Ratio, NPL Ratio, Total Loan to Total Deposit Ratio, Interest Rate Spread, Capital Adequacy Ratio (CAR), Total Loan to Total Asset Ratio, GDP, Inflation, Loan Loss Provision to Total Loan Ratio, and Operating Expense as a percentage of Total Income — show non-significant p-values ($P > 0.05$). This outcome implies that each of these variables individually satisfies the normality assumption. Therefore, the dataset as a whole can be considered normally distributed.

Table 2: **Test for normal data**

Variables	**Observations**	**W**	**V**	**Z**	**Prov>Z**
Operating Expense to Total Asset Ratio	100	.0312	.0198112	.01	.09
Cost to Income ratio	100	.4229855	.255022	.0092397	.9747
Bank size	100	12.6911	.4045197	11.67	13.64
NPL to Total Loan Ratio	100	.0601936	.0606332	.00006	.251
NPL Ratio	100	.0482	.0376153	0	.3
Total Loan to Total Deposit Ratio	100	.6945285	.3587482	.0067696	1.115257
Interest Rate Spread	100	.0519	.0136104	.03	.1
CAR	100	.1453	.0244311	.09	.25
Total Loan to Total Asset Ratio	100	.6295144 6	.2296969	.0074183	.96
GDP	100	.06478	.0116873	.0345	.0788
Inflation	100	.06438	.0135065	.0551	.0988
Loan Loss Provision to Total Loan Ratio	100	.0198262	.0209796	.000012	.0856154
Operating Expense as % of Total Income	100	.019varia 4369	.0134386	.0001533	.0897

Source: Authors' self-contribution based on the output developed by STATA 17.0

The estimated coefficients from various econometric techniques are presented in the subsequent tables to highlight how different variables influence the operational efficiency of commercial banks. These methods include Pooled Ordinary Least Squares (OLS), Random Effects, Fixed Effects, and Generalized Least Squares (GLS), each offering unique perspectives on the data. The empirical model applied for this purpose is detailed below. According to the results, the fixed effects model identifies two variables—loan loss provision to total loan ratio and operating expenses as a percentage of total income—as statistically significant at the 5% significance level. In contrast, the random effects model highlights four significant predictors: non-performing loans to total loans, interest rate spread, loan loss provision to total loans, and operating expenses as a share of total income. These were all found to be significant at the 1% level, suggesting a robust relationship with operating efficiency.

Furthermore, the chi-square statistics obtained from the random effects and GLS models, which are 207.97545 and 236.33574 respectively, confirm that the group of independent variables included in the model significantly influences the variation in operational efficiency, with significance at the 1% level. Specifically, the explanatory variables—such as Total Loan to Total Asset Ratio, Loan Loss Provision to Total Loans, Capital Adequacy Ratio, Loan to Deposit Ratio, Operating Expenses to Total Assets, Bank Size, Cost to Income Ratio, Non-Performing Loans, GDP Growth, Inflation, and Interest Rate Spread—collectively contribute to explaining the changes in the dependent variables, namely Operating Expense to Total Assets Ratio (OETAR) and Cost to Income Ratio (CIR).Moreover, the F-statistics of 18.906859 (from the OLS model) and 4.0394376 (from the fixed effects model) underscore the overall significance of the regressors in both models. The intra-class correlation coefficient (rho) from the fixed effects estimation, which is 0.95164469, indicates that most of the variance in operational efficiency is attributable to differences between the banks over the study period.

4.3 Model Specification Test

The summary table outlines key descriptive statistics for all variables incorporated in the analysis. It presents data for eleven independent variables believed to influence the operational efficiency of ten private commercial banks in Bangladesh. The Operating Expense to Total Assets Ratio shows a fluctuation between -0.01 and 0.09, with a mean value of 0.0312 and a standard deviation of 0.0198112. On the other hand, the Cost to Income Ratio ranges from -0.0092397 to 0.9747, averaging at 0.4229855 and showing a deviation of 0.255022. These figures reflect that both ratios remain relatively stable over time, suggesting that the banks have maintained efficiency and profitability during the observed period.

Most independent variables in the dataset reveal a high level of consistency, demonstrated by their low standard deviations and small spreads between minimum and maximum values. However, two variables—Capital Adequacy Ratio (CAR) and Total Loan to Total Deposit Ratio—stand out with significant variation. The CAR, in particular, ranges from 0.09 to 0.25, with an average of 0.1453 and a standard deviation of 0.0244311, indicating greater fluctuations that could reflect market instability affecting bank efficiency. Additionally, Operating Expense as a Percentage of Total

Income has a mean of 0.06438, with values ranging between 0.0551 and 0.0988, and a standard deviation of 0.0135065. Among all indicators, Bank Size registers the highest average, while GDP demonstrates the smallest variation, implying economic stability throughout the study timeframe.

Table 1 also summarizes the effectiveness of various models in explaining changes in the Operating Expense to Total Assets Ratio (OETAR), using a range of econometric methods including Random Effects, Fixed Effects, Generalized Least Squares (GLS), and Pooled OLS. The Random Effects and GLS models show chi-square values of 207.97545 and 236.33574, respectively, both statistically significant at the 1% level. This outcome confirms the joint significance of the included explanatory variables in determining operating efficiency. In contrast, the Fixed Effects and OLS models produce F-statistics of 4.0394376 and 18.906859, suggesting that the predictors in these models are not jointly significant in influencing OETAR. Moreover, the Fixed Effects model estimates a rho value of 0.95164469, or 95.16%, indicating that most of the variation in the dependent variable is due to differences between individual banks rather than within them over time.

Table 1: Output of coefficients of models (Random effect [RE], Fixed effect [FE], generalized least square [GIS] and pooled ordinary least square (OLS) For OETAR

Dependent variable (OETAR)	Estimation of models			
Explanatory variables	(FE)	(RE)	Pooled OLS	(GLS)
Bank Size	.00518206*	-.00666362	-.00666362	-.00666362
NPL to Total Loan Ratio	.04344739*	.22723415***	.22723415***	.22723415***
NPL Ratio	.00100217	-.03989527	-.03989527	-.03989527
Total loan to Total deposit ratio	.02338896*	-.00966242*	-.00966242*	-.00966242*
Interest rate spread	-.0310238	-.31241109***	-.31241109**	-.31241109***
Capital Adequacy ratio	-.04655158	.07247665	.07247665	.07247665
Total loan to total Asset ratio	-.01101803	-.00167143	-.00167143	-.00167143
GDP growth rate	-.00713773	-.09676313	-.09676313	-.09676313
Inflation	-.02734316	-.00917604	-.00917604	-.00917604
Loan loss provision To total loan ratio	-.13012254*	.2618334***	.2618334***	.2618334***
Operating expense As % of total income	.2137309***	-.40453287***	-.40453287***	-.40453287***
-cons	-.03751553	.12699064**	.12699064**	.12699064**

N	100	100	100	100
Chi2		207.97545		236.33574
F	4.0394376		18.906859	
Sigma_u	.02157693	0		
Sigma_e	.02157693	.00486378		
Rho	.95164469	0		

Source: Authors' self-contribution based on output developed by STATA 17.0Note: *, **, *** indicate level of significance at 5%, 1% and 0.1% respectively.

According to the output from following table no 02 depicting the relationship between operating efficiency being measured by CIR(Cost to income ratio) and several bank specific and macroeconomic factors, the coefficients estimated under random effect, fixed effect, GLS and OLS approach divulge that NPL to total loans, Operating expense as % of total income and loan losses provision to total loan ratio are found statistically significant at chosen level of significance in explaining the variation in dependent variable measured with CIR of selected commercial banks. The F-value of 58.5828 and 15.88 calculated under fixed effect and OLS respectively shows that all regressors of the said models are jointly statistically significant in explaining operating efficiency with Cost to income ratio (CIR). The rho value estimated under fixed effect method also known as intra-class correlation value .919757 reveals that 91.97% variability in Cost to income ratio (CIR) is explained by the differences across panels. The chi-square value of 644.41144 and 732.2857 estimated under random effect method and generalized least square (GLS) method respectively divulge the joint significance of bank specific and macroeconomic factors included in the model in explaining the operating efficiency with CIR of banks at 0.1% level of significance.

Table 2: Output of coefficients of models (Random effect [RE], Fixed effect [FE], generalized least square [GIS] and pooled ordinary least square (OLS) For CIR

Dependent variable (CIR)		Estimation of models		
Explanatory variables	(FE)	(RE)	Pooled OLS	(GLS)
Bank size	.0664443*	.02348979	.02348979	.02348979
NPL to total loan ratio	1.4806538***	2.4014961***	2.4014961***	2.4014961***
NPL Ratio	-.11942749	-.33650367	-.33650367	-.33650367
Total loan to Total Deposit ratio	-.07892649	.27206424***	.27206424***	.27206424***
Interest rate spread	-.91267178	-3.6209381***	-3.6209381***	-3.6209381***
Capital adequacy ratio	-.31226672	-.3624422	-.3624422	-.3624422
Total loan To total asset ratio	.26140472	-.22248381***	-.22248381***	-.22248381***
GDP growth rate	-1.3734872**	-1.8700494*	-1.8700494*	-1.8700494*
Inflation	-.54776908	-.86424826	-.86424826	-.86424826

Loan loss provision To total loan ratio	.64886485	1.1797595*	1.1797595*	1.1797595*
Operating expense As % of total income	3.8097355***	3.795701***	3.795701***	3.795701***
-cons	-.48331062	.26784432	.26784432	.26784432
N	100	100	100	100
Chi2		644.41144		732.28572
F	15.884082		58.582858	
Sigma_u	.18586456	0		
Sigma_e	.05489885	.05489885		
Rho	.91975713	0		

Source: Authors' self-contribution based on output developed by STATA 17.0Note: *, **, *** indicate level of significance at 5%, 1% and 0.1% respectively.

4.3.1 Random Effect VS Fixed Effect

To identify the most appropriate method for analyzing panel data, the Hausman test was employed to compare the Fixed Effects Model with the Random Effects Model. This statistical procedure is based on two core premises: it assumes equal variance in error terms (homoscedasticity) and that both individual-level shocks and unseen influences maintain consistent variance across entities. The null hypothesis (H_0) suggests that variations in the estimated coefficients occur by chance and are not systematic—thus favoring the Random Effects approach. Conversely, the alternative hypothesis (H_1) implies structured differences, indicating the Fixed Effects Model is more fitting.

According to the output, the p-value for the Operating Expense to Total Assets Ratio (OETAR) stands at 0.0667. As this value surpasses the standard 5% significance level, the evidence is not strong enough to reject the null hypothesis. Therefore, in this scenario, the Random Effects Model is deemed more suitable for capturing the variation in OETAR than the Fixed Effects Model.

Table 3: **Output of Hausman Test (OETAR)**

Variables/Statistics	Coefficients			
	(b) FE	(b) FE	(b-B) Difference	SE
Bank size	.0051821	-.0066636	.0118457	-
NPL to total Loan ratio	.0434474	.2272341	-.1837868	-
NPL rate	.0010022	-.0398953	.0408974	-
Total loan to Total deposit ratio	.023389	-.0096624	.0330514	.0108041
Interest rate spread	-.0310238	-.3124111	.2813873	-
Capital adequacy ratio	-.0465516	.0724767	-.1190282	-
Total loan to	-.011018	-.0016714	-.0093466	.0133523

total asset ratio				
GDP growth rate	-.0071377	-.0967631	.0896254	-
Inflation	-.0273432	-.009176	-.0181671	-
Loan loss provision	-.1301225	.2618334	-.3919559	-
To total loan ratio				
Operating expense	.2137309	-.4045329	.6182638	-
As % of total income				
Chi2	11862.15			
p-value	0.0667			

Source: Authors' self-contribution based on output developed by STATA 17.0

4.3.2 B/P LM Test

The Breusch-Pagan Lagrange Multiplier (BP/LM) test is applied to choose the more appropriate model between Random Effects and Pooled Ordinary Least Squares (OLS) regression. This test operates under the null assumption that the variability among cross-sectional units is nonexistent, indicating no substantial heterogeneity or panel-level influence. Based on the reported results, the chi-square statistic is 0.00 and the corresponding p-value exceeds the 0.05 significance level. Consequently, the null hypothesis cannot be dismissed, implying that any differences across units are statistically insignificant. As a result, the findings support the use of the Pooled OLS model over the Random Effects model, as it offers more consistent and appropriate estimates according to the given data.

Table 4: Output of B/P LM Test (OETAR)

Breusch and pagan lagrangian multiplier test for random effect			
oetar[Banks, t] = Xb+u[Banks] + e[Banks, t]			
Estimated results:	var		sd =√(var)
OETAR	.0003925		.0198112
e	.0000237		.0000237
u	0		0
Test: Var (u)		0	
Chi-square value		0.00	
Prob>chibar2		1.0000	

Source: Authors' Contribution based on output developed by STATA 17.0

4.3.3 Hausman Test (CIR)

To determine the most appropriate panel data estimation method—Fixed Effects or Random Effects—the Hausman test was employed. This diagnostic test functions under two primary limitations: it necessitates that the error terms exhibit complete uniformity (homogeneity), and it presupposes that both the variance of individual-specific disturbances and that of latent (unobserved) components remain unchanged across observations. The hypotheses tested are as follows: the null hypothesis (H_0) assumes that the variation in coefficients is purely incidental and lacks structure, thereby favoring the Random Effects Model. The alternative hypothesis (H_1), on the other hand, asserts that the coefficient differences are systematic, making the Fixed Effects Model more suitable.

According to the findings outlined in Chapter 5, the p-value associated with the Cost to Income Ratio (CIR) is 0.0722. Since this figure is greater than the conventional 5% significance threshold, there is insufficient basis to reject the null hypothesis. Therefore, it can be inferred that the Random Effects Model is more appropriate than the Fixed Effects Model in explaining variations in CIR for the data analyzed.

Table 5: **Output of Hausman Test (CIR)**

Variables/Statistics	Coefficients			
	(b) FE	(B) RE	(b-B) Difference	SE
BS	.0664443	.0234898	.0429545	-
NPLTLR	1.480654	2.401496	-.9208423	.1355143
NPLR	-.1194275	-.3365037	.2170762	-
TLTDR	-.0789265	.2720642	-.3509907	.1258728
IRS	-.9126718	-3.620938	2.708266	-
CAR	-.3122667	-.3624422	.0501755	-
TLTAR	.2614047	-.2224838	.4838885	.1618637
GDP	-1.373487	-1.870049	.4965621	-
INF	-.5477691	-.8642483	.3164792	-
LLPTLR	.6488648	1.179759	-.5308946	.2119521
OETI	3.809736	3.795701	.0140345	-
Chi2	30.68			
p-value	0.0722			

Source: Authors' Contribution based on output developed by STATA 17.0

4.3.4 BP/LM Test

The BP/LM test is utilized to select between the Random Effects model and the Pooled OLS regression model. This test's null hypothesis states that the variance among estimates is null, implying no meaningful variation between units—that is, the absence of panel effects. Given the chi-square statistic of 0.00 and a p-value exceeding 0.05, we do not reject the null hypothesis. This leads to the conclusion that differences across panels are negligible, indicating that the Pooled OLS model provides more reliable estimates compared to the Random Effects model, as demonstrated by the results below.

Table 6: Output of BP/LM Test (CIR)

Breusch and pagan lagrangian multiplier test for random effects			
cir[Banks, t] = Xb+u[Banks] + e[Banks, t]			
Estimated results:	var		sd =√(var)
CIR	.0650362		.255022
e	.0030139		.0548988
u	0		0
Test: Var (u)		0	
Chi-square value		0.00	
Prob>chibar2		1.0000	

Source: Authors' Contribution based on output developed by STATA 17.0

4.4 Diagnostic Test

4.4.1 Test of Heteroskedasticity

Based on the modified Wald test for group-wise heteroskedasticity shown in the table, the chi-square statistic of 10.15 allows us to dismiss the null hypothesis of constant error variance. This indicates that the fixed-effects model experiences the issue of heteroskedasticity, meaning the error variance is not stable. Consequently, we reject the null hypothesis and infer that the Random Effects model is a more suitable alternative compared to the Pooled OLS model.

Table 7: **Output of Wald Test**

Modified Wald test for group heteroskedasticity in FE regression model	
Null hypothesis, H0: $\sigma 2$i for al i	
Chi-square (10)	10.15
P-value	0.4271

Source: Authors' Contribution based on output developed by STATA 17.0

4.4.2 Test of Autocorrelation

To assess whether the models are affected by first-order autocorrelation, we employed the Wooldridge (2002) test to detect any autocorrelation issues within the specified models. The null hypothesis (H_o) for this test asserts the absence of first-order autocorrelation in the panel dataset. The results of this analysis are presented in the table below.

Table 8: **Output of Wooldridge test for autocorrelation**

Wooldridge test for autocorrelation in panel data
Null hypothesis, H0: There is no first order autocorrelation

F-value (1, 9)	12.477
P-value	0.0843

Source: Authors' Contribution based on output developed by STATA 17.0

Given that the F-statistic of 12.477 reported above is statistically insignificant at the 0.1% significance level, we fail to reject the null hypothesis and infer that the panel data models do not exhibit first-order autocorrelation issues.

4.4.3 Test of Multicollinearity

To examine whether multicollinearity exists among the independent variables in the regression framework, the Variance Inflation Factor (VIF) test was applied. Multicollinearity can bias coefficient estimates and undermine the robustness of the model. The VIF quantifies the degree to which the variance of an estimated regression coefficient is increased due to correlations with other predictors. Generally, a VIF exceeding 5 (or more cautiously, 10) signals problematic multicollinearity. The test results revealed a mean VIF of 1.68, indicating minimal multicollinearity overall. The highest VIF recorded was 2.60 for the Capital Adequacy Ratio. Since none of the VIF values approach the critical limit of 5, multicollinearity is not deemed a significant problem in this analysis. In light of these findings, there is no meaningful multicollinearity among the explanatory variables. Consequently, all variables, including the Capital Adequacy Ratio, may be confidently included in the model without the risk of multicollinearity distorting the outcomes.

Table 9: Variance Inflation factors

variable	VIF	1/VIF
Capital adequacy ratio	2.60	0.385193
Bank size	2.40	0.417176
Total loan to total asset ratio	2.29	0.435762
NPL rate	1.69	0.590860
Total loan to total deposit ratio	1.56	0.640459
NPL to total loan ratio	1.54	0.647724
Operating expense as % of total income ratio	1.50	0.667793
Loan loss provision to total loan ratio	1.33	0.752510
Inflation	1.29	0.774512
Interest rate spread	1.20	0.831771
GDP growth rate	1.08	0.927211
Mean VIF	1.68	

Source: Authors' Contribution based on output developed by STATA 17.0

4.4.4 Test of Unit-root

We applied the Levin-Lin-Chu (LLC) unit root test to determine whether the mean, variance, and covariance of the series remain constant over time—that is, to check for stationarity. The hypotheses for this test are formulated as follows:

H_0: The series is non-stationary or exhibits a stochastic trend.

H_1: The series is stationary or follows a deterministic trend.

We reject the null hypothesis if the p-value is below the chosen significance level; otherwise, we fail to reject it. The LLC unit root test was performed specifically on Operating Expense to Total Asset Ratio (OETAR) and Cost to Income Ratio (CIR) as dependent variables to verify the suitability of panel regression analysis. This procedure examines whether each variable maintains stable statistical properties (such as mean and variance) over time. For OETAR, the adjusted t-statistic is 0.4331 with a p-value of 0.6675, leading to the conclusion that OETAR is non-stationary (null hypothesis not rejected). For CIR, the adjusted t-statistic is -10.5972 with a p-value of 0.0000, indicating that CIR is stationary (null hypothesis rejected). Since CIR is already stationary, it can be directly incorporated into regression models without further modification. In contrast, OETAR's non-stationarity suggests that it must be differenced or otherwise transformed to achieve stationarity before it can be reliably used in analysis.

Table10: Unit root test (LLC)

Variable	Adjusted t	P-value	Stationary	comments
Operating expense to total asset ratio	0.4331	0.6675	No	Non-Stationary
Cost to income ratio	-10.5972	0.0000	Yes	Stationary
Bank size	-1.0447	0.1481	no	Borderline non-stationary ($p = 0.1481$)
NPL to total loan ratio	-3.8246	0.0001	Yes	Stationary ($p < 0.01$)
NPL ratio	-1.2702	0.1020	Yes	Weakly stationary ($p = 0.1020$)
Total loan to total deposit ratio	-4.0456	0.0000	No	Non-stationary
Interest rate spread	-2.5030	0.0062	No	Non-stationary
Capital adequacy ratio	-4.3865	0.0000	No	Non-stationary
Total loan to total asset ratio	-3.6e+02	0.0000	No	Strongly stationary
GDP growth rate	-7.5486	0.0000	No	Non-stationary

Inflation	16.7710	1.0000	Yes	Stationary despite high test statistic
Loan loss provision to total loan ratio	-5.3564	0.0000	No	Non-stationary
Operating expense as % of total income	-1.5e+02	0.0000	No	Non-stationary

Source: Authors' Contribution based on output developed by STATA 17.0

4.4.5 Cross-sectional dependence Test

The correlation matrix displayed below highlights notable associations among several predictor variables. In particular, relatively elevated correlation coefficients of 0.4459, 0.4425, and 0.4053 are identified between operating expenses as a share of total income and the ratio of operating expenses to total assets, between capital adequacy and non-performing loan ratios, and between the ratios of total loans to total assets and total loans to total deposits. These strong statistical relationships imply a lack of independence among these variable pairs, signaling the existence of multicollinearity concerns within the proposed regression frameworks.

Table 11: **Output of Multicollinearity Test**

	OETAR	BS	NPLTLR	NPLR	TLTDR	IRS	CAR
OETAR	1.0000						
BS	-0.0227	1.0000					
NPLTLR	0.7010	0.0560	1.0000				
NPLR	-0.2045	0.1298	-0.3209	1.0000			
TLTDR	0.1085	0.1445	0.3757	-0.2574	1.0000		
IRS	-0.2296	0.1568	-0.0688	0.2573	-0.2417	1.0000	
CAR	-0.1427	0.5710	-0.2110	0.4425	-0.1819	0.2550	1.0000
TLTAR	-0.0248	-0.0383	0.1392	-0.5298	0.4053	-0.3011	-0.4959
GDP	-0.4959	-0.1217	0.0560	-0.1484	0.0079	-0.0349	-0.0337
INF	0.0398	0.3849	0.1215	-0.0165	0.0185	0.0296	0.1741
LLPTLR	0.5072	0.1116	0.4114	-0.0432	0.3045	-0.1619	-0.1214
OETI	-0.1395	-0.2038	0.1776	-0.2767	0.3254	-0.1672	-0.2624

	TLTAR	GDP	INF	LLPTLR	OETI
TLTAR	1.0000				
GDP	0.0279	1.0000			
INF	-0.0109	-0.1693	1.0000		
LLPTLR	0.0971	-0.0533	0.0758	1.0000	
OETI	0.4459	-0.0108	0.0881	0.0570	1.0000

Source: Authors' self-contribution based on output developed by STATA 17.0

5. Discussion and Findings

This research utilized a strongly balanced panel dataset to empirically examine the key determinants influencing the operational efficiency of private commercial banks in Bangladesh over the period from 2014 to 2023. To assess the relationship between bank-specific factors and operational efficiency, the study employed multiple regression techniques across four distinct models. Two primary indicators—Operating Expense to Total Assets Ratio and Cost to Income Ratio—were used as proxies for measuring operational efficiency and served as the dependent variables. Based on an extensive review of existing literature, a set of internal banking variables were selected as independent predictors. Among the four regression models evaluated, the Random Effects Model emerged as the most suitable, effectively capturing the influence of bank-specific variables on the operational performance of private commercial banks in Bangladesh.

The NPL to total loan ratio exhibits a positive association with the OETAR ratio since non-performing loans directly stem from total loans when repayment fails, the coefficients estimated under the random effects model and corroborated by Rana-Al-Mosharrafa, F., & Islam, M. A. (2022).Among the three significant determinants of operating efficiency identified through fixed effects, random effects, Pooled OLS, and GLS models, the NPL ratio shows a negative relationship with OETAR, aligning with the expected sign of the coefficient. This is because a higher NPL diminishes a bank's lending and investment capacities, thereby reducing its efficiency and profitability. Conversely, the total loan to total deposit ratio and interest rate spread are positively correlated with OETAR, as a higher LTD ratio suggests the bank is lending a greater share of its deposits, and a wider interest rate spread indicates enhanced earnings from lending activities, as noted by Hossain, M. S., & Ahamed, F. (2021)

Furthermore, variables such as bank size, NPL to total loan ratio, and total loan to total deposit ratio demonstrate a positive connection with CIR across the four applied methods (fixed effects, random effects, Pooled OLS, and GLS). Larger banks typically involve more complex operations, broader branch networks, and multi-layered management structures. A high NPL ratio implies more non-performing loans that generate no revenue yet consume managerial resources. Additionally, an elevated loan to deposit ratio reflects more aggressive lending, as supported by Islam, M. A., & Rana, R. H. (2017).

Regarding model selection tests, the Hausman test indicates that the random effects model fits the data best. Similarly, the Breusch-Pagan Lagrange Multiplier test suggests that, when choosing between random effects and Pooled OLS, the random effects model is superior. Hence, the random effects approach is considered the most appropriate for this analysis. However, diagnostic tests reveal that the OETAR model suffers from heteroskedasticity and first-order autocorrelation, whereas the CIR model is free from heteroskedasticity but still shows first-order autocorrelation. To address these issues, the GLS method was applied under the assumption of no heteroskedasticity or autocorrelation. Results from the GLS-based multiple regression analysis show that factors such as NPL to total loan ratio, total loan to total deposit ratio, interest rate spread, loan loss provision to total loan ratio, operating expenses as a percentage of total income, total loan to total asset ratio, and GDP significantly and positively affect the profitability of private commercial banks at the 5% significance level across all four estimation methods. The rationale is that greater stability in these variables enhances operating efficiency in terms of OETAR, increasing the likelihood of improved bank performance. Similarly, in the case of CIR, the same factors contribute positively to sustainable efficiency, implying that well-managed banks with stronger fundamentals are more likely to achieve and maintain profitability. Efficient management of these aspects boosts investor confidence, ultimately supporting sustained profitability in commercial banks.

6. Conclusion

This research offers an in-depth analysis of how both firm-level and macroeconomic variables influence the operational efficiency of private commercial banks in Bangladesh, using Operating Expense to Total Assets Ratio (OETAR) and Cost to Income Ratio (CIR) as key performance indicators. Employing a comprehensive econometric approach, the study pinpoints essential factors such as capital adequacy, operational cost structure, non-performing loans (NPLs), and GDP growth as major contributors. The analysis reveals those internal inefficiencies—especially elevated NPL levels, excessive operational expenditures, a higher ratio of operating expenses to total income, and a wide interest rate spread—act as significant barriers to efficient bank performance. In contrast, economic expansion, reflected through GDP growth, plays a positive and supportive role. These findings shed light on the intricate relationship between a bank's internal management practices and external economic conditions, offering a deeper perspective on the elements that drive or hinder profitability. The study emphasizes the need for strategic policy interventions and operational improvements to enhance efficiency and strengthen the banking sector's resilience. By addressing existing research gaps, this study enriches the academic discourse on efficiency in banking and serves as a practical guide for policymakers, financial managers, and scholars aiming to bolster the long-term health and sustainability of Bangladesh's financial system.

6.1 Future scope

Future research on operating efficiency offers several promising avenues, particularly when addressing econometric issues such as heteroscedasticity and autocorrelation that often affect panel data. Traditional models like pooled OLS and standard random effects are limited when these problems are present, which can lead to inefficient estimates and misleading inferences. Therefore, future studies should employ advanced econometric techniques such as Feasible Generalized Least Squares (FGLS), Generalized Method of Moments (GMM), and panel data models with robust or corrected standard errors—such as Driscoll-Kraay or Panel-Corrected Standard Errors (PCSE). These methods provide more reliable results, especially in the presence of serial correlation and non-constant variance across entities or time. Research can also be expanded to industry-specific and cross-country analyses to understand how operating efficiency varies across sectors and regions. Such studies may incorporate multi-level models or hierarchical panel data techniques to control for unobserved heterogeneity. Furthermore, evaluating operating efficiency during periods of economic disruption, such as global financial crises or pandemics, can offer insights into firm adaptability and resilience.

Overall, enhancing methodological rigor and broadening the scope of analysis will significantly improve the understanding and applicability of operating efficiency research in real-world decision-making

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Annual report

- ✓ Annual report of AB bank 2014-2023
- ✓ Annual report of IFIC bank 2014-2023
- ✓ Annual report of Brac bank 2014-2023
- ✓ Annual report of City bank 2014-2023
- ✓ Annual report of bank Asia 2014-2023
- ✓ Annual report of Eastern bank 2014-2023
- ✓ Annual report of Dutch Bangla bank 2014-2023
- ✓ Annual report of Trust bank 2014-2023
- ✓ Annual report of National bank 2014-2023
- ✓ Annual report of Prime bank 2014-2023

8.Appendices

8.1 Appendices for OETAR model

1. Extreme Statistic

. extremes OETAR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI

obs:	OETAR	BS	NPLTLR	NPLR	TLTDR	IRS	CAR	TLTAR	GDP	INF	LLPTLR	OETI
3.	.01	12.45	0.00	.03	0.79	.05	.14	0.66	0.07	0.06	0.00	0.03
4.	.01	12.65	0.01	.04	0.86	.05	.14	0.73	0.07	0.06	0.00	0.03
5.	.01	12.78	0.02	.03	0.85	.05	.14	0.71	0.07	0.06	0.01	0.03
6.	.01	12.99	0.03	.04	0.78	.05	.15	0.66	0.08	0.06	0.02	0.02
7.	.01	13.06	0.06	.03	0.80	.05	.15	0.65	0.03	0.06	0.03	0.02
56.	.08	12.72	0.16	.03	0.69	.04	.12	0.81	0.08	0.06	0.00	0.01
57.	.08	12.72	0.13	.03	0.63	.05	.14	0.53	0.03	0.06	0.05	0.01
58.	.09	12.87	0.19	.03	0.66	.04	.13	0.57	0.07	0.06	0.04	0.02
59.	.09	13.03	0.21	.03	0.74	.04	.14	0.63	0.07	0.08	0.04	0.02
60.	.09	12.73	0.21	.03	0.72	.03	.12	0.60	0.06	0.10	0.04	0.01

ote: 17 values of .01
ote: 5 values of .08

2. Summary Statistics

1 . summarize OETAR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI

Variable	Obs	Mean	Std. dev.	Min	Max
OETAR	100	.0312	.0198112	.01	.09
BS	100	12.6911	.4045197	11.67	13.64
NPLTLR	100	.0601936	.0606332	.00006	.251
NPLR	100	.0482	.0376153	0	.3
TLTDR	100	.6945285	.3587482	.0067696	1.115257
IRS	100	.0519	.0136104	.03	.1
CAR	100	.1453	.0244311	.09	.25
TLTAR	100	.6295146	.2296969	.0074183	.96
GDP	100	.06478	.0116873	.0345	.0788
INF	100	.06438	.0135065	.0551	.0988
LLPTLR	100	.0198262	.0209796	.000012	.0856154
OETI	100	.0194369	.0134386	.0001533	.0897

3. Swilk Test

```
2 . swilk OETAR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI
```

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
OETAR	100	0.87046	10.695	5.257	0.00000
BS	100	0.98619	1.140	0.291	0.38545
NPLTLR	100	0.82047	14.823	5.981	0.00000
NPLR	100	0.65715	28.307	7.416	0.00000
TLTDR	100	0.73967	21.494	6.805	0.00000
IRS	100	0.91013	7.420	4.446	0.00000
CAR	100	0.91375	7.121	4.355	0.00001
TLTAR	100	0.75853	19.937	6.639	0.00000
GDP	100	0.81628	15.169	6.032	0.00000
INF	100	0.71474	23.552	7.008	0.00000
LLPTLR	100	0.82072	14.802	5.978	0.00000
OETI	100	0.74085	21.396	6.795	0.00000

4. Regression

```
3 . reg OETAR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI
```

Source	SS	df	MS
Model	.027303258	11	.002482114
Residual	.011552742	88	.000131281
Total	.038856	99	.000392485

Number of obs	=	100
F(11, 88)	=	18.91
Prob > F	=	0.0000
R-squared	=	0.7027
Adj R-squared	=	0.6655
Root MSE	=	.01146

OETAR	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
BS	-.0066636	.0044074	-1.51	0.134	-.0154224	.0020952
NPLTLR	.2272341	.0235981	9.63	0.000	.1803378	.2741305
NPLR	-.0398953	.0398269	-1.00	0.319	-.1190429	.0392524
TLTDR	-.0096624	.004011	-2.41	0.018	-.0176334	-.0016915
IRS	-.3124111	.0927708	-3.37	0.001	-.4967736	-.1280485
CAR	.0724767	.0759453	0.95	0.343	-.0784488	.2234021
TLTAR	-.0016714	.0075946	-0.22	0.826	-.0167641	.0134212
GDP	-.0967631	.1023244	-0.95	0.347	-.3001114	.1065852
INF	-.009176	.0968783	-0.09	0.925	-.2017013	.1833492
LLPTLR	.2618334	.0632746	4.14	0.000	.1360884	.3875784
OETI	-.4045329	.1048599	-3.86	0.000	-.6129199	-.1961458
_cons	.1269906	.0470117	2.70	0.008	.0335648	.2204164

5. VIF

```
. vif
```

Variable	VIF	1/VIF
CAR	2.60	0.385193
BS	2.40	0.417176
TLTAR	2.29	0.435762
NPLR	1.69	0.590860
TLTDR	1.56	0.640459
NPLTLR	1.54	0.647724
OETI	1.50	0.667793
LLPTLR	1.33	0.752510
INF	1.29	0.774512
IRS	1.20	0.831771
GDP	1.08	0.927211
Mean VIF	1.68	

6. Xtreg of Random Effect

```
. xtreg OETAR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI,re

Random-effects GLS regression                   Number of obs     =        100
Group variable: Banks                           Number of groups  =         10

R-squared:                                      Obs per group:
     Within  = 0.0086                                         min =         10
     Between = 0.9250                                         avg =       10.0
     Overall = 0.7027                                         max =         10

                                                Wald chi2(11)     =     207.98
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000
```

OETAR	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
BS	-.0066636	.0044074	-1.51	0.131	-.015302	.0019748
NPLTLR	.2272341	.0235981	9.63	0.000	.1809826	.2734857
NPLR	-.0398953	.0398269	-1.00	0.316	-.1179546	.0381641
TLTDR	-.0096624	.004011	-2.41	0.016	-.0175238	-.0018011
IRS	-.3124111	.0927708	-3.37	0.001	-.4942386	-.1305836
CAR	.0724767	.0759453	0.95	0.340	-.0763735	.2213268
TLTAR	-.0016714	.0075946	-0.22	0.826	-.0165565	.0132137
GDP	-.0967631	.1023244	-0.95	0.344	-.2973153	.1037891
INF	-.009176	.0968783	-0.09	0.925	-.199054	.1807019
LLPTLR	.2618334	.0632746	4.14	0.000	.1378175	.3858494
OETI	-.4045329	.1048599	-3.86	0.000	-.6100546	-.1990112
_cons	.1269906	.0470117	2.70	0.007	.0348495	.2191318

7. Xtreg of Fixed Effect

```
10 . xtreg OETAR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI,fe

  Fixed-effects (within) regression               Number of obs     =        100
  Group variable: Banks                           Number of groups  =         10

  R-squared:                                      Obs per group:
       Within  = 0.3600                                         min =         10
       Between = 0.0058                                         avg =       10.0
       Overall = 0.0153                                         max =         10

                                                  F(11,79)          =       4.04
  corr(u_i, Xb) = -0.3625                         Prob > F          =     0.0001
```

OETAR	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
BS	.0051821	.0023708	2.19	0.032	.0004632	.009901
NPLTLR	.0434474	.0209006	2.08	0.041	.0018458	.085049
NPLR	.0010022	.0179611	0.06	0.956	-.0347484	.0367528
TLTDR	.023389	.0115246	2.03	0.046	.0004497	.0463282
IRS	-.0310238	.0553851	-0.56	0.577	-.1412651	.0792175
CAR	-.0465516	.0347819	-1.34	0.185	-.1157832	.02268
TLTAR	-.011018	.0153611	-0.72	0.475	-.0415934	.0195574
GDP	-.0071377	.044895	-0.16	0.874	-.0964991	.0822236
INF	-.0273432	.043442	-0.63	0.531	-.1138123	.059126
LLPTLR	-.1301225	.0495676	-2.63	0.010	-.2287843	-.0314608
OETI	.2137309	.05661	3.78	0.000	.1010516	.3264102
_cons	-.0375155	.024096	-1.56	0.123	-.0854775	.0104464
sigma_u	.02157693					
sigma_e	.00486378					
rho	.95164469	(fraction of variance due to u_i)				

```
st that all u_i=0: F(9, 79) = 45.48                          Prob > F = 0.0000
```

8. Hausman Test of OETAR

	Coefficients (b) fe	Coefficients (B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
BS	.0051821	-.0066636	.0118457	.
NPLTLR	.0434474	.2272341	-.1837868	.
NPLR	.0010022	-.0398953	.0408974	.
TLTDR	.023389	-.0096624	.0330514	.0108041
IRS	-.0310238	-.3124111	.2813873	.
CAR	-.0465516	.0724767	-.1190282	.
TLTAR	-.011018	-.0016714	-.0093466	.0133523
GDP	-.0071377	-.0967631	.0896254	.
INF	-.0273432	-.009176	-.0181671	.
LLPTLR	-.1301225	.2618334	-.3919559	.
OETI	.2137309	-.4045329	.6182638	.

```
              b = Consistent under H0 and Ha; obtained from xtreg
   B = Inconsistent under Ha, efficient under H0; obtained from xtreg
```

9. Breusch and Pagan LM Test

```
Breusch and Pagan Lagrangian multiplier test for random effects

        OETAR[Banks,t] = Xb + u[Banks] + e[Banks,t]

        Estimated results:
                         |       Var     SD = sqrt(Var)
                ---------+-----------------------------
                   OETAR |   .0003925       .0198112
                       e |   .0000237       .0048638
                       u |          0              0

        Test: Var(u) = 0
                             chibar2(01) =     0.00
                          Prob > chibar2 =   1.0000
```

10. Hausman for FE and RE

	(b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
BS	.0051821	-.0066636	.0118457	.
NPLTLR	.0434474	.2272341	-.1837868	.
NPLR	.0010022	-.0398953	.0408974	.
TLTDR	.023389	-.0096624	.0330514	.0108041
IRS	-.0310238	-.3124111	.2813873	.
CAR	-.0465516	.0724767	-.1190282	.
TLTAR	-.011018	-.0016714	-.0093466	.0133523
GDP	-.0071377	-.0967631	.0896254	.
INF	-.0273432	-.009176	-.0181671	.
LLPTLR	-.1301225	.2618334	-.3919559	.
OETI	.2137309	-.4045329	.6182638	.

b = Consistent under H0 and Ha; obtained from xtreg.
B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

12. Random-effects GLS regression

```
Cross-sectional time-series FGLS regression

Coefficients:  generalized least squares
Panels:        homoskedastic
Correlation:   no autocorrelation

Estimated covariances      =         1          Number of obs     =       100
Estimated autocorrelations =         0          Number of groups  =        10
Estimated coefficients     =        12          Time periods      =        10
                                                Wald chi2(11)     =    236.34
Log likelihood             =  311.4063          Prob > chi2       =    0.0000
```

OETAR	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
BS	-.0066636	.0041345	-1.61	0.107	-.0147671	.0014399
NPLTLR	.2272341	.022137	10.26	0.000	.1838464	.2706219
NPLR	-.0398953	.037361	-1.07	0.286	-.1131214	.0333309
TLTDR	-.0096624	.0037626	-2.57	0.010	-.017037	-.0022878
IRS	-.3124111	.0870268	-3.59	0.000	-.4829804	-.1418418
CAR	.0724767	.071243	1.02	0.309	-.0671572	.2121105
TLTAR	-.0016714	.0071243	-0.23	0.815	-.0156349	.012292
GDP	-.0967631	.0959888	-1.01	0.313	-.2848978	.0913715
INF	-.009176	.0908799	-0.10	0.920	-.1872974	.1689453
LLPTLR	.2618334	.0593568	4.41	0.000	.1454961	.3781707
OETI	-.4045329	.0983673	-4.11	0.000	-.5973293	-.2117364
_cons	.1269906	.0441008	2.88	0.004	.0405546	.2134267

13. Generalized Least Squares

```
Cross-sectional time-series FGLS regression

Coefficients:  generalized least squares
Panels:        homoskedastic
Correlation:   no autocorrelation

Estimated covariances      =         1     Number of obs     =       100
Estimated autocorrelations =         0     Number of groups  =        10
Estimated coefficients     =        12     Time periods      =        10
                                           Wald chi2(11)     =    236.34
Log likelihood             =  311.4063     Prob > chi2       =    0.0000
```

OETAR	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
BS	-.0066636	.0041345	-1.61	0.107	-.0147671	.0014399
NPLTLR	.2272341	.022137	10.26	0.000	.1838464	.2706219
NPLR	-.0398953	.037361	-1.07	0.286	-.1131214	.0333309
TLTDR	-.0096624	.0037626	-2.57	0.010	-.017037	-.0022878
IRS	-.3124111	.0870268	-3.59	0.000	-.4829804	-.1418418
CAR	.0724767	.071243	1.02	0.309	-.0671572	.2121105
TLTAR	-.0016714	.0071243	-0.23	0.815	-.0156349	.012292
GDP	-.0967631	.0959888	-1.01	0.313	-.2848978	.0913715
INF	-.009176	.0908799	-0.10	0.920	-.1872974	.1689453
LLPTLR	.2618334	.0593568	4.41	0.000	.1454961	.3781707
OETI	-.4045329	.0983673	-4.11	0.000	-.5973293	-.2117364
_cons	.1269906	.0441008	2.88	0.004	.0405546	.2134267

14. GLS vs Pooled OLS

Variable	Pooled_OLS	fe	re	GLS
BS	-.00666362	.00518206*	-.00666362	-.00666362
NPLTLR	.22723415***	.04344739*	.22723415***	.22723415***
NPLR	-.03989527	.00100217	-.03989527	-.03989527
TLTDR	-.00966242*	.02338896*	-.00966242*	-.00966242*
IRS	-.31241109**	-.0310238	-.31241109***	-.31241109***
CAR	.07247665	-.04655158	.07247665	.07247665
TLTAR	-.00167143	-.01101803	-.00167143	-.00167143
GDP	-.09676313	-.00713773	-.09676313	-.09676313
INF	-.00917604	-.02734316	-.00917604	-.00917604
LLPTLR	.2618334***	-.13012254*	.2618334***	.2618334***
OETI	-.40453287***	.2137309***	-.40453287***	-.40453287***
_cons	.12699064**	-.03751553	.12699064**	.12699064**
N	100	100	100	100
chi2			207.97545	236.33574
F	18.906859	4.0394376		
sigma_u		.02157693	0	
sigma_e		.00486378	.00486378	
rho		.95164469	0	

Legend: * p<0.05; ** p<0.01; *** p<0.001

15. Correlation Matrix

	OETAR	BS	NPLTLR	NPLR	TLTDR	IRS	CAR
OETAR	1.0000						
BS	-0.0227	1.0000					
NPLTLR	0.7010	0.0560	1.0000				
NPLR	-0.2045	0.1298	-0.3209	1.0000			
TLTDR	0.1085	0.1445	0.3757	-0.2574	1.0000		
IRS	-0.2296	0.1568	-0.0688	0.2573	-0.2417	1.0000	
CAR	-0.1427	0.5710	-0.2110	0.4425	-0.1819	0.2550	1.0000
TLTAR	-0.0248	-0.0383	0.1392	-0.5298	0.4053	-0.3011	-0.4959
GDP	0.0015	-0.1217	0.0560	-0.1484	0.0079	-0.0349	-0.0337
INF	0.0398	0.3849	0.1215	-0.0165	0.0185	0.0296	0.1741
LLPTLR	0.5072	0.1116	0.4114	-0.0432	0.3045	-0.1619	-0.1214
OETI	-0.1395	-0.2038	0.1776	-0.2767	0.3254	-0.1672	-0.2624

	TLTAR	GDP	INF	LLPTLR	OETI
TLTAR	1.0000				
GDP	0.0279	1.0000			
INF	-0.0109	-0.1693	1.0000		
LLPTLR	0.0971	-0.0533	0.0758	1.0000	
OETI	0.4459	-0.0108	0.0881	0.0570	1.0000

15. Xtunitroot

```
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8 . xtunitroot llc OETAR

Levin-Lin-Chu unit-root test for OETAR
-------------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -4.0275
 Adjusted t*          0.4331        0.6675
------------------------------------------------------------------------------

9 . xtunitroot llc BS

Levin-Lin-Chu unit-root test for BS
-------------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -1.6869
 Adjusted t*         -1.0447        0.1481
------------------------------------------------------------------------------

0 . xtunitroot llc NPLTLR

Levin-Lin-Chu unit-root test for NPLTLR
-------------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -5.9495
 Adjusted t*         -3.8246        0.0001
------------------------------------------------------------------------------
```

```
1 . xtunitroot llc NPLR

Levin-Lin-Chu unit-root test for NPLR
-----------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -5.7087
 Adjusted t*         -1.2702        0.1020
------------------------------------------------------------------------------

2 . xtunitroot llc TLTDR

Levin-Lin-Chu unit-root test for TLTDR
------------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -6.2726
 Adjusted t*         -4.0456        0.0000
------------------------------------------------------------------------------

3 . xtunitroot llc IRS

Levin-Lin-Chu unit-root test for IRS
----------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -6.2504
 Adjusted t*         -2.5030        0.0062
------------------------------------------------------------------------------
```

```
. xtunitroot llc IRS CAR
too many variables specified
r(103);

. xtunitroot llc CAR

Levin-Lin-Chu unit-root test for CAR
---------------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t         -6.1519
 Adjusted t*          -4.3865       0.0000
------------------------------------------------------------------------------

. xtunitroot llc TLTAR

Levin-Lin-Chu unit-root test for TLTAR
---------------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -3.3e+02
 Adjusted t*         -3.6e+02       0.0000
------------------------------------------------------------------------------

. xtunitroot llc GDP

Levin-Lin-Chu unit-root test for GDP
---------------------------------------------
H0: Panels contain unit roots                 Number of panels  =     10
Ha: Panels are stationary                     Number of periods =     10

AR parameter: Common                          Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -11.7021
 Adjusted t*          -7.5486       0.0000
------------------------------------------------------------------------------
```

```
. xtunitroot llc INF

Levin-Lin-Chu unit-root test for INF
------------------------------------
H0: Panels contain unit roots              Number of panels  =     10
Ha: Panels are stationary                  Number of periods =     10

AR parameter: Common                       Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -0.8129
 Adjusted t*         16.7710        1.0000
------------------------------------------------------------------------------
```


```
. xtunitroot llc INF

Levin-Lin-Chu unit-root test for INF
------------------------------------
H0: Panels contain unit roots              Number of panels  =     10
Ha: Panels are stationary                  Number of periods =     10

AR parameter: Common                       Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -0.8129
 Adjusted t*         16.7710        1.0000
------------------------------------------------------------------------------
```


```
. xtunitroot llc OETI

Levin-Lin-Chu unit-root test for OETI
-------------------------------------
H0: Panels contain unit roots              Number of panels  =     10
Ha: Panels are stationary                  Number of periods =     10

AR parameter: Common                       Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 6.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t       -1.4e+02
 Adjusted t*        -1.5e+02        0.0000
------------------------------------------------------------------------------
```

16.Dynamic panel data model

```
. xtabond OETAR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI, vce (gmm

Arellano-Bond dynamic panel-data estimation     Number of obs     =         80
Group variable: Banks                           Number of groups  =         10
Time variable: Years
                                                Obs per group:
                                                              min =          8
                                                              avg =          8
                                                              max =          8

Number of instruments =     46                  Wald chi2(12)     =      20.50
                                                Prob > chi2       =     0.0582
One-step results
```

OETAR	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
OETAR						
L1.	.220506	.11862	1.86	0.063	-.011985	.452997
BS	.0017391	.0024093	0.72	0.470	-.002983	.0064611
NPLTLR	.0229014	.0213928	1.07	0.284	-.0190277	.0648306
NPLR	.005154	.0143175	0.36	0.719	-.0229079	.0332158
TLTDR	.0040325	.0120132	0.34	0.737	-.019513	.0275779
IRS	-.0611885	.0473104	-1.29	0.196	-.1539151	.0315381
CAR	.0203658	.0415304	0.49	0.624	-.0610324	.1017639
TLTAR	-.0032827	.0134129	-0.24	0.807	-.0295715	.023006
GDP	.004309	.0340399	0.13	0.899	-.062408	.0710261
INF	-.0007571	.0346098	-0.02	0.983	-.0685911	.0670768
LLPTLR	-.0240889	.0559713	-0.43	0.667	-.1337906	.0856128
OETI	.057464	.0627847	0.92	0.360	-.0655918	.1805198
_cons	-.0006127	.0230307	-0.03	0.979	-.0457521	.0445268

8.2Appendices for CIR model

1. Extreme Statistic

```
extremes CIR BS NPLR NPLTLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI
```

obs:	CIR	BS	NPLR	NPLTLR	TLTDR	IRS	CAR	TLTAR	GDP	INF	LLPTLR	OETI
80.	0.01	13.03	.03	0.00	0.02	.06	.14	0.96	0.06	0.10	0.00	0.02
78.	0.01	12.78	.03	0.00	0.01	.05	.14	0.92	0.07	0.06	0.00	0.02
79.	0.01	12.95	.05	0.00	0.02	.05	.14	0.94	0.07	0.08	0.00	0.02
72.	0.01	12.11	.04	0.00	0.01	.05	.11	0.90	0.07	0.06	0.01	0.03
73.	0.01	12.25	.03	0.00	0.01	.05	.15	0.91	0.07	0.06	0.00	0.03

52.	0.90	11.67	.03	0.17	0.56	.05	.11	0.47	0.07	0.06	0.07	0.02
53.	0.95	12.26	.03	0.21	0.63	.05	.13	0.52	0.07	0.06	0.06	0.02
57.	0.95	12.72	.03	0.13	0.63	.05	.14	0.53	0.03	0.06	0.05	0.01
58.	0.97	12.87	.03	0.19	0.66	.04	.13	0.57	0.07	0.06	0.04	0.02
60.	0.97	12.73	.03	0.21	0.72	.03	.12	0.60	0.06	0.10	0.04	0.01

2.Summary table

```
. summarize CIR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI
```

Variable	Obs	Mean	Std. dev.	Min	Max
CIR	100	.4229855	.255022	.0092397	.9747
BS	100	12.6911	.4045197	11.67	13.64
NPLTLR	100	.0601936	.0606332	.00006	.251
NPLR	100	.0482	.0376153	0	.3
TLTDR	100	.6945285	.3587482	.0067696	1.115257
IRS	100	.0519	.0136104	.03	.1
CAR	100	.1453	.0244311	.09	.25
TLTAR	100	.6295146	.2296969	.0074183	.96
GDP	100	.06478	.0116873	.0345	.0788
INF	100	.06438	.0135065	.0551	.0988
LLPTLR	100	.0198262	.0209796	.000012	.0856154
OETI	100	.0194369	.0134386	.0001533	.0897

3.Swilk table

. swilk CIR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
CIR	100	0.92094	6.528	4.162	0.00002
BS	100	0.98619	1.140	0.291	0.38545
NPLTLR	100	0.82047	14.823	5.981	0.00000
NPLR	100	0.65715	28.307	7.416	0.00000
TLTDR	100	0.73967	21.494	6.805	0.00000
IRS	100	0.91013	7.420	4.446	0.00000
CAR	100	0.91375	7.121	4.355	0.00001
TLTAR	100	0.75853	19.937	6.639	0.00000
GDP	100	0.81628	15.169	6.032	0.00000
INF	100	0.71474	23.552	7.008	0.00000
LLPTLR	100	0.82072	14.802	5.978	0.00000
OETI	100	0.74085	21.396	6.795	0.00000

4.Regression table

. reg CIR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI

Source	SS	df	MS			
				Number of obs	=	100
				F(11, 88)	=	58.58
Model	5.66498348	11	.514998498	Prob > F	=	0.0000
Residual	.773602883	88	.008790942	R-squared	=	0.8798
				Adj R-squared	=	0.8648
Total	6.43858636	99	.065036226	Root MSE	=	.09376

CIR	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
BS	.0234898	.0360662	0.65	0.517	-.0481843	.0951639
NPLTLR	2.401496	.1931054	12.44	0.000	2.01774	2.785253
NPLR	-.3365037	.3259068	-1.03	0.305	-.9841749	.3111676
TLTDR	.2720642	.032822	8.29	0.000	.2068375	.337291
IRS	-3.620938	.7591507	-4.77	0.000	-5.129591	-2.112286
CAR	-.3624422	.6214664	-0.58	0.561	-1.597476	.8725917
TLTAR	-.2224838	.062147	-3.58	0.001	-.345988	-.0989797
GDP	-1.870049	.8373284	-2.23	0.028	-3.534064	-.206035
INF	-.8642483	.7927623	-1.09	0.279	-2.439697	.7112002
LLPTLR	1.179759	.5177808	2.28	0.025	.1507789	2.20874
OETI	3.795701	.8580766	4.42	0.000	2.090454	5.500948
_cons	.2678443	.3846999	0.70	0.488	-.4966659	1.032355

5.VIF

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         CAR |      2.60    0.385193
          BS |      2.40    0.417176
       TLTAR |      2.29    0.435762
        NPLR |      1.69    0.590860
       TLTDR |      1.56    0.640459
      NPLTLR |      1.54    0.647724
        OETI |      1.50    0.667793
      LLPTLR |      1.33    0.752510
         INF |      1.29    0.774512
         IRS |      1.20    0.831771
         GDP |      1.08    0.927211
-------------+----------------------
    Mean VIF |      1.68
```

6. Xtreg of Random Effect

```
. xtreg CIR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI,re

Random-effects GLS regression                   Number of obs     =        100
Group variable: Banks                           Number of groups  =         10

R-squared:                                      Obs per group:
     Within  = 0.5904                                         min =         10
     Between = 0.9425                                         avg =       10.0
     Overall = 0.8798                                         max =         10

                                                Wald chi2(11)     =     644.41
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
         CIR | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
          BS |   .0234898   .0360662     0.65   0.515    -.0471987    .0941783
      NPLTLR |   2.401496   .1931054    12.44   0.000     2.023016    2.779976
        NPLR |  -.3365037   .3259068    -1.03   0.302    -.9752692    .3022619
       TLTDR |   .2720642    .032822     8.29   0.000     .2077344    .3363941
         IRS |  -3.620938   .7591507    -4.77   0.000    -5.108846    -2.13303
         CAR |  -.3624422   .6214664    -0.58   0.560    -1.580494    .8556096
       TLTAR |  -.2224838    .062147    -3.58   0.000    -.3442897   -.1006779
         GDP |  -1.870049   .8373284    -2.23   0.026    -3.511183   -.2289158
         INF |  -.8642483   .7927623    -1.09   0.276    -2.418034    .6895372
      LLPTLR |   1.179759   .5177808     2.28   0.023     .1649277    2.194591
        OETI |   3.795701   .8580766     4.42   0.000     2.113902      5.4775
       _cons |   .2678443   .3846999     0.70   0.486    -.4861536    1.021842
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  .05489885
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

7. Xtreg of Fixed Effect

```
. xtreg CIR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI,fe

Fixed-effects (within) regression               Number of obs     =        100
Group variable: Banks                           Number of groups  =         10

R-squared:                                      Obs per group:
     Within  = 0.6886                                         min =         10
     Between = 0.4887                                         avg =       10.0
     Overall = 0.5039                                         max =         10

                                                F(11,79)          =      15.88
corr(u_i, Xb) = 0.2218                          Prob > F          =     0.0000
```

CIR	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
BS	.0664443	.0267596	2.48	0.015	.0131807	.1197079
NPLTLR	1.480654	.2359106	6.28	0.000	1.011085	1.950222
NPLR	-.1194275	.2027312	-0.59	0.557	-.5229539	.2840989
TLTDR	-.0789265	.1300817	-0.61	0.546	-.3378476	.1799946
IRS	-.9126718	.6251467	-1.46	0.148	-2.156995	.3316516
CAR	-.3122667	.3925925	-0.80	0.429	-1.093702	.469169
TLTAR	.2614047	.1733843	1.51	0.136	-.0837081	.6065176
GDP	-1.373487	.5067424	-2.71	0.008	-2.382133	-.3648417
INF	-.5477691	.4903415	-1.12	0.267	-1.523769	.4282313
LLPTLR	.6488648	.5594825	1.16	0.250	-.4647573	1.762487
OETI	3.809736	.6389718	5.96	0.000	2.537894	5.081577
_cons	-.4833106	.2719782	-1.78	0.079	-1.02467	.0580485
sigma_u	.18586456					
sigma_e	.05489885					

8. Breusch and Pagan LM Test

```
Breusch and Pagan Lagrangian multiplier test for random effects

        CIR[Banks,t] = Xb + u[Banks] + e[Banks,t]

        Estimated results:
```

	Var	SD = sqrt(Var)
CIR	.0650362	.255022
e	.0030139	.0548988
u	0	0

```
        Test: Var(u) = 0
                             chibar2(01) =     0.00
                          Prob > chibar2 =   1.0000
```

9. Hausman for FE and RE

```
hausman fe re
```

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
BS	.0664443	.0234898	.0429545	.
NPLTLR	1.480654	2.401496	-.9208423	.1355143
NPLR	-.1194275	-.3365037	.2170762	.
TLTDR	-.0789265	.2720642	-.3509907	.1258728
IRS	-.9126718	-3.620938	2.708266	.
CAR	-.3122667	-.3624422	.0501755	.
TLTAR	.2614047	-.2224838	.4838885	.1618637
GDP	-1.373487	-1.870049	.4965621	.
INF	-.5477691	-.8642483	.3164792	.
LLPTLR	.6488648	1.179759	-.5308946	.2119521
OETI	3.809736	3.795701	.0140345	.

10. Random-effects GLS regression

```
. xtreg CIR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI,re

Random-effects GLS regression                   Number of obs     =        100
Group variable: Banks                           Number of groups  =         10

R-squared:                                      Obs per group:
     Within  = 0.5904                                         min =         10
     Between = 0.9425                                         avg =       10.0
     Overall = 0.8798                                         max =         10

                                                Wald chi2(11)     =     644.41
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000
```

CIR	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
BS	.0234898	.0360662	0.65	0.515	-.0471987	.0941783
NPLTLR	2.401496	.1931054	12.44	0.000	2.023016	2.779976
NPLR	-.3365037	.3259068	-1.03	0.302	-.9752692	.3022619
TLTDR	.2720642	.032822	8.29	0.000	.2077344	.3363941
IRS	-3.620938	.7591507	-4.77	0.000	-5.108846	-2.13303
CAR	-.3624422	.6214664	-0.58	0.560	-1.580494	.8556096
TLTAR	-.2224838	.062147	-3.58	0.000	-.3442897	-.1006779
GDP	-1.870049	.8373284	-2.23	0.026	-3.511183	-.2289158
INF	-.8642483	.7927623	-1.09	0.276	-2.418034	.6895372
LLPTLR	1.179759	.5177808	2.28	0.023	.1649277	2.194591
OETI	3.795701	.8580766	4.42	0.000	2.113902	5.4775
_cons	.2678443	.3846999	0.70	0.486	-.4861536	1.021842
sigma_u	0					
sigma_e	.05489885					
rho	0	(fraction of variance due to u_i)				

11. Generalized Least Squares

```
. xtreg CIR BS NPLTLR NPLR TLTDR IRS CAR TLTAR GDP INF LLPTLR OETI,re

Random-effects GLS regression                   Number of obs     =        100
Group variable: Banks                           Number of groups  =         10

R-squared:                                      Obs per group:
     Within  = 0.5904                                         min =         10
     Between = 0.9425                                         avg =       10.0
     Overall = 0.8798                                         max =         10

                                                Wald chi2(11)     =     644.41
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000
```

CIR	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
BS	.0234898	.0360662	0.65	0.515	-.0471987	.0941783
NPLTLR	2.401496	.1931054	12.44	0.000	2.023016	2.779976
NPLR	-.3365037	.3259068	-1.03	0.302	-.9752692	.3022619
TLTDR	.2720642	.032822	8.29	0.000	.2077344	.3363941
IRS	-3.620938	.7591507	-4.77	0.000	-5.108846	-2.13303
CAR	-.3624422	.6214664	-0.58	0.560	-1.580494	.8556096
TLTAR	-.2224838	.062147	-3.58	0.000	-.3442897	-.1006779
GDP	-1.870049	.8373284	-2.23	0.026	-3.511183	-.2289158
INF	-.8642483	.7927623	-1.09	0.276	-2.418034	.6895372
LLPTLR	1.179759	.5177808	2.28	0.023	.1649277	2.194591
OETI	3.795701	.8580766	4.42	0.000	2.113902	5.4775
_cons	.2678443	.3846999	0.70	0.486	-.4861536	1.021842
sigma_u	0					
sigma_e	.05489885					
rho	0	(fraction of variance due to u_i)				

12. GLS vs Pooled OLS

```
estimates table Pooled_OLS fe re GLS, star stats(N, chi2, F, sigma_u, sigma_e rho)
```

Variable	Pooled_OLS	fe	re	GLS
BS	.02348979	.0664443*	.02348979	.02348979
NPLTLR	2.4014961***	1.4806538***	2.4014961***	2.4014961***
NPLR	-.33650367	-.11942749	-.33650367	-.33650367
TLTDR	.27206424***	-.07892649	.27206424***	.27206424***
IRS	-3.6209381***	-.91267178	-3.6209381***	-3.6209381***
CAR	-.3624422	-.31226672	-.3624422	-.3624422
TLTAR	-.22248381***	.26140472	-.22248381***	-.22248381***
GDP	-1.8700494*	-1.3734872**	-1.8700494*	-1.8700494*
INF	-.86424826	-.54776908	-.86424826	-.86424826
LLPTLR	1.1797595*	.64886485	1.1797595*	1.1797595*
OETI	3.795701***	3.8097355***	3.795701***	3.795701***
_cons	.26784432	-.48331062	.26784432	.26784432
N	100	100	100	100
chi2			644.41144	732.28572
F	58.582858	15.884082		
sigma_u		.18586456	0	
sigma_e		.05489885	.05489885	
rho		.91975713	0	

Legend: * p<0.05; ** p<0.01; *** p<0.001

13. Correlation Matrix

	CIR	BS	NPLTLR	NPLR	TLTDR	IRS	CAR
CIR	1.0000						
BS	0.0385	1.0000					
	0.7036						
NPLTLR	0.7906	0.0560	1.0000				
	0.0000	0.5800					
NPLR	-0.3315	0.1298	-0.3209	1.0000			
	0.0008	0.1981	0.0011				
TLTDR	0.6803	0.1445	0.3757	-0.2574	1.0000		
	0.0000	0.1514	0.0001	0.0097			
IRS	-0.3280	0.1568	-0.0688	0.2573	-0.2417	1.0000	
	0.0009	0.1191	0.4966	0.0098	0.0154		
CAR	-0.2447	0.5710	-0.2110	0.4425	-0.1819	0.2550	1.0000
	0.0141	0.0000	0.0351	0.0000	0.0701	0.0105	
TLTAR	0.2312	-0.0383	0.1392	-0.5298	0.4053	-0.3011	-0.4959
	0.0206	0.7053	0.1671	0.0000	0.0000	0.0023	0.0000
GDP	-0.0451	-0.1217	0.0560	-0.1484	0.0079	-0.0349	-0.0337
	0.6556	0.2279	0.5802	0.1406	0.9381	0.7300	0.7390
INF	0.0757	0.3849	0.1215	-0.0165	0.0185	0.0296	0.1741
	0.4539	0.0001	0.2284	0.8708	0.8552	0.7700	0.0831
LLPTLR	0.4833	0.1116	0.4114	-0.0432	0.3045	-0.1619	-0.1214
	0.0000	0.2692	0.0000	0.6694	0.0021	0.1076	0.2289
OETI	0.3866	-0.2038	0.1776	-0.2767	0.3254	-0.1672	-0.2624
	0.0001	0.0420	0.0771	0.0053	0.0010	0.0963	0.0084

	TLTAR	GDP	INF	LLPTLR	OETI
TLTAR	1.0000				
GDP	0.0279	1.0000			
	0.7830				
INF	-0.0109	-0.1693	1.0000		
	0.9143	0.0923			
LLPTLR	0.0971	-0.0533	0.0758	1.0000	
	0.3366	0.5987	0.4537		
OETI	0.4459	-0.0108	0.0881	0.0570	1.0000
	0.0000	0.9151	0.3837	0.5733	

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