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Fintech, Banking Factors, and Economic Drivers of Efficiency in Jordan's Banking Sector: Insights from DEA, SBM, and Logit Models

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ABSTRACT

The study aims to evaluate the efficiency of the banking sector in Jordan from 2011 to 2022, employing the data envelopment analysis (DEA) methodology, slacks-based models (SBM), and Logit regression models. The findings show that, overall, the Jordanian banking sector demonstrates high efficiency, though there is variation across individual banks, despite the economic and geopolitical challenges faced during the study period. The study also examines the factors influencing the efficiency of Jordanian commercial banks, including banking and economic variables, as well as the impact of the COVID-19 pandemic. The results reveal that capital adequacy and Fintech adoption have the most significant positive effect on bank efficiency, while market concentration, measured by the Herfindahl-hirschman index (HHI), has the most substantial negative impact. The paper emphasizes the importance of continuous improvements in risk management, technological adoption, and operational efficiency, as well as fostering greater competition between banks. Additionally, it highlights the critical role of macroeconomic stability in supporting long-term banking sector efficiency.

Keywords: Technical Efficiency, Data Envelopment Analysis, Slacks-Based Models, Logit Model, Capital Adequacy, Fintech
JEL Classifications: G21, G28, O16, E44

1. INTRODUCTION[1]

The banking sector plays a pivotal role in the financial system by acting as an intermediary between savers and borrowers, thereby driving economic growth and development. The efficiency with which banks transform inputs—such as capital, labor, and technology—into outputs like loans, deposits, and investments, is crucial for ensuring the stability and expansion of an economy. Efficient banks not only provide better services to customers but also enhance profitability and contribute to the overall competitiveness of the financial sector. This efficiency is particularly vital for the smooth flow of capital, which is essential for sustaining economic activity and fostering innovation.

In Jordan, the banking sector is the cornerstone of the financial system, with assets totaling JOD 64.0 billion (USD 90.3 billion) at the end of 2023, up from JOD 60.6 billion (USD 85.5 billion) at the end of 2022. This represents 96.2% of the total assets in the financial sector and, as of 2022, 179.9% of GDP. Despite the local, regional, and global challenges faced by Jordan, the region, and the world, the Jordanian banking sector has maintained high levels of capital adequacy, well above the international standards set by Basel III (10.5%), indicating strong solvency and the capacity to absorb potential losses (Central Bank of Jordan, 2023).

Throughout the study period, the Jordanian economy encountered numerous challenges, notably the COVID-19 pandemic, followed by geopolitical tensions in the Arab region and beyond, along with broader economic repercussions. Nonetheless, the banking sector demonstrated resilience, thanks to the proactive policies of the

1 Disclaimer: The views and opinions expressed in this paper are those of the author and do not necessarily reflect the official policy or position of any organization or institution.

Central Bank of Jordan and the effective risk management and operational efficiency of banks.

Overall, financial stability indicators suggest that the Jordanian banking sector is sound, resilient, and generally capable of withstanding shocks and high risks. However, it remains crucial to continuously assess the sector's performance, both in normal and stressful times. Operational efficiency is a key financial stability indicator used to evaluate risk management and overall bank performance. It enables the sector to continue playing its vital role in supporting liquidity within the economy.

Assessing the efficiency of the banking sector is essential for sustaining both economic and financial stability, as it directly influences the broader economy's performance. Efficient banks are better equipped to manage risks, reduce operational costs, and offer competitive financial products, collectively enhancing economic productivity and growth. Regular evaluations of banking efficiency—through metrics such as profitability, liquidity, and credit risk management—enable regulators to identify potential vulnerabilities or inefficiencies that could undermine the sector's stability. A well-evaluated banking system ensures credit is allocated to productive sectors, financial markets remain stable, and consumers are shielded from excessive risks, especially during times of economic uncertainty.

Various methods are used to assess bank efficiency, with data envelopment analysis (DEA) being one of the most widely applied non-parametric techniques. DEA estimates efficiency scores by comparing a bank's performance to an optimal frontier of best-practice banks. However, it has certain limitations, such as its sensitivity to outliers and its assumption of constant returns to scale. To address these issues, Slacks-based models (SBM) have been developed to provide more accurate measurements by accounting for excess inputs and outputs. Additionally, Logit models are commonly used to explore the factors influencing banking efficiency by linking efficiency scores to various bank-specific and macroeconomic variables. These models offer valuable insights into the determinants of bank performance.

This study seeks to assess the efficiency of Jordan's banking sector using DEA, SBM, and Logit models, examining the factors that influence banking efficiency and investigating the relationship between these factors and the performance of financial institutions. The study is organized into four main sections: A comprehensive literature review, methodology and data description, result analysis, and a concluding discussion with key findings and policy implications.

2. LITERATURE REVIEW

DEA is a widely used non-parametric method for evaluating the efficiency of decision-making units (DMUs), such as banks. It compares the relative efficiency of banks by analyzing their input-output combinations, with the goal of maximizing outputs given the available inputs. This method has been extensively employed to assess both technical and cost efficiency in banks across various regions.

Efficiency analysis has been a key focus in studies examining the global banking sector. Scholars like Berger and Humphrey (1997) and Sherman and Gold (1985) have used DEA to evaluate bank performance, highlighting the importance of operational efficiency for financial stability and growth. Nataraja et al. (2018) demonstrated that higher operational efficiency reduces operating expenses and enhances return on assets (ROA), which in turn impacts profitability. Jackson and Fethi (2000) applied DEA to Turkish banks, finding that larger, more profitable banks tend to be more efficient. In the Middle East, studies such as Apergis and Polemis (2016) explored the relationship between competition and efficiency in MENA banks, revealing significant linkages. Achi (2023) used DEA to assess Algerian banks' efficiency and factors influencing their performance. In Islamic banking, DEA has also been widely applied to assess performance. Researchers like Hasan and Dridi (2011) and Rosman et al. (2014) highlighted the unique challenges faced by Islamic banks, while Johnes et al. (2014) compared Islamic and conventional banks, showing that, although Islamic banks had comparable efficiency, they faced issues due to a lack of product standardization. Recent studies, such as Istaiteyeh et al. (2024), applied DEA to evaluate the efficiency of Jordanian banks, finding significant relationships between banking efficiency and factors such as return on assets, return on equity, and GDP growth, with Islamic banks showing higher efficiency than conventional ones.

Despite its widespread use, DEA has some limitations, including its sensitivity to outliers and its assumption of constant returns to scale. To address these limitations, complementary methods such as the Slacks-based measure (SBM) have been developed. Introduced by Tone (2001), SBM incorporates both input and output slacks into the efficiency analysis, allowing for a more detailed identification of inefficiencies by considering excess inputs and outputs. This method provides a more granular analysis, which is especially valuable in the banking sector, where various inefficiencies can emerge simultaneously.

Liu (2009) employed DEA with SBM to evaluate the performance of 24 commercial banks in Taiwan. By incorporating slacks in both input and output factors, this study overcomes the typical time lag associated with DEA evaluations. Rather than relying on the publication of financial statements, Liu calculates efficiency scores based on financial forecasts. The results show that the efficiency scores derived from forecasts are not significantly different from those based on actual financial statements, and the study successfully predicted poor bank performance in advance. Shafiee et al. (2013) demonstrated that the dynamic SBM model offers a more comprehensive evaluation of Iranian banks' performance, providing a clearer understanding of the relationship between profits and losses.

While DEA and SBM are powerful tools for measuring efficiency, they do not directly address the factors that influence efficiency. To fill this gap, Logit models—an econometric technique—are commonly used to identify determinants of banking efficiency. These models link efficiency outcomes (often binary, such as efficient vs. inefficient) to various independent variables, including internal bank characteristics and external macroeconomic factors.

For instance, Ullah et al. (2023) applied Logit models to identify the factors influencing banking efficiency in emerging economies. Their findings show that corporate governance, ultimate global ownership, and return on equity have a positive and significant impact on bank efficiency. On the other hand, enterprise risk management and financial leverage negatively affect efficiency. The study suggests that effective corporate governance allows banks to better manage risk and capital costs, thereby improving capital efficiency. Strong risk management practices also contribute to more effective operational and strategic decision-making, helping banks succeed in competitive markets. Further, several studies have used Logit models to predict banking sector failure (e.g., Cheong and Ramasamy, 2019; Obeid, 2022).

In conclusion, recent studies using DEA, SBM, and Logit models have provided valuable insights into both measuring banking efficiency and identifying its determinants. The incorporation of SBM has improved the accuracy of efficiency assessments, while Logit models have been instrumental in exploring the factors that influence bank performance. Further research is needed to continue investigating the dynamic interplay between internal and external determinants, as well as the effects of emerging technologies on banking efficiency.

3. DATA AND METHODOLOGY

3.1. Data and Variables

This study uses panel data from 14 Jordanian commercial banks over the period from 2011 to 2022. The data are derived from the banks' annual financial statements, which include key financial indicators such as total assets, capital adequacy ratios, return on assets (ROA), and other relevant performance metrics. The chosen time period enables an analysis of trends and changes in the banking sector over a decade, capturing the impact of economic fluctuations, regulatory shifts, and other macroeconomic factors. The panel data approach allows us to explore both cross-sectional variations across different banks and time-series variations within each bank, offering a comprehensive view of the factors affecting the banks' efficiency and overall performance.

To evaluate the efficiency of the banking sector and identify its determinants, we apply data envelopment analysis (DEA), Slacks-based models (SBM), and Logit models. The variables used in these models are presented in Table 1, which assesses bank performance and efficiency.

3.2. Study Methodology

We first use DEA, a non-parametric method used to assess the relative efficiency of DMUs, in this case, banks. DEA evaluates how efficiently a bank uses its inputs (e.g., assets, labor, capital) to generate outputs (e.g., loans, deposits, profits).

DEA assumes that there is a production frontier formed by the best-performing banks. These banks are deemed efficient and are used as benchmarks to compare the efficiency of other banks. DEA operates under the assumption of constant returns to scale (CRS) or variable returns to scale (VRS). The model calculates an efficiency score between 0 and 1, where a score of 1 indicates

Table 1: Variables for assessing the efficiency of the Arab Banking sector using DEA, SBM, and logit models

Variable	Definition	Explanation	Data source
(i). Category: Efficiency			
Efficiency Score (DEA/SBM) (Dependent Variable)	The efficiency score derived from DEA/SBM models, which measures how efficiently a bank uses its inputs to produce outputs.	The dependent variable, reflecting the operational efficiency of banks. A higher efficiency score (closer to 1) indicates better performance, while inefficiency is represented by lower scores.	Bank's annual financial statements
(ii). Category: Input			
Bank Size (Total Assets)	The total value of assets held by a bank (The natural logarithm)	Larger banks are expected to be more efficient due to economies of scale. Therefore, bank size typically has a positive relationship with efficiency.	Bank's annual financial statements
Labor (Employees)	The total number of employees or labor used in the production process.	More labor input may lead to inefficiency if it exceeds the output, thus a negative relationship with efficiency.	Bank's annual financial statements
Capital	The total amount of capital employed by a bank in the business.	Greater capital allows for a bank to take on more risk, which may lead to better efficiency, thus a positive relationship.	Bank's annual financial statements
(iii). Category: Output			
Loans	Total value of loans granted to customers.	A greater volume of loans implies better resource utilization, which enhances efficiency. Positive relationship expected.	Bank's annual financial statements
Deposits	Total value of deposits made by customers.	More deposits indicate better financial health and are generally associated with improved efficiency. Positive relationships are expected.	Bank's annual financial statements
Profits	The net income earned by the bank from its operations.	Higher profits reflect better performance, hence a positive relationship with efficiency is expected.	Bank's annual financial statements
(iv). Category: Determinant			
Capital adequacy ratio (CAR)	The ratio of a bank's capital to its risk-weighted assets, indicating the bank's financial strength.	This ratio is a measure of a bank's ability to absorb losses. A higher CAR suggests that the bank is more stable, which should improve efficiency.	Bank's annual financial statements

(Contd...)

Table 1: *(Continued)*

Variable	Definition	Explanation	Data source
Return on assets (ROA)	Measures profitability as the ratio of net income to total assets.	This profitability measure indicates how well a bank utilizes its assets to generate profits. A higher ROA indicates higher operational efficiency.	Bank's annual financial statements
Non-performing loans (NPL)	The ratio of loans that are in default or close to default.	A higher ratio of NPLs indicates inefficiency because it reflects the bank's struggle with bad loans, which negatively affects profitability and operational performance.	Bank's annual financial statements
Liquidity ratio (LIQ)	The ratio of liquid assets to short-term liabilities, showing a bank's ability to meet its short-term obligations.	Banks with higher liquidity can better manage their short-term obligations, leading to better efficiency in operations.	Bank's annual financial statements
Fintech Index (FIN)	Building on the work of Guo and Zhang (2023), textual analysis methods using word segmentation algorithms and word frequency statistics were employed. Python software was utilized to calculate the frequency of keywords at the bank-year level. This process involved dividing the number of occurrences of each keyword in a bank's annual report by the total word count of the report to determine its relative frequency[2].	Banks with higher FIN scores are likely to experience enhanced efficiency, as they adopt Fintech solutions that streamline operations and open new revenue streams.	Author calculation based on the annual reports of banks.
GDP growth rate (GDP)	The annual percentage growth rate of the country's Gross Domestic Product (GDP).	A growing economy creates better conditions for bank profitability and efficiency, leading to a positive relationship with bank performance.	Central bank of Jordan data base
Inflation rate (INF)	The rate of inflation in the economy.	High inflation can decrease the purchasing power of a bank's assets and liabilities, negatively affecting operational efficiency.	Central bank of Jordan data base
Interest rate (IR)	The prevailing interest rates set by central banks.	Higher interest rates typically improve profitability by allowing banks to charge higher interest on loans, improving efficiency.	Central bank of Jordan data base
Herfindahl-hirschman index (HHI)	A measure of market concentration, calculated as the sum of the squares of the market shares of all banks in the market.	A higher HHI indicates less competition in the market. This can reduce the pressure on banks to improve efficiency, thus leading to a negative relationship with efficiency.	Central bank of Jordan data base
COVID	COVID takes binary values: 1 for the year 2020 and 0 for all other years.	It is expected that this variable will have a negative impact on banking efficiency.	-

that the bank is efficient (operating on the frontier) and a score <1 indicates inefficiency.

The general form of the DEA model is as follows:

$$Maximize\ \theta = \frac{\sum_{r=1}^{m} \lambda_r y_r}{y_0} \quad (1)$$

Subject to:

$$\sum_{r=1}^{m} \lambda_r y_r \le y_0 \ for\ outputs$$

$$\sum_{s=1}^{n} \lambda_s x_s \le x_0 \ for\ inputs$$

Where:
θ is the efficiency score of the DMU (bank) being evaluated.
y_0 and x_0 are the outputs and inputs of the evaluated bank (under evaluation), respectively.
y_r and x_s are the outputs and inputs of the evaluated bank, respectively.
λ_r is a set of weights assigned to each bank.
m is the total numbers of banks.

DEA generates an efficiency score, which is critical for analyzing the relative performance of banks within a sector. This score helps identify which banks are operating efficiently and which are not, offering valuable insights into their performance.

To address some of DEA's limitations, we then use SBM. Unlike DEA, SBM specifically focuses on the "slacks"—the excess inputs and outputs—that contribute to inefficiency. By incorporating these slacks, SBM provides a more detailed and accurate measure of inefficiency, allowing for a clearer understanding of where banks can improve their operations.

While DEA identifies inefficiency, it does not specify how much "excess" input or "deficiency" in output contributes to that

2 This index measures the frequency of Fintech-related terms or keywords in the annual reports of banks, serving as a proxy for the bank's engagement with Fintech and its commitment to innovation (Guo et al., 2023). In accordance with this study, keyword frequencies are normalised

The formula is $\dfrac{\sum_{i=1}^{n} Frequency\ of\ Fintech\ or\ related\ terms\ in\ the\ annual\ report\ of\ bank\ i}{Total\ words\ count\ or\ pages\ in\ the\ annual\ report}$

inefficiency. SBM overcomes this by measuring the slack in both inputs and outputs, offering a more nuanced and comprehensive understanding of inefficiency.

SBM is formulated as:

$$Minimize\ \theta = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{S_i^+}{X_i}+\frac{S_i^-}{Y_i}\right) \quad (2)$$

Where θ is the efficiency score, N is the number of decision-making units (DMUs). S_i^+ represents the input slack (excess inputs), and S_i^- represents the output slack (deficiency in outputs). These are the excess inputs and outputs that need to be reduced or increased to improve efficiency. X_i and Y_i are the input and output values, respectively, for the i-th DMU.

SBM enables a more precise identification of inefficiencies and offers a more detailed approach to managing banking performance. By highlighting specific input and output slacks, it provides banks with actionable insights into areas where they can optimize their operations, making it a valuable tool for enhancing overall efficiency.

Finally, we employ the Logit regression model, which is particularly useful when the dependent variable is binary, such as classifying banks as either efficient (1) or inefficient (0). The Logit model predicts the likelihood of a bank being efficient (i.e., achieving an efficiency score above a certain threshold) based on a set of independent variables. These variables include both bank-specific characteristics, market industry indicators, and macroeconomic factors (see Table 1).

The Logit model for the probability that a bank i is efficient is given by:

$$P_{i,t}(efficient) = \begin{cases} P(Z) = \dfrac{1}{1+e^{-(\beta_0+\beta_1 X_{i,t})}},\ y=1 \\ 1-P(Z) = 1-\dfrac{1}{1+e^{-(\beta_0+\beta_1 X_{i,t})}},\ y=0 \end{cases} \quad (3)$$

Where:
$P_{i,t}$: Probability that bank (i) is efficient at time (t), P€ [0,1].
X_i: Vector which contains the variables that will be used to predict efficiency of bank (i).
Z_{it}: Linear regression extracted from vector X_i, Z € (-∞,∞).
e: Euler's Number.
β: Vector contains the regression`s coefficients.
The generalized linear method will be used in order to calculate the scores (Nelder and Wedderburn, 1972).

4. ANALYSIS OF THE RESULTS

Table 2 summaries average technical efficiency per year for the Jordanian banking sector during the period 2011-2022. We can classify the study period into three phases.

4.1. Rising Efficiency (2011-2016)

From 2011 to 2016, there is a clear upward trend in the average technical efficiency of the Jordanian banking sector. The efficiency score increased from 88.2% in 2011 to a peak of 92.0% in 2016. This upward trajectory suggests that banks were improving in their ability to transform inputs (such as assets, labor, and capital) into outputs (such as loans, deposits, and profits). Several factors may have contributed to this trend, including:

- Technological Advancements: The adoption of digital banking solutions and IT infrastructure likely played a key role in improving operational efficiency.
- Better Risk Management: During this period, banks in Jordan may have refined their risk management strategies, which allowed them to operate more efficiently despite potential economic uncertainties.
- Macroeconomic Stability: Economic stability in Jordan during these years likely contributed to improved performance, with banks benefiting from stable interest rates and relatively low inflation.

Table 2: Average technical efficiency per year for the Jordanian banking sector during the period 2011-2022

Year	Average efficiency (%)	Year	Average efficiency (%)
2011	88.2	2017	88.7
2012	88.0	2018	90.4
2013	91.3	2019	92.4
2014	91.1	2020	87.3
2015	90.8	2021	89.2
2016	92.0	2022	90.2

4.2. Decline in Efficiency in 2020 (COVID-19 Impact)

In 2020, the technical efficiency score dropped to 87.3%, a significant decline from the previous year's score of 92.4%. The onset of the COVID-19 pandemic had a negative impact on the banking sector:

- Increased non-performing loans (NPLs): The pandemic led to a downturn in key economic indicators, adversely affecting the balance sheets of both individuals and corporations. This, in turn, caused a rise in loan defaults, which negatively impacted the efficiency of banks.
- Operational changes: The pandemic forced banks to shift to remote operations, which could have introduced inefficiencies in service delivery, especially in sectors where in-person banking remained critical.
- Reduced lending: In response to the heightened risks associated with the pandemic, many banks reduced their lending activities, leading to a decrease in output relative to inputs. More broadly, it is important to note that periods of uncertainty impacted the economic environment (Tomić, 2019; Durguti et al., 2024), further exacerbating risks in the financial sector.

It is important to highlight that the Central Bank of Jordan has implemented a series of robust measures to maintain financial stability and mitigate the COVID impact. These include reducing interest rates on monetary policy instruments, supporting the small and medium-sized enterprises (SMEs) sector, deferring loan repayments, and suspending the distribution of bonuses and dividends for the commercial banks, among other actions. Furthermore, the Central Bank of Jordan enforces capital adequacy requirements that are more stringent than those outlined in Basel

III. Additionally, it adheres to international financial reporting standard No. 9 (IFRS 9), which incorporates a forward-looking approach to credit risk, enabling banks to set aside additional provisions to mitigate default risks.

4.3. Post-COVID Recovery (2021-2022)

Following the decline in 2020, there was a gradual recovery in the average technical efficiency score, with values of 89.2% in 2021 and 90.2% in 2022. The recovery can be attributed to several factors:

- Digital transformation: Many banks accelerated their digital transformation efforts in response to the pandemic, improving their operational efficiency by reducing reliance on physical branches and increasing automation.
- Risk mitigation strategies: As the pandemic continued, banks likely implemented more effective risk management strategies, which helped mitigate some of the inefficiencies seen in 2020.
- Economic recovery: As the global and local economies began to recover in 2021, demand for banking services increased, and many businesses resumed operations, improving overall sector performance.

Regarding the average technical efficiency of banks in the Jordanian banking sector (2011-2022), some banks maintained consistently high efficiency scores. For example, Bank 1 (100%), Bank 2 (99.3%), and Bank 3 (99.1%) demonstrated superior performance throughout the period. These banks were likely able to leverage factors such as effective management, advanced technology, and strong financial positions, positioning them as leaders in the sector.

Conversely, banks such as Bank 14 (77.5%) and Bank 13 (79.8%) had significantly lower average efficiency scores. These banks likely faced challenges such as higher operational costs, weaker management, or difficulties adapting to market and economic changes.

Additionally, some banks experienced considerable fluctuations in their efficiency scores, particularly in 2020, when the COVID-19 pandemic had a clear impact. For instance, Bank 10 saw a notable decline in efficiency in 2020, suggesting it may have been more vulnerable during the crisis compared to its more resilient competitors.

The results from the logistic regression model provide valuable insights into the key factors influencing the efficiency of Jordanian banks (Table 3). The model includes several variables, namely, the capital adequacy ratio (CAR), Return on assets (ROA), non-performing loans (NPL), liquidity (LIQ), fintech (FIN), gross domestic product (GDP), Inflation (INF), interest rates (IR), the Herfindahl-Hirschman Index (HHI), and the impact of the COVID-19 pandemic.

Table 4 reveals a positive coefficient of 0.711 for CAR, suggesting that banks with higher capital adequacy ratios are more likely to be efficient. This finding supports the idea that banks with solid capital reserves are better equipped to handle financial stress and economic uncertainty. Strong capitalization enables banks

Table 3: Average technical efficiency per bank for the Jordanian banking sector during the period 2011-2022

Year	Average efficiency score (%)	Year	Average efficiency score (%)
Bank 1	100.0	Bank 8	92.5
Bank 2	99.3	Bank 9	89.5
Bank 3	99.1	Bank 10	85.4
Bank 4	98.3	Bank 11	83.1
Bank 5	96.0	Bank 12	82.0
Bank 6	95.8	Bank 13	79.8
Bank 7	95.1	Bank 14	77.5

Table 4: Logistic regression results: Determinants of the efficiency of the banking sector in Jordan

Variable	Coefficient	P-value
Constant	−9.017**	(0.035)
CAR	0.711***	(0.000)
ROA	0.221**	(0.031)
NPL	−0.132**	(0.024)
LIQ	0.087	(0.669)
FIN	0.505**	(0.022)
GDP	0.321*	(0.088)
INF	0.106	(0.451)
IR	0.035*	(0.074)
HHI	−0.066**	(0.033)
COVID	−0.243***	(0.000)
McFadden R-squared	0.4916	
−2 Loglikelihood	203.36	
LR statistics	196.64 (0.000)	

The values in brackets represent the *P* values. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. CAR: Capital adequacy ratio, ROA: Return on assets, NPL: Non-performing loans, LIQ: Liquidity, FIN: Fintech, GDP: Gross domestic product, INF: Inflation, IR: Interest rates, HHI: Herfindahl-Hirschman index

to weather economic shocks, maintain liquidity, and operate efficiently, especially in unpredictable environments. As previous studies have shown (Altunbas et al., 2001; Casu and Molyneux, 2003; Pessarossi and Weill, 2015), better-capitalized banks are typically more efficient and resilient.

When we look at ROA, the positive coefficient of 0.221 indicates that banks that are more profitable are more likely to be efficient. Specifically, a 1% increase in ROA raises the probability of a bank's efficiency by 22.1%. This is in line with the findings of Obeid (2024) and Istaiteyeh et al. (2024) which suggest that more profitable banks are generally better at managing costs, which ultimately boosts their operational efficiency.

On the topic of credit risk, the negative coefficient for NPL (−0.132) indicates that as non-performing loans increase, bank efficiency tends to decrease. This matches the broader literature, which has pointed out that rising levels of NPLs drive up management costs and force banks to hold more capital reserves (Phung et al., 2022; Obeid, 2024). Thus, the management of credit risk remains a critical challenge for improving efficiency in Jordanian banks.

Liquidity (LIQ), with a coefficient of 0.087, shows a positive but statistically insignificant relationship with bank efficiency. This suggests that, during the study period, liquidity was not a major driver of efficiency for Jordanian banks, possibly because they maintained sufficient liquidity buffers, preventing any noticeable inefficiencies.

Regarding Fintech (FIN), the positive coefficient of 0.505 suggests that as a bank's Fintech score increases, its likelihood of achieving higher operational efficiency also improves. This implies that banks investing in Fintech are more likely to enhance their performance and streamline operations. This result aligns with the findings of Wu et al. (2022) and Obeid (2023a), emphasizing the pivotal role of technology adoption in boosting efficiency. Specifically, technologies such as digital banking platforms, AI-driven customer service, and blockchain for secure transactions are integral to this process. These insights are crucial for informing bank strategies, underscoring the importance of embracing innovative technologies to optimize overall performance.

In terms of economic indicators, the GDP coefficient of 0.321 reveals a positive link between a growing economy and improved bank efficiency. This relationship is statistically significant at the 10% level, suggesting that higher economic output typically leads to greater demand for banking services and a more favorable operating environment. These results are consistent with Grigorian and Manole (2006) and Banna et al. (2020) who found that economic growth tends to improve banking sector efficiency. However, the coefficient for inflation (0.106) was not statistically significant, implying that inflation did not have a major impact on bank efficiency during the period under review.

Interest rates, with a positive coefficient of 0.035, show a weak but statistically significant relationship with bank efficiency. Higher interest rates can enhance bank profitability by widening the margin between lending and borrowing rates, contributing to more efficient operations (Casu and Molyneux, 2003). However, the relatively modest coefficient suggests that interest rates had a limited effect on efficiency in Jordanian banks during this period.

The Herfindahl-Hirschman index (HHI), which measures market concentration, shows a negative coefficient of −0.066, indicating that higher market concentration is linked to lower bank efficiency. This aligns with the "structure-conduct-performance" hypothesis, which suggests that concentrated markets reduce competition, leading to inefficiencies (Obeid, 2023b). Encouraging more competition in the banking sector could therefore help improve efficiency, suggesting that regulatory policies promoting competition might benefit the sector.

Lastly, the negative coefficient of −0.243 for COVID-19 indicates that the pandemic significantly reduced the efficiency of Jordanian banks. This outcome aligns with expectations, as the pandemic negatively impacted banking operations by increasing default rates and forcing banks to quickly adapt to rapidly changing market conditions. The challenges posed by COVID-19, including rising non-performing loans and the shift to digital banking, highlight the importance of building resilience and preparing for future shocks.

The Logit regression coefficients represent the change in the log-odds of the dependent variable (banking efficiency) for a one-unit change in an independent variable. However, Odds Ratios provide a more intuitive interpretation by illustrating how the odds of the dependent variable occurring change as the independent variable changes. In terms of the magnitude of the impact of the logistic model variables on the probability of a bank's efficiency, Table 5 shows that the capital adequacy ratio (CAR) has the most significant effect. Specifically, a one-unit increase in CAR roughly doubles the odds of improving banking efficiency. The adoption of Fintech (FIN) also has a substantial impact on efficiency. The odds ratio of 1.656 indicates a moderate yet meaningful effect, suggesting that adopting Fintech solutions increases the likelihood of a bank being efficient. This supports the notion that investing in Fintech is an effective strategy for banks to enhance cost-effectiveness and service quality, aligning with the growing body of research on the topic.

Table 5: Odds ratio for the significat variables

Variable	Odds ratio
Constant	0
CAR	2.034
ROA	1.247
NPL	0.877
FIN	1.656
GDP	1.378
IR	1.036
HHI	0.936
COVID	0.784

CAR: Capital adequacy ratio, ROA: Return on assets, NPL: Non-performing loans, LIQ: Liquidity, FIN: Fintech, GDP: Gross domestic product, INF: Inflation, IR: Interest rates, HHI: Herfindahl-Hirschman index

Regarding the goodness-of-fit statistics for the full model, Table 3 reports that the value of McFadden R-squared = 0.4916. This indicates that the model explains about 49.16% of the variance in the dependent variable, which is considered a strong fit, particularly in the social sciences and economics where such values above 0.4 are often regarded as very good (McFadden, 1973; Hosmer and Lemeshow, 2000). Moreover, the LR statistic of 196.64 suggests that the inclusion of predictors in the model significantly improves the fit compared to the null model. A larger LR statistic indicates that the model with predictors has strong explanatory power, and we would typically find a very small P-value (e.g., $P < 0.05$) for this statistic, confirming that the full model is statistically significant.

5. CONCLUSION

The Jordanian banking sector displayed a generally high level of technical efficiency between 2011 and 2022, with fluctuations due to the economic challenges posed by the COVID-19 pandemic. While 2020 saw a decline in efficiency across the sector, there was a notable recovery in subsequent years. Banks with higher average technical efficiency consistently outperformed their competitors, benefiting from strong management and operational strategies. In contrast, less efficient banks faced challenges in coping with pandemic shock, highlighting the importance of effective management practices and adaptability.

The findings emphasize the need for continuous improvement in risk management, technology adoption, and operational efficiency in the banking sector, particularly in response to external shocks like the COVID-19 pandemic. As the sector moves forward, it will be crucial for banks to maintain their focus on efficiency to support economic growth and stability in Jordan.

Based on the results of the logit model assessing the efficiency of Jordanian banks, it is vital for the Central Bank of Jordan to continue focusing on strengthening the capital adequacy of banks, especially in light of the recent amendments to Basel III standards, as the capital adequacy ratio (CAR) significantly contributes to efficiency. Policymakers should encourage banks to maintain higher capital buffers, which would enhance resilience and operational efficiency, particularly during periods of economic uncertainty. Additionally, improving profitability (as indicated by ROA) should be prioritized through better financial management and operational practices. Efforts to reduce non-performing loans (NPLs) should be a top priority, as their negative impact on efficiency is significant. This could be achieved through enhanced risk management and loan recovery strategies. Furthermore, fostering competition by reducing market concentration (as indicated by HHI) could drive efficiency improvements in the sector. The negative impact of COVID-19 on efficiency highlights the importance of building digital infrastructure and crisis management strategies to better handle future shocks. Finally, while liquidity and inflation did not show significant effects, macroeconomic stability and a robust economic environment, as indicated by GDP, should continue to be nurtured to sustain long-term bank efficiency.

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