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Determinants of Operating Efficiency for the Jordanian Banks: A Panel Data Econometric Approach

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Abstract: This paper presents a comprehensive analysis of key financial indicators influencing the operational efficiency of banks in Jordan over the period 2006 to 2021. The study, focusing on fifteen commercial banks, employs seven regression models to assess the impact of selected variables on bank operating efficiency. Our findings reveal novel insights with substantial contributions to banking practice. We identify a statistically significant influence of both bank-specific factors and temporal effects, demonstrating the nuanced dynamics shaping the operational efficiency of Jordanian banks. Notably, a positive and significant correlation is established between the operating efficiency ratio and return on assets, bank size, and the ratio of loan loss provisions to net interest income, providing valuable strategic guidance for effective management. Conversely, a significant negative relationship is observed between the operating efficiency ratio and the total expense ratio, underscoring the critical importance of careful cost management. No significant associations are found between the operating efficiency ratio and credit risk, the equity-to-asset ratio, the deposit-to-liability ratio, and the equity-to-liability ratio. This study makes a unique contribution by shedding light on these previously unexplored correlations, offering actionable insights for enhancing operational efficiency in the banking sector. Additionally, our research advocates for the Central Bank of Jordan (CBJ) to persist in adaptive policy measures, which are crucial for ongoing banking reforms and improved monitoring practices. Based on our empirical findings, these recommendations aim to fortify the resilience and adaptability of Jordan's banking sector, contributing both academically and practically. Importantly, they reinforce the symbiotic link between a stable banking sector and sustained economic development in Jordan.

Keywords: operating efficiency; panel analysis; banks; Jordan; financial performance; economic development

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1. Introduction

The central activities of the banking system revolve around acquiring deposits from savers and extending credit to investors and consumers. Deposit reception is regarded as an 'input' activity, while lending constitutes an 'output' activity. Within these operations, the banking system assumes a crucial role in the economy by facilitating the flow of deposited funds, allocating capital, employing credit management tools, and furnishing essential information, liquidity, payment, and transaction services to various economic sectors. The significance of a financial intermediary in furnishing capital for the advancement of emerging industries holds particular importance, as highlighted by Ghannadian and Goswami in 2004. Consequently, banks are exposed to diverse risks, including operational, credit, and liquidity risks. The potential for destabilization as a result of improper resource allocation, whether due to faulty risk assessment or contract design, could be significant

(Ghannadian and Goswami 2004). The efficient execution of these activities is not only crucial for fostering robust and sustainable economic growth but also for providing risk management tools and high-quality financial services. It is imperative to recognize that a stable and efficient banking sector is a prerequisite for supporting economic development. Economic growth is regarded as an essential means of alleviating poverty and improving country well-being (Bayar et al. 2021). The stability of the banking sector has a positive impact on economic growth. Bank disruptions and insecurity can jeopardize financial stability and have serious long-term consequences (Bayar et al. 2021).

In Jordan, the financial sector encompasses banks, insurance companies, exchange entities, financial intermediaries, financial services providers, financing and leasing companies, factoring, mortgage financing, mortgage refinancing, and lending-based crowdfunding. Banks notably dominate the financial landscape in Jordan, accounting for 96% of the financial sector's total assets, which equates to 186% of the GDP as of the end of 2021. Credit facilities constitute the largest segment of banks' total assets, representing approximately 49% and, more significantly, contributing to 94% of the GDP by the end of 2021. Deposits emerge as the primary source of funding, making up 69% of total sources and, notably, 124% of the GDP by the end of 2021. The Jordanian banking system comprises 23 licensed banks, including 16 Jordanian banks (including 3 Islamic banks) and 7 branches of foreign banks, with 1 branch being a foreign Islamic bank. The characteristics of Jordanian banks explain a significant portion of the variation in bank profitability. High Jordanian bank profitability is associated with well-capitalized banks, high lending activities, low credit risk, and cost management efficiency (Ramadan et al. 2011).

The Jordanian banking system has undergone extensive reforms since 1993, aiming to establish a more diversified, profitable, and efficient system. These reforms include the implementation of Basel II, enhancements to risk management systems, adoption of new accounting standards, and advancements in technology, transparency, disclosures, and governance. The major developments brought about by Jordan's banking reform have wide-ranging practical and managerial implications for various decision makers, regulators at the Central Bank of Jordan, and academics (Migdadi 2014). Consequently, there is a keen interest in comprehending the operating efficiency of Jordanian banks. Examining the impact of key financial fundamentals on banks' operating efficiency is not only crucial for maintaining financial stability in Jordan but also aligns with the objective of monetary stability set by the Central Bank of Jordan (CBJ). Operating efficiency, in this context, pertains to a bank's adept management of costs.

Accordingly, our study is driven by the overarching goal of investigating the impact of diverse financial fundamentals on the operational efficiency of banks in Jordan. The inclusiveness of factors examined in our study distinguishes it, as there is no existing research in Jordan that has adopted such an extended perspective. Previous studies have provided limited insight into the explanatory variables influencing banks' operating efficiency in Jordan. Consequently, our study seeks to address this gap by comprehensively exploring the relationships between the response variable (CIR) and a range of explanatory variables, including CR, ROA, TETA, TDTL, TCTA, LOTA, TETL, and LLPII. This extended perspective is deemed relevant and valuable for a nuanced understanding of the intricate dynamics shaping the operational efficiency of banks in the Jordanian context.

The pivotal role of the banking system in driving economic growth motivates our investigation into the Jordanian banking sector, providing fresh insights into the determinants of bank operating efficiency. Our study addresses a critical gap in the existing literature by scrutinizing key financial fundamentals, offering a comprehensive and inclusive perspective.

Importantly, our findings have practical implications for both Jordanian bank managers and policymakers. Our insights offer a valuable guide for decision-makers in refining cost-cutting strategies, optimizing resource allocation, and navigating the volatile financial landscape. Armed with the knowledge gained from our research, bank executives can make informed decisions to improve internal processes, increase profitability, and strengthen the overall health and sustainability of the banking sector.

For policymakers at the Central Bank of Jordan (CBJ), our research is closely tied to the goal of achieving monetary stability. Policymakers can leverage our nuanced insights into the operational efficiency of Jordanian banks to develop strategic reforms, regulatory measures, and policy interventions, ultimately contributing to a more stable, efficient, and resilient banking sector.

Distinguished by its comprehensive exploration of factors affecting operational efficiency, our study addresses a significant gap in the existing literature. The inclusivity of our methodology fosters a thorough understanding of intricacies within the Jordanian banking system, establishing a groundwork for future research endeavors. Our research not only contributes to academic discourse but also serves as a practical guide for industry professionals and policymakers. Navigating the intricacies of the Jordanian banking sector, this study stands as a valuable resource for those seeking to improve the efficiency, stability, and sustainability of the financial sector.

The remainder of this paper is organized as follows. Section 2 briefly reviews related literature. Section 3 describes our research methodology, including data and samples as well as the model used to estimate bank operating efficiency. In Section 4, we present and discuss our empirical results as well as the sensitivity analysis. Finally, the conclusions and implications of our findings are discussed in Section 5.

2. Literature Review

The operating efficiency of any commercial institution is the most critical variable that determines its sustainability, efficiency, and productivity (Ghosh and Sanyal 2019). Furthermore, bank liquidity and capital adequacy are related to bank operating efficiency (Lotto 2019). In highly competitive banks, asset quality, capital adequacy, credit risk, and liquidity all have a positive and significant impact on operating efficiency (Eldomiaty et al. 2015). More efficient banks have greater market power. Concentration also has a positive effect on market power (Kasman and Carvallo 2014).

There are ample studies on financial fundamentals and their impact on banks' operating efficiency. The literature on banks' operating efficiency can be broadly organized into different categories. Many researchers have focused on internal bank-specific performance factors in addition to macroeconomic and risk factors when examining the operational efficiency of banks. Similarly, other researchers have focused on economies of scale, scope, and productivity factors to examine the operational efficiency of banks. The methodology used by researchers to examine the operational efficiency of banks has been dominantly focused on different dynamics of data envelopment analysis and stochastic frontier analysis.

The empirical studies focused on various internal bank-specific performance factors and their impact on the operating efficiency of banks (like Berger and Mester 1999; Ataullah et al. 2004; Moradi and Ali 2014). Some researchers specifically emphasized the importance of nonperforming loan and capital adequacy ratios to account for the operating efficiency of banks (Niswander and Swanson 2000; Barth et al. 2003; Das and Ghosh 2006; Denizer et al. 2007; Nguyen et al. 2018).

In other studies, researchers highlighted the association between operational efficiency and profitability of banks (Alexiou and Sofoklis 2009; Olson and Zoubi 2011; Zafar et al. 2016). However, for other studies, researchers regarded risk as an input factor to explore efficiency analysis (Huang and Paradi 2011; Chiu et al. 2013; Chen et al. 2015). Other classes of studies related capital structure variables to bank effectiveness indexes (Amidu 2007; Anafo et al. 2015; Zafar et al. 2016; Siddik et al. 2017).

From different perspectives, many studies examined the impact of financial reforms and restructuring processes on banks' operating efficiency (Yildirim and Philippatos 2007; Zhao et al. 2010; Hsiao et al. 2010). Some studies suggested that financial reform improves efficiency. For instance, Brissimis et al. (2008) found a positive impact of banking sector reform on banking efficiency, and Koutsomanoli-Filippaki et al. (2009) found that efficiency has improved with progress on institutional and structural reforms in the Central and Eastern European banking industry. However, banking efficiency in the US was relatively unchanged by reforms, as seen by Elyasiani and Mehdian (1995). Similarly, Fukuyama and Weber (2002) found that the efficiency of Japanese banks during the reform period of 1992–1996 declined, and Park and Weber (2006) found declines in efficiency for Korean banks during the reform period of 1992–2002.

Rahman (2023) examined the effects of business intelligence on the bank's operational efficiency and perceptions of profitability in Bangladesh. The study found that business intelligence is positively associated with operational efficiency and profitability. Gupta and Raman (2020) examined the impact of intellectual capital (IC) in improving the efficiency of Indian banks. The results indicate a positive and significant relationship between IC and efficiency. The results also show that all the components of IC, that is, human capital, relational capital, process capital, and capital employed, have a significant impact on efficiency.

Nguyen et al. (2018) investigated whether there is a causal relationship between bank loans and deposits in the Vietnamese banking system and the efficiency with which Vietnamese banks use loans and deposits. They discovered that in a less-developed banking system like that of Vietnam, bank deposits have a positive and significant impact on bank loans, but the opposite relationship is not significant. Berger et al. (1993) examined the input technical efficiency of US banks using both deposits and non-deposit funds as input variables, as well as several employees, while Assaf et al. (2011) utilized three inputs to produce bank outputs in Saudi Arabia: total employees, fixed assets, and total deposits. In contrast, Fujii et al. (2014) studied the output-oriented efficiency of Indian banks in their creation of customer loans.

There is also a vast literature discussing the relationship between macroeconomic fundamentals and bank operating efficiency. They focused on the explanatory power of bank efficiency on economic growth and vice versa (Levine 2005; Ang 2008; Siddiqui et al. 2012; Ozili and Outa 2017; Umar and Sun 2018; Fu et al. 2018; Neves et al. 2020; Ercegovac et al. 2020). For example, Koetter and Wedow (2010) for German banks in 97 regions, Ferreira (2016) in the European Union, Bernini and Brighi (2018) in 101 provinces of Italy, and Ferreira (2018) in 28 European Union countries have found a significant positive contribution of bank cost efficiency to economic growth. From the experience of developing countries, Mensah et al. (2012) examined the link between banking sector efficiency and African economic growth. Saqib (2013) used data from 50 developing countries, Mirzaei and Moore (2016) utilized data from Qatar, Hasan et al. (2017) employed data from 30 provinces of China, Diallo (2018) collected and analyzed data from 38 different countries in 2009, Fu et al. (2018) used parameters from 14 Asia–Pacific countries, Mirzaei and Moore (2019) used data from 49 countries, and all found a positive contribution of bank cost efficiency to economic growth.

From the experience of different structures of financial institutions, many other studies examine the operating efficiency of small loan institutions and rural banks. Bassem (2008) measured the efficiency of the 35 small loan institutions in the Mediterranean region. Haq et al. (2010) analyzed the cost efficiency of 39 microfinance institutions in Asia, Africa, and Latin America. Lingjuan et al. (2017) examined 65 rural banks in China's Jiangsu Province and concluded that the comprehensive technical efficiency value of sample banks originated by state-owned banks and joint-stock banks is higher than that of rural commercial banks and city commercial banks. Chou and Buchdadi (2016) collected information from 164 rural banks on Java Island. Their findings suggest that efficiency and prudence in management policies for the banking industry in Indonesia are becoming increasingly important.

As for studies in the Jordanian case, several studies have enlightened the performance and efficiency of the Jordanian banking system. Bdour and Al-khoury (2008) investigated the relative efficiency pattern of Jordanian banks between 1998 and 2004. Except for 2003 and 2004, when a few banks in the sample showed a decrease in bank efficiency, their results showed an increase in bank efficiency throughout the period. Their study also discovered that asset utilization and the labor factor had a negative impact on bank efficiency, particularly in terms of employee count. Zeitun and Benjelloun (2012) assessed the relative efficiency of Jordanian banks from 2005 to 2010. According to the findings, only a few Jordanian banks were technically efficient in managing their financial resources and generating profit. Furthermore, only a few banks were discovered to be efficient on a pure technical efficiency scale in a few years.

Ajlouni et al. (2011) used data envelopment analysis to assess the relative efficiency of Jordanian banks. According to their findings, the sampled banks had a consistently high and stable average efficiency score over time. Notably, the study found a significant performance disparity, with larger banks outperforming their smaller and medium-sized counterparts, establishing bank size as an important determinant of efficiency. Kharabsheh and Gharaibeh (2022) conducted a comprehensive investigation into the factors influencing financial stability within the context of Jordanian banks. The findings of their study revealed a significant and positive impact on the stability of commercial banks in Jordan attributable to SME loans and capital adequacy. Al-Abedallat (2017) analyzed the impact of Jordan's banking sector on economic development as measured by gross domestic product (GDP). The results of this analysis show that banking sector deposits and credit facilities have a statistically significant impact on GDP.

Prior research underscores the significance of operational efficiency for a commercial institution's sustainability. Internal factors such as nonperforming loans, capital adequacy ratios, and profitability, as well as external factors like financial reforms, have been explored for their impact on operating efficiency.

However, the literature reveals certain shortcomings in existing research efforts. First, there is a need for more nuanced investigations into the interplay between internal and external factors affecting operational efficiency. While some studies emphasize individual components such as nonperforming loans or capital adequacy, a holistic understanding of their integrated effects is often lacking. Secondly, the methodologies employed in prior studies, primarily centered around data envelopment analysis and stochastic frontier analysis, may not comprehensively capture the dynamic nature of banking operations. There is a call for diversified approaches that go beyond these conventional methods to offer a more holistic view of operational efficiency. Moreover, the literature often lacks specificity regarding the contextual factors influencing the observed relationships. The global nature of banking and the unique economic landscapes of different regions, including Jordan, necessitate a more granular examination of the contextual nuances affecting operational efficiency.

In the Jordanian context, while studies by Bdour and Al-khoury (2008), Zeitun and Benjelloun (2012), and Ajlouni et al. (2011) provide valuable insights, there remains a gap in understanding the evolving factors influencing operational efficiency over time. Additionally, there is a need for more comparative analyses between Jordanian banks and those in other regions to identify unique challenges and opportunities.

This synthesis informs our study, highlighting the existing gaps in the literature and underscoring the necessity of a more nuanced and context-specific exploration of operational efficiency in Jordanian banks.

3. Methodology

The total sample comprised 15 banks for a period of 16 years ranging from 2006 to 2021 (Table 1). The data, therefore, comprised 240 observations (16 observations per bank). Among the 15 banks, 13 were conventional banks and 2 were Islamic banks.

Table 2 shows the variables considered in this study. The response variable was the operating efficiency ratio (CIR). The explanatory variables of interest included credit risk (CR), return on assets (ROA), return on equity (ROE), equity to asset ratio (TETA), deposit-to-liability ratio (TDTL), total expense ratio (TCTA), bank size (LOTA), and equity-to-liability ratio (TETL).

Table 1. Sample composition.

Number	Bank Name	Type
1	Arab Bank	Conventional
2	Arab Banking Corporation (Jordan)	Conventional
3	Arab Jordan Investment Bank	Conventional
4	Bank Al Etihad	Conventional
5	Bank of Jordan	Conventional
6	Cairo Amman Bank	Conventional
7	Capital Bank of Jordan	Conventional
8	INVESTBANK	Conventional
9	Jordan Ahli Bank	Conventional
10	Jordan Commercial Bank	Conventional
11	Jordan Kuwait Bank	Conventional
12	Societe Generale De Banque (Jordanie)	Conventional
13	The Housing Bank for Trade & Finance	Conventional
14	Islamic International Arab Bank (IIAB)	Islamic
15	Jordan Islamic Bank (JIB)	Islamic

Table 2. Study variables.

Variable	Symbol	Measurement
Operating efficiency ratio	CIR	Operating income/(Operating cost–Loan loss provision)
Credit risk	CR	Non-Performing Loans/Total Loans
Return on assets	ROA	Net income/Total assets
Return on equity	ROE	Net income/Total equity
Equity-to-asset ratio	TETA	Total equity/Total assets
Deposit-to-liability ratio	TDTL	Total deposit/Total liability
Total expense ratio	TCTA	Total cost/Total assets
Bank size	LOTA	The logarithm of total assets
Equity-to-liability ratio	TETL	Total equity/Total liability
Ratio of loan loss provisions to net interest income	LLPII	Loan loss provisions/Net interest income

Several potential explanatory variables can influence the operating efficiency of Jordan banks. These variables can vary across banks and can be categorized into internal and external factors. Credit risk (CR), return on assets (ROA) and equity (ROE), total equity to total asset (TETA), total deposit to total liability (TDTL), total expense to total asset (TCTA), bank size measured by total assets (TA), total equity to total liability (TETL), and loan loss provisions to net interest income are considered as the most important recognized financial fundamentals in the banking sector, and our study will consider them to explain the behavior of banks' operating efficiency. We will use banking data for the 16 years for a sample of 15 commercial banks in Jordan. The data shown in Table 1 comprised 240 observations (16 observations per bank). Among the 15 banks, 13 were conventional banks and 2 were Islamic banks.

Table 3 provides summary statistics for the study variables. The mean operating efficiency ratio was 0.766 (SD = 0.585), with a minimum of −0.060 and a maximum of 3.681.

The average credit risk was 0.079 (SD = 0.052). The means of ROA and ROE were 0.012 (SD = 0.005) and 0.095 (SD = 0.042), respectively. Equity was roughly 13.2% of total assets and 21.1% of total liability, deposit was about 158.8% of total liability, and cost was around 2.4% of total assets. Bank size (LOTA) was measured as the logarithm of total assets, and the average LOTA was 9.11 (SD = 0.560). The average ratio of loan loss provisions to net interest income was 0.110 (SD = 0.108).

Table 3. Summary statistics of the study variables.

Variable	Mean	SD	Min	Max
CIR	0.766	0.585	−0.060	3.681
CR	0.079	0.052	0.001	0.281
ROA	0.012	0.005	−0.002	0.025
ROE	0.095	0.042	−0.010	0.218
TETA	0.132	0.031	0.071	0.220
TDTL	1.588	0.366	0.232	3.221
TCTA	0.024	0.010	0.007	0.074
LOTA	9.118	0.560	7.266	10.454
TETL	0.211	0.175	0.085	1.834
LLPII	0.110	0.108	−0.014	0.788

Table 4 presents pair-wise correlations among the variables involved in the study. The response variable, CIR, was statistically significantly positively correlated with ROA (r = 0.545), ROE (r = 0.474), TDTL (r = 0.135), and LOTA (r = 0.156), and statistically significantly negatively correlated with TCTA (r = −0.568). The correlation matrix also provides a first indication of possible multicollinearity issues: correlation values between two explanatory variables close to ±1 indicate that the given explanatory variables are multicollinear (Chatterjee and Hadi 2006). Table 4 shows that there may be issues of multicollinearity, as there were relatively high correlations between ROA and ROE (r = 0.802), and between ROE and LLPII (r = −0.503). The issue of multicollinearity was further assessed via the variance inflation factor (VIF), with VIF > 10 being a concern of multicollinearity (Chatterjee and Hadi 2006). As shown in Table 5, there may be collinearity between ROA (VIF = 17.312) and ROE (VIF = 17.690). Since both ROA and ROE were positively correlated with CIR and there was collinearity between ROA and ROE, it was decided to retain only ROA (the explanatory variable with a higher correlation with CIR) in the analysis of this study.

Table 4. Pearson's correlation coefficients.

Variables	CIR	CR	ROA	ROE	TETA	TDTL	TCTA	LOTA	TETL	LLPII
CIR	1	−0.049	0.545 *	0.474 *	0.086	0.135 **	−0.568 *	0.156 **	0.120	−0.037
CR		1	−0.229 *	−0.386 *	0.253 *	0.120	0.121	−0.115	−0.013	0.212 *
ROA			1	0.802 *	0.268 *	−0.037	−0.161 **	0.037	0.216 *	−0.408 *
ROE				1	−0.310 *	0.028	−0.337 *	0.193 *	0.047	−0.503 *
TETA					1	−0.184 *	0.284 *	−0.303 *	0.263 *	0.190 *
TDTL						1	−0.194 *	−0.077	−0.151 **	−0.091
TCTA							1	−0.125	−0.037	0.214 *
LOTA								1	−0.036	−0.087
TETL									1	0.059
LLPII										1

Note. * significant at the 0.01 level; ** significant at the 0.05 level.

Table 5. Variance inflation factors.

Variables	All Explanatory Variables	After Removing ROE
CR	1.144	1.236
ROA	17.312	1.649
ROE	17.690	
TETA	7.206	1.734
TDTL	1.185	1.141
TCTA	1.234	1.210
LOTA	1.155	1.146
TETL	1.146	1.139
LLPII	1.382	1.382

Analysis Methods

The data, involving repeated measurements on cross-sectional units (banks) over the period 2006–2021, were treated as panel data. Panel data econometric models (Greene 2012) were utilized for analysis due to their advantages in controlling heterogeneity and identifying effects not discernible through cross-sectional or time-series analysis alone (Hsiao 2003). The response variable under investigation is the cost-to-income ratio (CIR), with explanatory variables encompassing CR, ROA, TETA, TDTL, TCTA, LOTA, TETL, and LLPII. The methodology presented in this study compares seven different regression models between the selected financial fundamentals (the explanatory variables) and bank operating efficiency (the response variable): (1) a pooled regression model (POLS); (2) a one-way fixed group effect model (FE1g); (3) a one-way random group effect model (RE1g); (4) a one-way fixed time effect model (FE1t); (5) a one-way random group effect model (RE1t); (6) a two-way fixed effect model (FE2); and (7) a two-way random effect model (RE2). The SAS procedure PANEL was used to fit the panel data models.

Using the same formulation as Greene (2012), the panel data models can be written as the seven equations presented in Table 6, where $i = 1, \ldots, n$, and $t = 1, \ldots, T$, with n being the number of subjects and T being the number of time periods ($n = 15$ as there were 15 banks, and $T = 16$ as there were 16 time periods (2006–2021)). α is the intercept and βs are the regression coefficients. The error term ε_{it} is the random disturbance with mean equal to 0 and variance equal to σ_ε^2, and the errors are independent and identically distributed. α_1^g to α_k^g denote the group-specific constant term (k dummy variables were created for the group effect. K = 14). α_1^t to α_m^t denote the time-specific constant term (m dummy variables were created for the time effect. M = 15). The component u_i is the random heterogeneity specific to the i^{th} observation and is constant through time, with mean equal to 0 and variance equal to σ_u^2. The component ω_t is the random heterogeneity specific to the t^{th} year and is constant across banks, with mean equal to 0 and variance equal to σ_ω^2.

The F-test (Hill and Lim 2012) ($p < 0.05$ indicates that the fixed effects model is preferred over the pooled regression model), the Hausman statistic (Hausman 1978) ($p > 0.05$ indicates that the random effects model is preferred over the fixed effects model), and the Breusch and Pagan Lagrange multiplier (LM) test (Breusch and Pagan 1980) ($p < 0.05$ indicates that the random effects model is preferred over the pooled regression model) were used to aid in model specification. The Newey–West estimator (Newey and West 1986) was used for the heteroscedasticity- and autocorrelation-consistent (HAC) covariance matrix estimator to account for the possible autocorrelation and heteroskedasticity of the errors. Normality of the errors was examined via the quantile-quantile plots and was achieved for all panel regression models. The generalized R-squared (R2) (Buse 1973) was used to measure the proportion of the transformed sum of squares of the response variable that is attributable to the influence of the explanatory variables. The mean squared error (MSE) of the residuals was used to measure the amount of error in the econometric models. MSE assesses the average squared difference between the observed and predicted values for the response variable.

Table 6. Panel data models.

Model	Equation
POLS	$CIR_{it} = \alpha + \beta_1 CR_{it} + \beta_2 ROA_{it} + \beta_3 TETA_{it} + \beta_4 TDTL_{it} + \beta_5 TCTA_{it} + \beta_6 LOTA_{it} + \beta_7 TETL_{it} + \beta_8 LLPII_{it} + \varepsilon_{it}$
FE1g	$CIR_{it} = \alpha + \alpha_1^g + \alpha_2^g + \ldots + \alpha_k^g + \beta_1 CR_{it} + \beta_2 ROA_{it} + \beta_3 TETA_{it} + \beta_4 TDTL_{it} + \beta_5 TCTA_{it} + \beta_6 LOTA_{it} + \beta_7 TETL_{it} + \beta_8 LLPII_{it} + \varepsilon_{it}$
RE1g	$CIR_{it} = \alpha + \beta_1 CR_{it} + \beta_2 ROA_{it} + \beta_3 TETA_{it} + \beta_4 TDTL_{it} + \beta_5 TCTA_{it} + \beta_6 LOTA_{it} + \beta_7 TETL_{it} + \beta_8 LLPII_{it} + \mu_i + \varepsilon_{it}$
FE1t	$CIR_{it} = \alpha + \alpha_1^t + \alpha_2^t + \ldots + \alpha_m^t + \beta_1 CR_{it} + \beta_2 ROA_{it} + \beta_3 TETA_{it} + \beta_4 TDTL_{it} + \beta_5 TCTA_{it} + \beta_6 LOTA_{it} + \beta_7 TETL_{it} + \beta_8 LLPII_{it} + \varepsilon_{it}$
RE1t	$CIR_{it} = \alpha + \beta_1 CR_{it} + \beta_2 ROA_{it} + \beta_3 TETA_{it} + \beta_4 TDTL_{it} + \beta_5 TCTA_{it} + \beta_6 LOTA_{it} + \beta_7 TETL_{it} + \beta_8 LLPII_{it} + \omega_t + \varepsilon_{it}$
FE2	$CIR_{it} = \alpha + \alpha_1^g + \alpha_2^g + \ldots + \alpha_k^g + \alpha_1^t + \alpha_2^t + \ldots + \alpha_m^t + \beta_1 CR_{it} + \beta_2 ROA_{it} + \beta_3 TETA_{it} + \beta_4 TDTL_{it} + \beta_5 TCTA_{it} + \beta_6 LOTA_{it} + \beta_7 TETL_{it} + \beta_8 LLPII_{it} + \varepsilon_{it}$
RE2	$CIR_{it} = \alpha + \beta_1 CR_{it} + \beta_2 ROA_{it} + \beta_3 TETA_{it} + \beta_4 TDTL_{it} + \beta_5 TCTA_{it} + \beta_6 LOTA_{it} + \beta_7 TETL_{it} + \beta_8 LLPII_{it} + \mu_i + \omega_t + \varepsilon_{it}$

4. Results

In order to select the most appropriate estimator, a sequential choice process which relies on various specification tests, including the F-test ($p < 0.05$ indicates that the fixed effects model is preferred over the pooled regression model), the Hausman statistic ($p < 0.05$ indicates that the fixed effects model is preferred over the random effects model), and the Breusch and Pagan (LM) test ($p < 0.05$ indicates that the random effects model is preferred over the pooled regression model), was implemented (Table 7). The fixed effects model was preferred over the pool regression model and the random effects model, when comparing among (1) PLOS, FE1g, and RE1g; (2) PLOS, FE1t, and RE1t; and (3) PLOS, FE2, and RE2.

Table 7. Summary of panel regression models.

Variable	POLS	FE1g	RE1g	FE1t	RE1t	FE2	RE2
Intercept	−1.0806 (0.6622)	2.3743 (1.7208)	−1.2568 (1.3519)	−1.1192 (0.5982) ***	−1.0318 (0.5285) ***	−4.7331 (2.3568) **	−1.2346 (0.9648)
CR	0.8116 (0.4780) ***	1.1653 (0.7605)	0.8331 (0.8631)	0.3461 (0.4944)	0.6606 (0.3954) ***	0.4442 (0.6493)	0.5762 (0.5805)
ROA	67.8018 (5.8310) *	62.5929 (5.3917) *	64.4635 (9.2808) *	67.1775 (5.7283) *	67.7325 (5.1268) *	57.1628 (4.8961) *	62.7066 (5.8042) *
TETA	1.2528 (1.3092)	1.5327 (1.7250)	1.3453 (1.9663)	0.7278 (1.2262)	1.0420 (1.1878)	0.9018 (1.6803)	0.9479 (1.5219)
TDTL	0.1399 (0.0753) ***	0.1868 (0.0761) **	0.1598 (0.1290)	0.1119 (0.0744)	0.1309 (0.0624) **	0.0827 (0.0853)	0.1437 (0.0787) ***
TCTA	−32.9976 (6.2054) *	−28.9000 (6.2486) *	−31.3605 (5.7669) *	−29.8022 (6.0004) *	−31.8448 (5.8321) *	−25.4522 (5.5594) *	−29.0802 (6.2379) *
LOTA	0.1332 (0.0577) **	0.2699 (0.1651)	0.1482 (0.1253)	0.1295 (0.0508) **	0.1311 (0.0472) *	0.5117 (0.1820) *	0.1531 (0.0900) ***
TETL	−0.1508 (0.1989)	−0.1352 (0.2314)	−0.1350 (0.2239)	−0.1138 (0.1978)	−0.1350 (0.1989)	−0.0282 (0.1980)	−0.0948 (0.2128)
LLPII	1.6939 (0.2930) *	1.5137 (0.2655) *	1.6171 (0.3890) *	1.5624 (0.2810) *	1.6434 (0.2789) *	1.4303 (0.2335) *	1.5192 (0.2684) *

Table 7. *Cont.*

Variable	POLS	FE1g	RE1g	FE1t	RE1t	FE2	RE2
F test for fixed group effect		F(14, 217) = 1.93, $p = 0.0244$					
F test for fixed time effect				F(15, 216) = 1.78, $p = 0.0389$			
F test for fixed group and time effects						F(29, 202) = 2.18, $p = 0.0010$	
Hausman test			$\chi^2(8) = 21.35$, $p = 0.0063$		$\chi^2(8) = 16.99$, $p = 0.0302$		$\chi^2(8) = 15.67$, $p = 0.0474$
Breusch-Pagan LM test			$\chi^2(1) = 2.02$, $p = 0.1554$		$\chi^2(1) = 1.32$, $p = 0.2513$		$\chi^2(1) = 2.20$, $p = 0.1380$
MSE	0.1257	0.1190	0.1188	0.1204	0.1205	0.1095	0.1094
R^2	0.6445	0.6839	0.5962	0.6817	0.6299	0.7291	0.5489

Note: * indicates $p < 0.01$; ** indicates $p < 0.05$; *** indicates $p < 0.10$.

Since the F-test of FE1g (F(14, 217) = 1.93, $p = 0.0244$) suggested there was a statistically significant bank effect, and the F-test of FE1t (F(15, 216) = 1.78, $p = 0.0389$) suggested there was a statistically significant time effect, FE2 was selected as the final model. By fully considering the panel structure of the data, the FE2 specification enabled us to analyze the systematic CIR of a bank over both space (cross-sectional analysis) and time (time series analysis), thus allowing us to account for unobserved heterogeneity across banks and years that may be related with banks' CIR. The chosen model (FE2) was also the one associated with a lower MSE and the highest R-squared (the equation accounts for over 70% of the variability in bank CIR).

Based on the results of FE2:

- There was a statistically significantly positive relationship between the operating efficiency ratio (CIR) and return on assets (ROA, β = 57.1628), bank size (LOTA, β = 0.5117), and the ratio of loan loss provisions to net interest income (LLPII, β = 1.4303);
- There was a statistically significantly negative relationship between the operating efficiency ratio (CIR) and the total expense ratio (TCTA, β = −25.4522);
- There was no statistically significant relationship between the operating efficiency ratio (CIR) and credit risk (CR), the equity-to-asset ratio (TETA), the deposit-to-liability ratio (TDTL), and the equity-to-liability ratio (TETL).

Tables 8–11 demonstrate the full regressions results of the panel models.

Table 8. Detailed regression results for pooled OLS.

Variable	β	SE	*t*	DF	*p*
Intercept	−1.0806	0.6622	−1.63	231	0.1041
CR	0.8116	0.4780	1.70	231	0.0909
ROA	67.8018	5.8310	11.63	231	<0.0001
TETA	1.2528	1.3092	0.96	231	0.3396
TDTL	0.1399	0.0753	1.86	231	0.0644
TCTA	−32.9976	6.2054	−5.32	231	<0.0001
LOTA	0.1332	0.0577	2.31	231	0.0219
TETL	−0.1508	0.1989	−0.76	231	0.4491
LLPII	1.6939	0.2930	5.78	231	<0.0001

Note: β = parameter estimate; SE = standard error; *t* = *t*-statistic; DF = degrees of freedom (=number of observations − number of parameters); *p* = *p*-value.

Table 9. Detailed regression results for the one-way fixed group effects model and the one-way random group effects model.

	FE1g					RE1g				
Variable	**β**	**SE**	***t***	**DF**	***p***	**β**	**SE**	***t***	**DF**	***p***
Cross section effect 1	0.2491	0.3481	0.72	217	0.4750					
Cross section effect 2	−0.1501	0.1547	−0.97	217	0.3328					
Cross section effect 3	−0.1940	0.1617	−1.20	217	0.2317					
Cross section effect 4	−0.2343	0.1419	−1.65	217	0.1003					
Cross section effect 5	0.1377	0.1465	0.94	217	0.3481					
Cross section effect 6	−0.2215	0.1367	−1.62	217	0.1068					
Cross section effect 7	−0.2701	0.1624	−1.66	217	0.0977					
Cross section effect 8	−0.2250	0.1623	−1.39	217	0.1670					
Cross section effect 9	−0.2556	0.1447	−1.77	217	0.0788					
Cross section effect 10	−0.1150	0.1525	−0.75	217	0.4516					
Cross section effect 11	−0.0175	0.1604	−0.11	217	0.9133					
Cross section effect 12	−0.1475	0.1606	−0.92	217	0.3593					
Cross section effect 13	−0.0851	0.1911	−0.45	217	0.6565					
Cross section effect 14	−0.1397	0.1429	−0.98	217	0.3295					
Intercept	−2.3743	1.7208	−1.38	217	0.1691	−1.2568	1.3519	−0.93	231	0.3535
CR	1.1653	0.7605	1.53	217	0.1269	0.8331	0.8631	0.97	231	0.3355
ROA	62.5929	5.3917	11.61	217	<0.0001	64.4635	9.2808	6.95	231	<0.0001
TETA	1.5327	1.7250	0.89	217	0.3752	1.3453	1.9663	0.68	231	0.4945
TDTL	0.1868	0.0761	2.46	217	0.0149	0.1598	0.1290	1.24	231	0.2165
TCTA	−28.9000	6.2486	−4.63	217	<0.0001	−31.3605	5.7669	−5.44	231	<0.0001
LOTA	0.2699	0.1651	1.63	217	0.1036	0.1482	0.1253	1.18	231	0.2380
TETL	−0.1352	0.2314	−0.58	217	0.5596	−0.1350	0.2239	−0.60	231	0.5472
LLPII	1.5137	0.2655	5.70	217	<0.0001	1.6171	0.3890	4.16	231	<0.0001

Note: β = parameter estimate; SE = standard error; *t* = *t*-statistic; DF = degrees of freedom (=number of observations − number of parameters); *p* = *p*-value. For the cross section effect, bank #15 (Jordan Islamic Bank) was the reference group.

Table 10. Detailed regression results for the one-way fixed time effects model and the one-way random time effects model.

	FE1t					RE1t				
Variable	**β**	**SE**	***t***	**DF**	***p***	**β**	**SE**	***t***	**DF**	***p***
Time effect 1	−0.0122	0.1488	−0.08	216	0.9349					
Time effect 2	0.1754	0.1441	1.22	216	0.2249					
Time effect 3	0.0925	0.1406	0.66	216	0.5114					
Time effect 4	0.0825	0.1350	0.61	216	0.5416					
Time effect 5	0.2394	0.1376	1.74	216	0.0833					
Time effect 6	0.4097	0.1359	3.01	216	0.0029					
Time effect 7	0.3792	0.1348	2.81	216	0.0054					
Time effect 8	0.2280	0.1344	1.70	216	0.0911					

Table 10. *Cont.*

	FE1t					RE1t				
Time effect 9	0.1452	0.1337	1.09	216	0.2784					
Time effect 10	0.1836	0.1308	1.40	216	0.162					
Time effect 11	0.2946	0.1297	2.27	216	0.0241					
Variable	**β**	**SE**	***t***	**DF**	***p***	**β**	**SE**	***t***	**DF**	***p***
Time effect 12	0.0952	0.1291	0.74	216	0.4619					
Time effect 13	0.0808	0.1292	0.63	216	0.5326					
Time effect 14	0.0367	0.1279	0.29	216	0.7741					
Time effect 15	0.1288	0.1306	0.99	216	0.3248					
Intercept	−1.1192	0.5982	−1.87	216	0.0627	−1.0318	0.5285	−1.95	231	0.0521
CR	0.3461	0.4944	0.70	216	0.4846	0.6606	0.3954	1.67	231	0.0962
ROA	67.1775	5.7283	11.73	216	<0.0001	67.7325	5.1268	13.21	231	<0.0001
TETA	0.7278	1.2262	0.59	216	0.5534	1.0420	1.1878	0.88	231	0.3813
TDTL	0.1119	0.0744	1.50	216	0.1340	0.1309	0.0624	2.10	231	0.0370
TCTA	−29.8022	6.0004	−4.97	216	<0.0001	−31.8428	5.8321	−5.46	231	<0.0001
LOTA	0.1295	0.0508	2.55	216	0.0115	0.1311	0.0472	2.78	231	0.0059
TETL	−0.1138	0.1978	−0.58	216	0.5658	−0.1350	0.1989	−0.68	231	0.4979
LLPII	1.5624	0.2810	5.56	216	<0.0001	1.6434	0.2789	5.89	231	<0.0001

Note: β = parameter estimate; SE = standard error; *t* = *t*-statistic; DF = degrees of freedom (=number of observations − number of parameters); *p* = *p*-value. For the time effect, year = 2021 was the reference group.

Table 11. Detailed regression results for the two-way fixed effects model and the two-way random effects model.

	FE2					RE2				
Variable	**β**	**SE**	***t***	**DF**	***p***	**β**	**SE**	***t***	**DF**	***p***
Cross section effect 1	0.8536	0.4911	1.74	202	0.0837					
Cross section effect 2	0.0353	0.1735	0.20	202	0.8391					
Cross section effect 3	0.0001	0.1780	0	202	0.9993					
Cross section effect 4	−0.1457	0.1391	−1.05	202	0.2963					
Cross section effect 5	0.2768	0.1458	1.90	202	0.0591					
Cross section effect 6	−0.1068	0.1377	−0.78	202	0.4392					
Cross section effect 7	−0.1337	0.1618	−0.83	202	0.4095					
Cross section effect 8	−0.0680	0.1777	−0.38	202	0.7026					
Cross section effect 9	−0.1466	0.1437	−1.02	202	0.3091					
Cross section effect 10	0.0640	0.1732	0.37	202	0.7121					
Cross section effect 11	0.0679	0.1565	0.43	202	0.6648					
Cross section effect 12	0.1096	0.1970	0.56	202	0.5786					
Cross section effect 13	−0.0302	0.1937	−0.16	202	0.8761					
Cross section effect 14	0.0338	0.1586	0.21	202	0.8315					
Time effect 1	0.2393	0.1819	1.32	202	0.1898					
Time effect 2	0.3670	0.1704	2.15	202	0.0325					
Time effect 3	0.2654	0.1595	1.66	202	0.0976					

Table 11. *Cont.*

	FE2					RE2				
Variable	**β**	**SE**	***t***	**DF**	***p***	**β**	**SE**	***t***	**DF**	***p***
Time effect 4	0.2240	0.1500	1.49	202	0.1369					
Time effect 5	0.4002	0.1496	2.68	202	0.0081					
Time effect 6	0.5539	0.1457	3.8	202	0.0002					
Time effect 7	0.5191	0.1399	3.71	202	0.0003					
Time effect 8	0.3505	0.1381	2.54	202	0.0119					
Time effect 9	0.2544	0.1349	1.89	202	0.0607					
Time effect 10	0.2521	0.1283	1.96	202	0.0508					
Time effect 11	0.3815	0.1277	2.99	202	0.0032					
Time effect 12	0.1246	0.1254	0.99	202	0.3215					
Time effect 13	0.1171	0.1247	0.94	202	0.3487					
Time effect 14	0.0698	0.1230	0.57	202	0.5712					
Time effect 15	0.0921	0.1265	0.73	202	0.4676					
Intercept	−4.7331	2.3568	−2.01	202	0.0459	−1.2346	0.9648	−1.28	231	0.2020
CR	0.4442	0.6493	0.68	202	0.4947	0.5762	0.5805	0.99	231	0.3220
ROA	57.1628	4.8961	11.68	202	<0.0001	62.7066	5.8042	10.80	231	<0.0001
TETA	0.9018	1.6803	0.54	202	0.5920	0.9479	1.5219	0.62	231	0.5340
TDTL	0.0827	0.0853	0.97	202	0.3335	0.1437	0.0787	1.83	231	0.0692
TCTA	−25.4522	5.5594	−4.58	202	<0.0001	−29.0802	6.2379	−4.66	231	<0.0001
LOTA	0.5117	0.1820	2.81	202	0.0054	0.1531	0.0900	1.70	231	0.0903
TETL	−0.0282	0.1980	−0.14	202	0.8868	−0.0948	0.2128	−0.45	231	0.6564
LLPII	1.4303	0.2335	6.13	202	<0.0001	1.5192	0.2684	5.66	231	<0.0001

Note: β = parameter estimate; SE = standard error; *t* = *t*-statistic; DF = degrees of freedom (=number of observations − number of parameters); *p* = *p*-value. For the cross section effect, bank #15 (Jordan Islamic Bank) was the reference group. For the time effect, year = 2021 was the reference group.

5. Findings and Discussion

The study explores the impact of key financial indicators on Jordanian banks' operational efficiency from 2006 to 2021. Focusing on fifteen commercial banks, it employs seven regression models to assess the selected variables' impact. Findings reveal a statistically significant influence of both bank-specific factors and temporal effects. A positive correlation is identified between the operating efficiency ratio and return on assets (ROA), bank size (LOTA), and the ratio of loan loss provisions to net interest income (LLPII). This highlights that effective loss provisions policies, attention to ROA, and the promotion of bank size are essential for bank management. Conversely, a negative relationship is observed between the operating efficiency ratio and the total expense ratio (TCTA), emphasizing the crucial role of effective cost management in maintaining high operating efficiency.

No significant associations are found between the operating efficiency ratio and credit risk (CR), the equity-to-asset ratio (TETA), the deposit-to-liability ratio (TDTL), and the equity-to-liability ratio (TETL). It is important to note that the absence of direct associations does not rule out the importance of these financial indicators. While our study does not find statistically significant correlations, further research into the nuanced relationships between credit risk and operational efficiency, as well as the roles of equity and deposit-to-liability ratios, could provide useful insights. The dynamic nature of the banking sector, combined with Jordan's distinct economic landscape, may introduce complexities beyond this analysis's scope. Future research could delve deeper into contextual factors influencing the observed relationships, considering regulatory changes, market dynamics, and broader economic conditions.

Understanding the intricate interplay between these financial metrics and operational efficiency is critical for informing strategic banking decision-making. A comprehensive examination, taking into account not only statistical significance but also practical relevance, could contribute to a more comprehensive understanding of the factors influencing Jordanian banks' operational efficiency. As the financial sector evolves, ongoing research efforts will be critical in adapting management practices, regulatory frameworks, and policy measures to ensure Jordan's banking sector's resilience and sustainability.

6. Conclusions

In conclusion, our study conducts an in-depth exploration of the intricate dynamics influencing the operational efficiency of Jordanian banks over the period 2006 to 2021. Through a meticulous analysis of key financial indicators, we uncover notable correlations that shed light on critical areas for effective management. The positive relationships identified with return on assets (ROA), bank size (LOTA), and the ratio of loan loss provisions to net interest income (LLPII) underscore the importance of effective loss provisions policies and strategic attention to ROA and bank size. In contrast, the observed negative correlation with the total expense ratio (TCTA) highlights the imperative for banks to implement innovative cost-management strategies without compromising operational efficiency. Beyond these findings, the absence of significant associations with credit risk (CR), deposit-to-liability ratio (TDTL), and equity ratios (TETA and TETL) prompts further exploration into additional factors influencing operational efficiency.

The implications of our findings go beyond the Jordanian context, providing valuable guidance for global banking practices. Positive correlations emphasize the importance of tailoring policies for optimal performance, which is applicable to financial institutions worldwide. The negative relationship with TCTA suggests a universal need for innovative cost management, prompting international banks to reconsider expense strategies. While specific findings may be influenced by Jordan's unique context, the adaptable methodological framework can be used to study banking efficiency globally. Researchers can use our findings to account for local variations, resulting in a more nuanced understanding of operational efficiency drivers in a variety of international contexts.

While our study provides valuable insights, acknowledging certain limitations is essential for a comprehensive understanding. The modeling approach, comprising seven regression models, inherently involves simplifications and assumptions that may not fully encapsulate the complexities of the banking sector. Financial markets' dynamics, regulatory changes, and unforeseen external factors may introduce variations not accounted for in the models, necessitating cautious interpretation. The total sample of 15 banks, reflecting 240 observations over a 16-year period, allows for a comprehensive examination but raises considerations about result robustness. The relatively small sample size, particularly compared to the broader Jordanian banking system, may limit the generalizability of our findings. This study, while insightful for the selected banks, may not fully represent the entire sector, comprising 23 licensed banks.

These limitations underscore the necessity for future research to expand the scope and enhance the robustness of our findings. A larger and more diverse sample, encompassing a broader representation of banks within the Jordanian system, could offer a more comprehensive understanding. Additionally, alternative modeling techniques and methodological approaches may provide complementary perspectives, enhancing the applicability and reliability of future research. In navigating these limitations, our study contributes to the ongoing dialogue on banking efficiency, providing a foundation for future endeavors that strive for a more nuanced understanding of this complex landscape.

As we transition to a closer examination of our statistical models in Table 7, it becomes apparent that the determination coefficients (R-squared values) warrant discussion. These coefficients, while varying, play a crucial role in assessing the reliability of our models for decision-making. The nuances and considerations surrounding these coefficients are pivotal in understanding the strength of the relationships captured by our regression models.

The R-squared (R2) values for the presented panel regression models are shown above. It is acknowledged that these coefficients vary and may be considered relatively low. R-squared values range from 0.5489 to 0.7291 across various model specifications. While these values indicate that the models explain a moderate-to-substantial proportion of the variability in the dependent variable, they must be interpreted in the context of the specific phenomenon under investigation. In complex settings, such as the banking industry, where multiple factors influence the outcome, achieving high R-squared values can be challenging. Nevertheless, the models provide valuable insights into the relationships between the dependent and independent variables, contributing to our understanding of the dynamics at play.

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