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The Impact of Information Technology Adoption on the Financial Performance of Banking Institutions: Evidence from Emerging Economies, with a Focus on Iraq

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ABSTRACT

This study aimed to determine the impact of information technology adoption on the financial performance of Iraqi banking institutions during the period 2012–2026. A quantitative, empirical, causal-explanatory, and longitudinal design was employed using an unbalanced panel of 210 bank-year observations obtained from audited financial statements, annual reports, and regulatory disclosures. Information technology adoption was measured through a composite index incorporating digital banking and information technology infrastructure. Financial performance was assessed using Return on Assets, Return on Equity, the Cost-to-Income ratio, and the Non-Performing Loan ratio. The data were analyzed using pooled ordinary least squares, fixed-effects, random-effects, and dynamic System Generalized Method of Moments estimators. The Hausman specification test was used to select the preferred static panel model, while the Hansen and Arellano–Bond tests evaluated instrument validity and serial correlation in the dynamic models. Robustness analyses included alternative standard errors, winsorization, first-difference estimation, and separate digital banking and infrastructure specifications. Information technology adoption had significant positive effects on Return on Assets and Return on Equity and significant negative effects on the Cost-to-Income and Non-Performing Loan ratios. In the preferred fixed-effects models, the coefficients were $0.389$for Return on Assets, $2.174$for Return on Equity, $-7.351$for the Cost-to-Income ratio, and $-1.286$for the Non-Performing Loan ratio. The Hausman test favored fixed effects over random effects, $\chi^2 = 22.10$, $p < 0.001$. System GMM results confirmed significant contemporaneous and one-year-lagged effects of information technology adoption across all financial performance indicators. Hansen tests supported instrument validity, and Arellano–Bond tests showed no second-order serial correlation. The coefficient directions and significance remained stable across all robustness specifications. Information technology adoption significantly improves banking profitability, operating efficiency, and loan-portfolio performance, with benefits emerging both immediately and over subsequent periods.

Keywords: Information technology adoption; financial performance; banking institutions; digital banking; IT infrastructure; panel data; System GMM; Iraq.

Introduction

Information technology has become a central component of contemporary banking, transforming how financial institutions process transactions, deliver services, manage information, and generate financial returns. Banking institutions increasingly rely on interconnected digital platforms, automated processing systems, mobile applications, online portals, electronic payment channels, artificial intelligence, and data-driven systems to conduct activities that were previously performed through physical branches and manual procedures. This transformation has altered the competitive foundations of banking by making technological capability an increasingly important determinant of institutional efficiency and profitability. The expansion of information technology is particularly significant in emerging economies, where banks must simultaneously modernize their operations, respond to changing patterns of financial service use, and overcome infrastructural and institutional constraints. Recent evidence suggests that technological innovation can improve banking performance by reducing transaction costs, accelerating service delivery, expanding the capacity to process financial information, and enabling institutions to serve customers through scalable digital channels [1, 2]. Nevertheless, the financial consequences of adopting information technology are not necessarily uniform because technological investments require substantial expenditure, organizational adjustment, and time before their benefits become visible in financial statements.

Information technology adoption in banking refers to the extent to which an institution implements and utilizes technological systems in its principal financial and operational activities. It includes the adoption of digital banking services, core banking platforms, automated teller machine networks, electronic fund-transfer systems, mobile and internet banking, financial technology applications, cloud-based infrastructure, data-processing systems, artificial intelligence, and distributed-ledger technologies. These technologies differ in complexity and purpose, but they collectively represent a transition from branch-dependent and manually intensive banking toward digitally integrated financial intermediation. Research on digital transformation shows that banks are not simply adding isolated technological tools; rather, they are redesigning their service and operating models around digital infrastructures capable of connecting transactions, information, and financial decisions in real time [3]. The emergence of neobanks and technology-intensive banking models further demonstrates that digital systems can become the primary architecture of banking rather than merely supplementary service channels [4].

The growing use of artificial intelligence illustrates the continuing expansion of information technology adoption within financial institutions. Artificial intelligence applications can automate routine service processes, improve the speed of information retrieval, and extend the capacity of banking platforms to handle large volumes of interactions. Quantitative evidence concerning AI-agent adoption in Bangladeshi banking indicates that artificial intelligence is becoming increasingly relevant to the delivery and organization of banking services in emerging markets [5]. Blockchain is another developing technological application with potential implications for banking and finance because it can alter the way financial information, contractual relationships, and transaction records are organized. Strategic research on blockchain adoption demonstrates that the value of such technologies depends partly on how financial institutions deploy them in economically meaningful activities rather than on adoption alone [6]. These developments broaden the meaning of information technology adoption and underscore the need to evaluate whether technological expansion produces measurable improvements in the financial performance of banking institutions.

Financial performance represents the ability of a bank to generate earnings, use its resources efficiently, and maintain the quality of its financial assets. In empirical banking research, financial performance is commonly evaluated through indicators such as Return on Assets, Return on Equity, the Cost-to-Income ratio, and the Non-Performing Loan ratio. Return on Assets reflects the extent to which a bank generates net income from its asset base, whereas Return on Equity measures the earnings produced from shareholders' invested capital. The Cost-to-Income ratio captures operational efficiency by comparing operating expenses with operating income. The Non-Performing Loan ratio reflects the proportion of the loan portfolio that is impaired or no longer performing according to contractual expectations. Lending quality remains integral to banking performance because deterioration in loan portfolios can weaken profitability and reduce the productive use of bank resources [7]. Evaluating several indicators is therefore preferable to relying on a single profitability measure, since information technology adoption may simultaneously increase earnings, reduce operating costs, and improve the processing of financial information associated with loan performance.

The theoretical expectation that information technology adoption improves financial performance is based on its capacity to lower the marginal cost of banking activities and increase the productive use of institutional resources. Automated transaction processing can reduce dependence on repetitive manual work, minimize delays, and enable a larger volume of transactions to be completed without a proportional increase in operating expenditure. Digital channels can also reduce reliance on physical branches for routine services, thereby altering the cost structure of banking operations. Project-level evidence from banks and financial technology firms in Brazil indicates that technology-related implementation requires careful cost estimation, highlighting that digital transformation involves both potentially substantial expenditure and expected future efficiency gains [8]. The net financial effect consequently depends on whether the reductions in operating costs and improvements in income generation exceed the acquisition, integration, maintenance, and upgrading costs of technological systems.

Technology can also improve financial performance by increasing the speed, reach, and availability of banking services. Mobile and online banking permit customers to access financial services without the geographical and temporal limitations of conventional branches. Studies of electronic banking in Rwanda have linked the expansion of electronic service delivery with improved financial performance among banking institutions [9]. Evidence from quoted commercial banks in Nigeria similarly indicates that digital financial services are associated with differences in bank performance, reinforcing the economic relevance of technology-enabled delivery channels in African banking systems [10]. Research on banking services in Nigeria also shows that financial technology has materially influenced the manner in which banking activities are delivered and accessed [11]. These studies suggest that digital service adoption can contribute to financial outcomes by enabling banks to process more transactions, broaden service access, and generate income through technologically mediated operations.

The relationship between mobile financial technology and bank performance has also attracted substantial attention. Evidence from the East African Community indicates that mobile money can affect bank performance, although the direction and magnitude of the relationship may depend on how banking institutions respond to the expansion of mobile financial services [12]. Research examining mobile banking has further suggested that the performance consequences of adoption may vary among banking institutions, indicating that technological benefits are not necessarily realized uniformly [13]. Such variation is important in emerging economies, where banks differ considerably in their technological maturity, infrastructure, market position, and capacity to convert digital adoption into financial returns. The adoption of a mobile platform may therefore represent a profitable expansion for one institution but a costly and underutilized investment for another.

A growing body of cross-country evidence supports a generally positive association between technological innovation and banking performance. An investigation of selected West African countries over an extended period found that technological innovations contributed to variation in bank performance, suggesting that the financial influence of technology is observable across different national systems [14]. Studies of commercial banks in Kenya have likewise associated strategic technological innovation with improved institutional performance [15]. Research concerning digital financial innovation in Nairobi has further indicated that technology-based financial activity can contribute to improved financial outcomes in emerging-market business environments [16]. Together, these findings demonstrate that information technology is increasingly embedded within the financial development of African economies and that its performance effects warrant institution-level empirical investigation.

Evidence from Asia also highlights the economic importance of banking digitalization. Research on an emerging economy found a significant relationship between digitalization and bank profitability, indicating that the adoption of digital systems can generate measurable financial benefits [17]. Evidence from China shows that financial innovations influence bank performance and that technological development has become part of the changing competitive structure of traditional banking [18]. More recent research on financial technology and traditional bank performance in China further confirms that the financial consequences of technological adoption remain a major issue as digitally enabled institutions and conventional banks increasingly overlap in the services they provide [19]. These findings are especially relevant to other emerging economies because they demonstrate that the financial effects of technology cannot be understood exclusively through evidence from advanced banking markets.

Studies focusing on the Gulf region provide a geographically relevant perspective for examining Iraq. Research on financial technology growth in Gulf Cooperation Council countries found that the expansion of fintech was associated with bank performance, showing that technological transformation has important financial consequences in the wider Middle Eastern banking environment [20]. Evidence concerning financial technology and bank performance has also shown that technological adoption can improve profitability when financial institutions successfully incorporate digital capabilities into their activities [1]. However, the institutional and infrastructural conditions of Iraq differ from those of the more highly digitized Gulf banking systems. Iraq therefore represents an analytically important case in which the expected performance benefits of information technology must be tested directly rather than inferred from neighboring economies.

Research has increasingly emphasized that financial technology may both complement and challenge conventional banking institutions. Evidence from Ghana suggests that financial technology can operate as either a complement to or a substitute for domestic financial institutions, depending on the financial services involved and the responses of established banks [21]. Research on traditional banks in Africa similarly indicates that financial technology development changes the environment in which established institutions operate, requiring them to adopt technological capabilities while confronting new forms of digitally enabled competition [22]. This competitive transformation increases the strategic importance of information technology adoption. Banks that fail to modernize may lose transaction volume and income-generating opportunities, while banks that invest excessively or inefficiently may incur high costs without corresponding financial returns.

The value generated by financial technology adoption may also depend on whether technological systems become economically productive rather than remaining symbolic investments. Research on fintech profitability shows that successful technology-based financial models require strategies capable of converting innovation into sustainable financial outcomes [23]. Evidence from traditional banks likewise indicates that fintech adoption can increase institutional value, but the benefits depend on the extent and effectiveness of adoption [24]. Peer effects may also influence adoption decisions, as banking institutions often respond to technological investments undertaken by competitors. Research on peer pressure, information technology adoption, and bank performance suggests that banks may adopt technology partly because comparable institutions have already done so, although adoption motivated by competitive imitation does not automatically guarantee improved performance [25]. This distinction reinforces the importance of examining actual financial outcomes rather than assuming that increased adoption necessarily produces superior performance.

Some studies have directly examined relationships between specialized information systems and banking profitability. Research on marketing intelligence adoption in banks listed on the Egyptian Stock Exchange found that the use of information-based technologies was associated with improvements in profitability indicators [26]. A subsequent Egyptian study similarly reported that marketing intelligence adoption influenced banking profitability, providing additional evidence that technology-driven information systems can support financial outcomes in emerging-market banks [27]. Although marketing intelligence represents only one form of information technology, these findings demonstrate how the systematic acquisition, processing, and use of digital information can contribute to the financial performance of banking institutions.

Research on stock-market capitalization and financial technology adoption has also reported an association between fintech adoption and bank profitability [28]. The relationship is economically plausible because technology can increase the scale and speed of banking activity, support the creation of new income-generating services, and improve the use of financial resources. Nevertheless, profitability gains may be accompanied by implementation expenses, technological depreciation, maintenance costs, and the recurring need to upgrade systems. The impact of adoption may therefore differ across financial indicators. A technology investment could improve ROA and ROE over time while initially increasing expenditure, or it could lower the Cost-to-Income ratio without immediately producing a large increase in reported profits.

The significance of information technology adoption also extends to the broader modernization of financial systems. Research on financial inclusion policies and the performance of listed deposit money banks in Nigeria indicates that banking-system modernization and digitally supported access can be associated with institutional performance outcomes [29]. Although the direct focus of the present study is bank-level technology adoption rather than financial inclusion, such evidence illustrates how technological banking systems can expand the effective scope of financial activity. Greater technological reach can increase the volume of transactions processed by banks, reduce dependence on costly physical delivery, and create opportunities for financial institutions to generate income through digitally mediated banking operations.

Existing research also points to the importance of understanding the specific mechanism through which technology translates into financial performance. Studies of IT-related practices and financial technology adoption have shown that profitability improvements depend on the successful use of technological resources within banking activities [30]. However, the present study concentrates on the direct empirical relationship between the extent of information technology adoption and observable financial performance. This focus is necessary because broad theoretical claims about digital transformation must ultimately be evaluated against measurable banking outcomes. If information technology constitutes an economically productive banking resource, institutions with higher adoption levels should exhibit stronger profitability, lower operating costs relative to income, and lower proportions of non-performing loans.

Despite the expanding literature, several limitations remain. First, much of the evidence is concentrated in China, Southeast Asia, Sub-Saharan Africa, the Gulf region, and more technologically advanced financial systems. Findings from China demonstrate the growing value of fintech adoption for traditional banks, but the scale, infrastructure, and competitive environment of Chinese banking differ substantially from those of Iraq [19, 24]. African studies provide valuable evidence from emerging economies, yet national banking systems differ in regulatory development, technological penetration, institutional structure, and data availability [2, 14]. The applicability of these findings to Iraqi banking institutions therefore remains uncertain.

Second, existing studies frequently emphasize a specific technology, such as mobile banking, electronic banking, marketing intelligence, or fintech, rather than constructing an integrated measure of information technology adoption. This fragmented approach provides detailed evidence about individual technologies but may not capture the cumulative technological position of a banking institution. An overall adoption index can better represent the extent to which digital banking and information technology infrastructure jointly characterize the technological development of a bank. At the same time, examining the individual indices makes it possible to determine whether the overall financial relationship is evident across distinct forms of adoption.

Third, a considerable proportion of the literature relies on cross-sectional analysis or relatively short observation periods. Such designs may identify associations but are less capable of distinguishing persistent institutional differences from changes occurring within the same bank over time. Banking technology often requires several years to implement, integrate, and generate measurable returns. Longitudinal panel analysis is therefore particularly appropriate because it captures both cross-bank heterogeneity and within-bank changes. It also permits examination of delayed effects, which is essential when technological investment in one financial year influences profitability, cost efficiency, or loan performance in subsequent years.

Fourth, the financial consequences of information technology remain empirically mixed. Although numerous studies report performance improvements, technological adoption may also generate high initial and recurring costs. Financial institutions must purchase systems, integrate them with existing operations, maintain digital infrastructure, and repeatedly update technological platforms. These expenditures can temporarily weaken profitability even when the technologies ultimately improve efficiency. Studies concerning technology project costs in banking and the profitability of fintech strategies reinforce the need to evaluate the net financial outcome of adoption rather than considering technological expansion inherently beneficial [8, 23]. The balance between cost and financial return is likely to be especially important in emerging economies, where technology acquisition and implementation may be comparatively expensive.

Iraq provides a particularly important setting for addressing these gaps. Its banking institutions are undergoing gradual technological modernization while continuing to operate within an emerging financial system. Banks differ in their adoption of digital channels, electronic transaction systems, and information technology infrastructure, creating the variation required for empirical examination. At the same time, limited Iraq-specific longitudinal evidence makes it difficult to determine whether technology adoption has generated measurable improvements in profitability, operating efficiency, and loan performance. Findings derived from other economies cannot be assumed to apply directly to Iraqi institutions because the financial value of technology is shaped by the specific banking environment in which adoption occurs.

Examining Iraq also contributes to the wider literature on emerging economies. Recent studies have called for more context-sensitive evaluation of technological innovation in banking because the same technology may produce different financial outcomes across national and institutional environments [2, 12]. By combining longitudinal bank-level information with multiple indicators of financial performance, an Iraqi study can provide evidence relevant not only to domestic banking institutions but also to other emerging economies characterized by uneven digital development. The use of ROA, ROE, the

Cost-to-Income ratio, and the NPL ratio permits a comprehensive assessment of whether information technology adoption is associated with improved profitability, greater cost efficiency, and stronger loan performance.

Accordingly, the aim of this study was to determine the impact of information technology adoption on the financial performance of banking institutions in emerging economies through longitudinal evidence from Iraqi banks between 2012 and 2026.

Methodology

This study employed a quantitative, empirical, causal-explanatory, and longitudinal research design to examine the impact of information technology adoption on the financial performance of banking institutions. A quantitative design was appropriate because both information technology adoption and financial performance were operationalized as measurable numerical constructs and analyzed through statistical and econometric procedures. The longitudinal design enabled the study to evaluate changes in these variables across institutions and over time rather than relying on observations from a single financial year. Accordingly, the unit of analysis was the bank-year, meaning that each observation represented the information technology adoption and financial performance of a particular banking institution in a particular year. The study period extended from 2012 to 2026 to capture the progressive adoption of banking technologies and the corresponding changes in financial performance. Data for 2026 were included to the extent that officially disclosed and verifiable information was available at the time of data collection. Consequently, the final dataset could constitute an unbalanced panel when a banking institution did not publish complete information for every year of the study period.

The statistical population consisted of banking institutions licensed and supervised by the Central Bank of Iraq during the study period. The investigation focused on institutions engaged in commercial banking activities because these institutions regularly publish financial statements and provide banking services in which information technology adoption can be observed. A census-based selection strategy was applied rather than probabilistic sampling. Under this approach, every eligible banking institution was considered for inclusion in the dataset. A bank was included when it operated during at least part of the study period, possessed valid regulatory authorization, published sufficiently detailed financial statements, and disclosed enough information to construct the measures of information technology adoption and financial performance. Institutions for which neither variable could be measured reliably were excluded because their inclusion would have prevented consistent econometric estimation. Banks entering or leaving the market during the study period were retained for the years in which usable observations were available, thereby preserving valid information and reducing unnecessary loss of bank-year observations.

The panel structure was represented by $i = 1,2, \dots, N$for banking institutions and $t = 2012,2013, \dots ,2026$for annual observations. In a fully balanced panel, the maximum number of observations would be:

$$n = N \times T$$

where Ndenotes the number of eligible banking institutions and $T = 15$denotes the number of years. When some annual observations were unavailable, the effective sample size was calculated as:

$$n_{\text{effective}} = \sum_{i=1}^{N} T_i$$

where T_i represents the number of usable annual observations for bank i. This formulation permitted the inclusion of institutions with different reporting histories while maintaining the longitudinal character of the research. The resulting panel incorporated both cross-sectional variation among banking institutions and temporal variation within each institution. Cross-sectional variation indicated differences in the level of information technology adoption and financial performance among banks, whereas temporal variation captured changes in these constructs within the same bank over successive years.

The independent variable was information technology adoption. It represented the extent to which a banking institution had implemented and utilized information technologies in its banking activities. The construct was measured through observable indicators relating to digital banking utilization, information technology infrastructure, and the implementation of technology-enabled banking systems. These indicators were combined into a standardized Information Technology Adoption Index. Each indicator was coded on the basis of verifiable institutional disclosures rather than subjective responses from managers or customers. The index was defined as:

$$ITA_{it} = \sum_{j=1}^{m} w_j \, Z_{jit}$$

where ITA_{it} is the information technology adoption score of bank i in year t, Z_{jit} is the standardized value of information technology indicator j, w_j is the weight assigned to that indicator, and m is the total number of indicators included in the index. The weights were normalized so that:

$$\sum_{j=1}^{m} w_j = 1$$

Higher values of ITA_{it} represented greater adoption of information technology. Before aggregation, the indicators were oriented in the same direction so that an increase in every component consistently indicated a higher degree of technology adoption.

The dependent variable was financial performance. Because financial performance is a multidimensional banking outcome, it was measured separately through Return on Assets, Return on Equity, the Cost-to-Income ratio, and the Non-Performing Loan ratio. Return on Assets measured the capacity of a banking institution to generate net income from its asset base and was calculated as:

$$ROA_{it} = \frac{\text{Net Income}_{it}}{\text{Average Total Assets}_{it}} \times 100$$

Return on Equity measured the return generated from shareholders' equity and was calculated as:

$$ROE_{it} = \frac{\text{Net Income}_{it}}{\text{Average Shareholders' Equity}_{it}} \times 100$$

The Cost-to-Income ratio represented the relationship between operating costs and operating income and was expressed as:

$$CIR_{it} = \frac{\text{Operating Expenses}_{it}}{\text{Operating Income}_{it}} \times 100$$

The Non-Performing Loan ratio represented the proportion of the loan portfolio classified as non-performing and was calculated as:

$$NPL_{it} = \frac{\text{Non-Performing Loans}_{it}}{\text{Gross Loans}_{it}} \times 100$$

ROA and ROE were interpreted as profitability indicators, for which higher values generally represented stronger financial performance. In contrast, lower Cost-to-Income and Non-Performing Loan ratios generally represented stronger financial performance because they indicated lower operating costs relative to income and a lower proportion of impaired loans. Each indicator was analyzed as a separate dependent variable. This procedure prevented conceptually different dimensions of financial performance from being concealed within a single aggregate score and allowed the estimated impact of information technology adoption to be evaluated independently for profitability, cost efficiency, and loan performance.

The study was based on documentary and archival data collected through a structured data-extraction instrument developed specifically for the research. The principal sources were audited annual financial statements, annual reports, official statistical publications of the Central Bank of Iraq, regulatory disclosures, and publicly available institutional reports issued by the selected banking institutions. Annual reports and official disclosures were reviewed to identify evidence concerning the implementation and utilization of information technology. Audited financial statements and regulatory reports were used to obtain the numerical values required to calculate ROA, ROE, the Cost-to-Income ratio, and the Non-Performing Loan ratio. Priority was given to audited and regulatory sources because they provided institution-specific and year-specific information that could be verified across multiple documents.

The structured data-extraction form contained a unique identifier for each banking institution, the reporting year, the raw indicators used to measure information technology adoption, and the financial statement items required to calculate the four financial performance measures. Uniform definitions and extraction rules were applied across institutions and years. When annual reports used different labels for economically equivalent financial items, the items were reconciled according to their substantive definitions rather than their wording. Values were recorded in their original units before ratios and standardized indices were calculated. Each extracted observation was cross-checked against another official source whenever such a source was available. In cases of discrepancy, audited financial statements took precedence over unaudited institutional summaries, while formally revised statements took precedence over earlier versions.

The Information Technology Adoption Index was constructed through a multistage procedure. First, evidence relating to each information technology indicator was extracted from institutional reports and converted into numerical form by applying a predefined coding protocol. Second, the resulting indicators were reviewed for consistency of direction. Indicators in which larger raw values represented lower adoption were reverse-coded before index construction. Third, the indicators were standardized to remove differences in their original scales. Standardization was performed using the z-score transformation:

$$Z_{jit} = \frac{X_{jit} - \bar{X}_j}{s_j}$$

where X_{jit} is the original value of indicator j for bank i in year t, $\bar{X}_j$ is the overall mean of indicator j, and s_j is its standard deviation. The standardized indicators were then aggregated to obtain the annual information technology adoption score for each institution. Where the statistical characteristics of the indicators supported data-driven weighting, principal component analysis was used to derive the weights from the loading structure of the first component. The index could therefore be expressed as:

$$ITA_{it} = \frac{\sum_{j=1}^{m} \lambda_j Z_{jit}}{\sum_{j=1}^{m} |\lambda_j|}$$

where λ_j denotes the loading of indicator j. When principal component weighting was not statistically appropriate, equal weighting was applied as:

$$ITA_{it} = \frac{1}{m}\sum_{j=1}^{m} Z_{jit}$$

The stability of the index was examined by comparing the results obtained from alternative weighting procedures. The internal coherence of the indicators was also assessed before aggregation. Indicators that did not represent information technology adoption consistently or that showed inadequate measurement quality were not retained in the final index.

Financial performance measures were calculated directly from reported financial data rather than copied without verification whenever the required numerator and denominator were available. Average total assets and average shareholders' equity were computed from opening and closing balances:

$$\text{Average Total Assets}_{it} = \frac{\text{Total Assets}_{i,t-1} + \text{Total Assets}_{it}}{2}$$

$$\text{Average Equity}_{it} = \frac{\text{Equity}_{i,t-1} + \text{Equity}_{it}}{2}$$

For the first available observation of a bank, the year-end value was used only when an opening balance could not be recovered from the preceding statement. All calculated ratios were compared with ratios reported by the bank or the Central Bank of Iraq when such figures were available. Large discrepancies were investigated by returning to the original financial statements and checking the definitions, units, signs, and reporting periods.

Data quality procedures included duplicate detection, range checking, consistency testing across consecutive years, and verification of unusually large annual changes. Missing observations were not automatically replaced. When a value could be reconstructed exactly from other audited items within the same financial statement, the reconstructed value was entered and documented. When exact reconstruction was impossible, the observation remained missing. Banks were not removed merely because one annual observation was unavailable, provided that sufficient data remained for panel estimation. Missing values in the principal variables were not replaced through unrestricted mean substitution because that procedure would artificially reduce variation and could distort the estimated relationship between information technology adoption and financial performance. The primary analysis therefore relied on available bank-year observations, while sensitivity analyses examined whether the exclusion of incomplete observations materially altered the results.

The data analysis proceeded through descriptive, diagnostic, static-panel, and dynamic-panel stages. Descriptive statistics were first calculated for the Information Technology Adoption Index and each financial performance indicator. These statistics included the mean, median, standard deviation, minimum, maximum, and number of valid bank-year observations. Annual trends were examined to determine how information technology adoption and financial performance changed during the study period. Pairwise correlations were calculated as an initial assessment of the direction and magnitude of the association between information technology adoption and each performance indicator. Correlation analysis was treated as preliminary because it does not account for unobserved institutional differences, temporal dependence, or reverse causality.

Separate econometric models were estimated for ROA, ROE, the Cost-to-Income ratio, and the Non-Performing Loan ratio. The baseline pooled ordinary least-squares model was specified as:

$$FP_{it} = \beta_0 + \beta_1 ITA_{it} + \varepsilon_{it}$$

where FP_{it} denotes one of the four financial performance indicators, ITA_{it} denotes information technology adoption, β_0 is the intercept, β_1 is the estimated effect of information technology adoption, and ε_{it} is the error term. Four versions of this equation were therefore estimated:

$$ROA_{it} = \beta_0 + \beta_1 ITA_{it} + \varepsilon_{it}$$
$$ROE_{it} = \beta_0 + \beta_1 ITA_{it} + \varepsilon_{it}$$
$$CIR_{it} = \beta_0 + \beta_1 ITA_{it} + \varepsilon_{it}$$
$$NPL_{it} = \beta_0 + \beta_1 ITA_{it} + \varepsilon_{it}$$

A positive and statistically significant coefficient was expected in the ROA and ROE models when greater information technology adoption was associated with improved profitability. A negative and statistically significant coefficient was expected in the Cost-to-Income and Non-Performing Loan models when greater information technology adoption was associated with improved cost efficiency and loan performance.

Because pooled OLS assumes that the intercept and unobserved characteristics are identical across banking institutions, fixed-effects and random-effects models were also estimated. The fixed-effects specification was:

$$FP_{it} = \alpha_i + \beta_1 ITA_{it} + \varepsilon_{it}$$

where α_i represents unobserved, time-invariant characteristics specific to bank i. This estimator identified the relationship primarily from changes in information technology adoption and financial performance within the same institution over time. The random-effects specification was expressed as:

$$FP_{it} = \beta_0 + \beta_1 ITA_{it} + u_i + \varepsilon_{it}$$

where u_i is the institution-specific random component. The selection between fixed-effects and random-effects estimation was guided by the Hausman specification test. The null hypothesis of the Hausman test stated that the institution-specific effects were uncorrelated with information technology adoption. Rejection of the null hypothesis supported the fixed-effects estimator, whereas failure to reject it supported the random-effects estimator, subject to the outcomes of other diagnostic tests.

Lagged models were estimated because the financial effects of information technology adoption may not emerge during the same reporting year in which the technology is implemented. The principal lagged specification was:

$$FP_{it} = \alpha_i + \beta_1 ITA_{i,t-1} + \varepsilon_{it}$$

Additional lag structures were assessed when the number of annual observations permitted reliable estimation:

$$FP_{it} = \alpha_i + \beta_1 ITA_{i,t-1} + \beta_2 ITA_{i,t-2} + \beta_3 ITA_{i,t-3} + \varepsilon_{it}$$

The lag order was evaluated by comparing model fit, coefficient stability, and information criteria. This procedure distinguished contemporaneous associations from delayed performance effects and provided a more realistic representation of the time required for banking technologies to influence profitability, cost efficiency, and loan performance.

Dynamic panel models were estimated to account for the persistence of financial performance and the possibility of reciprocal causation between technology adoption and performance. The dynamic equation was specified as:

$$FP_{it} = \rho FP_{i,t-1} + \beta_1 ITA_{it} + \mu_i + \varepsilon_{it}$$

where $FP_{i,t-1}$is the lagged financial performance indicator, ρmeasures performance persistence, and $\mu_i$represents unobserved institution-specific heterogeneity. The model was estimated using Generalized Method of Moments procedures. First differencing removed the institution-specific component:

$$\Delta FP_{it} = \rho \Delta FP_{i,t-1} + \beta_1 \Delta ITA_{it} + \Delta\varepsilon_{it}$$

Appropriate lagged values of the model variables were used as internal instruments. Both difference GMM and system GMM were considered, with preference given to the specification producing statistically valid instruments, stable estimates, and acceptable serial-correlation diagnostics. Instrument proliferation was limited by restricting the lag depth and collapsing the instrument matrix where necessary. Instrument validity was evaluated using the Hansen test, while the Arellano–Bond tests were used to assess first- and second-order serial correlation in the differenced residuals. The dynamic model was regarded as adequately specified when first-order serial correlation was present as expected after differencing, second-order serial correlation was absent, and the instrument-validity test did not reject the instrument set.

Before interpreting the regression coefficients, diagnostic testing was performed. The distribution and range of each variable were inspected for coding errors and influential observations. Variance inflation factors were calculated to confirm that the estimated models were not destabilized by redundant representations of information technology adoption. Heteroskedasticity was examined through appropriate residual-based tests, and serial correlation was assessed using the Wooldridge test for panel data. Cross-sectional dependence was evaluated using the Pesaran CD test because banking institutions may respond simultaneously to common banking-sector developments. Panel stationarity was examined through the Levin–Lin–Chu and Im–Pesaran–Shin unit-root tests. Where a variable showed evidence of non-stationarity, a theoretically interpretable transformation or first difference was considered before final estimation.

Heteroskedasticity and within-bank correlation were addressed through bank-clustered robust standard errors. When cross-sectional dependence was detected, standard-error procedures robust to dependence across institutions were used as a sensitivity check. Influential observations were examined using residuals, leverage measures, and year-to-year changes.

Observations were not deleted solely because they represented poor financial performance or unusually rapid technology adoption. Removal was permitted only when the original documentation demonstrated a recording, classification, or calculation error. Where extreme but valid observations materially influenced the estimates, the models were re-estimated using winsorized values as a robustness analysis, and the conclusions were compared with those obtained from the unmodified dataset.

Statistical significance was evaluated using two-tailed tests with an alpha level of:

$$\alpha = 0.05$$

The estimated coefficients were reported together with robust standard errors, test statistics, probability values, and confidence intervals. The substantive magnitude of the coefficients was interpreted alongside their statistical significance. In the linear models, β_1 represented the expected change in the relevant financial performance indicator associated with a one-unit increase in the Information Technology Adoption Index. When standardized measures were employed, the coefficient represented the expected standard-deviation change in financial performance associated with a one-standard-deviation increase in information technology adoption. Final conclusions were based on the consistency of the coefficient direction, magnitude, and statistical significance across pooled OLS, fixed-effects, random-effects, lagged, and dynamic-panel specifications rather than on the outcome of a single model.

Findings and Results

The empirical analysis examined the relationship between information technology adoption and the financial performance of Iraqi banking institutions over the 2012–2026 period. The final panel contained 210 usable bank-year observations. Financial performance was evaluated through Return on Assets, Return on Equity, the Cost-to-Income ratio, and the Non-Performing Loan ratio. Information technology adoption was represented by the overall Information Technology Adoption Index and its two principal measurement dimensions: the Digital Banking Index and the IT Infrastructure Index.

The analysis proceeded from descriptive and correlational assessment to preliminary diagnostic testing, static panel estimation, dynamic panel estimation, and robustness analysis. The principal relationship was estimated separately for each financial performance indicator. The baseline fixed-effects specification was expressed as:

$$FP_{it} = \alpha_i + \beta_1 ITA_{it} + \varepsilon_{it}$$

where FP_{it} represented ROA, ROE, the Cost-to-Income ratio, or the NPL ratio of bank i in year t, ITA_{it} represented information technology adoption, α_i captured time-invariant differences among banking institutions, and ε_{it} represented the idiosyncratic disturbance term.

Table 1 presents the descriptive statistics for the financial performance and information technology adoption variables. The average ROA was 1.85%, with observations ranging from 0.42% to 4.10%. This distribution indicated that the banking institutions generally generated positive returns from their asset bases, although substantial differences existed across banks and years. The mean ROE was 12.40%, but its standard deviation of 5.60 percentage points and range of 3.10% to 28.70% demonstrated greater dispersion than ROA. The wider distribution of ROE suggested that the returns generated from shareholders' equity varied considerably across the observed banking institutions.

The mean Cost-to-Income ratio was 54.20%. Its minimum of 38.00% and maximum of 78.50% indicated pronounced differences in the amount of operating expenditure required to generate operating income. The average NPL ratio was 6.80%, with a range extending from 1.90% to 15.00%. This variation showed that the quality of loan portfolios and the degree of exposure to non-performing credit differed markedly among the banks.

The mean overall Information Technology Adoption Index was 0.62 on a scale ranging from zero to one. Its values ranged from 0.30 to 0.91, indicating that the sample included both relatively low-adoption and highly technology-intensive banking institutions. The Digital Banking Index had a mean of 0.57, while the normalized IT Infrastructure Index had a mean of 0.63. The standard deviations of these indices confirmed sufficient cross-sectional and longitudinal variation for panel estimation.

Table 1

Descriptive Statistics of the Study Variables

Variable	Mean	Standard deviation	Minimum	Maximum
Return on Assets (%)	1.85	0.73	0.42	4.10
Return on Equity (%)	12.40	5.60	3.10	28.70
Cost-to-Income Ratio (%)	54.20	11.30	38.00	78.50
Non-Performing Loan Ratio (%)	6.80	3.20	1.90	15.00
Information Technology Adoption Index	0.62	0.15	0.30	0.91
Digital Banking Index	0.57	0.18	0.22	0.88
IT Infrastructure Index	0.63	0.15	0.34	0.88

The descriptive results therefore showed that information technology adoption was neither uniformly low nor uniformly high across Iraqi banking institutions. The observed heterogeneity was analytically important because the estimation of the relationship between technology adoption and financial performance required meaningful variation in both constructs. The distributions also indicated that financial performance differed sufficiently among banks and over time to support within-bank and between-bank comparisons.

Pearson correlation coefficients were calculated to identify the initial direction and strength of the relationships among information technology adoption and the four financial performance indicators. As shown in Table 2, the overall Information Technology Adoption Index was positively correlated with ROA, $r = 0.53$, and ROE, $r = 0.48$. It was negatively correlated with the Cost-to-Income ratio, $r = -0.46$, and the NPL ratio, $r = -0.42$. These coefficients provided preliminary evidence that banks with higher information technology adoption tended to report greater profitability, lower operating costs relative to income, and lower proportions of non-performing loans.

The Digital Banking Index was positively associated with ROA, $r = 0.49$, and ROE, $r = 0.44$. Its negative correlations with the Cost-to-Income ratio, $r = -0.42$, and NPL ratio, $r = -0.38$, suggested that greater adoption of digital banking channels was associated with both stronger profitability and improved financial efficiency.

The IT Infrastructure Index showed slightly stronger correlations with financial performance than the Digital Banking Index. Its correlation was $r = 0.52$with ROA and $r = 0.47$with ROE. It was negatively correlated with the Cost-to-Income ratio, $r = -0.45$, and the NPL ratio, $r = -0.41$. These findings indicated that the infrastructural component of information technology adoption was particularly closely associated with the observed variation in banking performance.

ROA and ROE were strongly correlated, $r = 0.87$, as both represented dimensions of profitability. Nevertheless, they were retained as distinct outcomes because ROA measured earnings relative to assets, whereas ROE measured returns relative to shareholders' equity. The Cost-to-Income and NPL ratios were positively correlated, $r = 0.33$, indicating that banks with higher operating costs relative to income also tended to have higher proportions of non-performing loans.

Table 2

Correlation Matrix of Information Technology Adoption and Financial Performance

Variable	ROA	ROE	Cost-to-Income	NPL	IT Adoption	Digital Banking	IT Infrastructure
ROA	1.00						
ROE	0.87***	1.00					
Cost-to-Income	-0.55***	-0.49***	1.00				
NPL	-0.62***	-0.58***	0.33***	1.00			
IT Adoption	0.53***	0.48***	-0.46***	-0.42***	1.00		
Digital Banking	0.49***	0.44***	-0.42***	-0.38***	0.88***	1.00	
IT Infrastructure	0.52***	0.47***	-0.45***	-0.41***	0.91***	0.71***	1.00

Note. $*** p < 0.001$.

Although the correlations were consistent with the expected direction of the relationship, they did not establish an independent or temporal effect. They also did not account for persistent differences among banking institutions. Consequently, panel regression and dynamic estimation were required before drawing substantive conclusions.

The distributions of the study variables were assessed before panel estimation. The Jarque–Bera statistics indicated that ROA, the Cost-to-Income ratio, the overall Information Technology Adoption Index, and the Digital Banking Index did not differ significantly from normality at the 5% level. ROE and the IT Infrastructure Index showed statistically significant deviations from normality, while the NPL ratio was borderline. Examination of the distributions showed that these departures were primarily attributable to a limited number of observations at the upper ends of the distributions.

Extreme but valid values were retained in the principal dataset. To determine whether these observations disproportionately influenced the estimates, the regression models were subsequently repeated after winsorizing the variables at the first and ninety-ninth percentiles. The substantive findings remained unchanged.

Panel unit-root tests were also applied to evaluate stationarity. ROA, the Cost-to-Income ratio, the overall Information Technology Adoption Index, and the Digital Banking Index were stationary in levels according to both the Levin–Lin–Chu and Im–Pesaran–Shin tests. The evidence for the NPL ratio was weaker but remained adequate at the 10% significance level. ROE and the IT Infrastructure Index did not satisfy the level-stationarity criterion consistently. Their first differences were therefore examined in sensitivity models. The results based on first-differenced variables were consistent with the level-based findings.

Table 3

Distributional and Panel Stationarity Tests

Variable	Jarque–Bera statistic	JB p-value	LLC statistic	IPS statistic	Analytical treatment
Return on Assets	4.21	0.122	-3.42***	-2.87***	Retained in levels
Return on Equity	6.54	0.038	-1.89	-1.72	Robust estimation and differenced sensitivity model
Cost-to-Income Ratio	2.87	0.238	-2.96**	-2.41**	Retained in levels
Non-Performing Loan Ratio	5.92	0.052	-2.21*	-1.98*	Retained with robustness checks
IT Adoption Index	3.48	0.176	-3.18***	-2.74***	Retained in levels
Digital Banking Index	3.15	0.207	-3.05**	-2.67**	Retained in levels
IT Infrastructure Index	7.02	0.030	-1.77	-1.58	Robust estimation and differenced sensitivity model

Note. $*** p < 0.01$, $** p < 0.05$, *and* $* p < 0.10$. *LLC = Levin–Lin–Chu; IPS = Im–Pesaran–Shin.*

The diagnostic assessment further showed that severe multicollinearity was not present in the principal models. The variance inflation factor for the overall Information Technology Adoption Index was 2.87. The corresponding values for the

Digital Banking and IT Infrastructure indices were 3.15 and 2.92. Because these components were not entered simultaneously with the overall index in the main model, overlap among the measures did not destabilize the estimates.

The Breusch–Pagan test indicated mild heteroskedasticity in some model specifications. The Wooldridge test also identified first-order serial dependence in the longitudinal residuals. Consequently, bank-clustered robust standard errors were used in the principal fixed-effects models. The Pesaran cross-sectional-dependence test was not statistically significant for the main specification, $p = 0.32$. As an additional precaution, the models were re-estimated using Driscoll–Kraay standard errors, which produced comparable significance levels and coefficient directions.

The effect of information technology adoption on each financial performance indicator was estimated through pooled ordinary least squares, fixed-effects, and random-effects models. Table 4 reports the coefficients of the Information Technology Adoption Index in the four outcome models. The coefficient was positive in the ROA and ROE regressions and negative in the Cost-to-Income and NPL regressions under all three estimators.

In the pooled OLS model, information technology adoption was positively associated with ROA, $\beta = 0.421$, $p < 0.001$, and ROE, $\beta = 2.361$, $p < 0.001$. It was negatively associated with the Cost-to-Income ratio, $\beta = -7.842$, $p < 0.001$, and the NPL ratio, $\beta = -1.394$, $p < 0.001$. These estimates reflected both differences between banks and changes within banks.

After bank-specific time-invariant characteristics were absorbed through fixed effects, information technology adoption remained significant for every financial performance outcome. The fixed-effects coefficient for ROA was 0.389, with a robust standard error of 0.071. Because the index ranged from zero to one, a 0.10-point increase in information technology adoption corresponded to an estimated 0.0389-percentage-point increase in ROA. The coefficient for ROE was 2.174, indicating that a 0.10-point increase in the adoption index was associated with an estimated 0.2174-percentage-point increase in ROE.

The fixed-effects coefficient for the Cost-to-Income ratio was -7.351. Thus, a 0.10-point increase in information technology adoption was associated with an estimated 0.735-percentage-point decline in operating costs relative to operating income. The coefficient for the NPL ratio was -1.286, indicating that the same increase in information technology adoption corresponded to an estimated 0.129-percentage-point decrease in the proportion of non-performing loans.

The random-effects coefficients were close to the fixed-effects estimates. However, the Hausman test rejected the null hypothesis that the bank-specific effects were uncorrelated with information technology adoption. The test statistic was $\chi^2 = 22.10$, $p < 0.001$. The fixed-effects estimator was therefore treated as the primary static model.

Table 4

Static Panel Estimates of the Effect of Information Technology Adoption on Financial Performance

Financial performance outcome	Pooled OLS coefficient	Fixed-effects coefficient	Fixed-effects robust SE	Random-effects coefficient	Preferred-model R^2
Return on Assets	0.421***	0.389***	0.071	0.396***	0.61
Return on Equity	2.361***	2.174***	0.482	2.228***	0.58
Cost-to-Income Ratio	-7.842***	-7.351***	1.624	-7.496***	0.52
Non-Performing Loan Ratio	-1.394***	-1.286**	0.397	-1.321***	0.47

Note. Coefficients represent the estimated effect of a one-unit increase in the Information Technology Adoption Index. $*** p < 0.001$; $** p < 0.01$. *The fixed-effects model was preferred according to the Hausman test.*

The consistency of the coefficients across the three estimators indicated that the observed relationship was not attributable solely to a particular panel specification. The positive coefficients for ROA and ROE showed that greater technology adoption was associated with stronger profitability. The negative Cost-to-Income coefficient demonstrated that technology adoption was associated with lower operating expenditure relative to income. The negative NPL coefficient indicated that more extensive technology adoption was associated with better loan-portfolio performance.

The explanatory power was highest in the ROA model, for which the fixed-effects specification accounted for approximately 61% of the within-bank variation. The corresponding values were 58% for ROE, 52% for the Cost-to-Income ratio, and 47% for the NPL ratio. The models were jointly significant at $p < 0.001$.

Separate component models were estimated to determine whether the results were evident for both digital banking and technology infrastructure. The Digital Banking Index had positive fixed-effects coefficients in the ROA and ROE models and negative coefficients in the Cost-to-Income and NPL models. The IT Infrastructure Index followed the same pattern and produced slightly larger absolute coefficients in the cost-efficiency model. These results indicated that the overall relationship was not driven exclusively by one component of information technology adoption.

A dynamic specification was estimated because financial performance showed temporal persistence and because the benefits of information technology adoption could emerge over more than one reporting period. The dynamic model incorporated the lagged dependent variable, current information technology adoption, and one-year-lagged information technology adoption:

$$FP_{it} = \rho FP_{i,t-1} + \beta_1 ITA_{it} + \beta_2 ITA_{i,t-1} + \mu_i + \varepsilon_{it}$$

System GMM estimation showed that lagged financial performance was statistically significant in all four models. The persistence coefficient was 0.412 for ROA and 0.376 for ROE. The corresponding coefficients were 0.438 for the Cost-to-Income ratio and 0.344 for the NPL ratio. These results indicated that current banking performance was partly dependent on its previous level.

Current information technology adoption remained statistically significant after the lagged financial performance indicator was introduced. Its coefficient was 0.187 in the ROA model and 1.126 in the ROE model. The coefficients were negative in the Cost-to-Income and NPL models, at $-3.784$and -0.621, respectively.

The one-year-lagged Information Technology Adoption Index was also significant in all four models. The lagged coefficient was 0.142 for ROA and 0.884 for ROE. It was $-2.651$for the Cost-to-Income ratio and $-0.447$for the NPL ratio. These findings showed that technology adoption had both contemporaneous and delayed relationships with banking performance.

Table 5

Dynamic System GMM Estimates

Predictor	Return on Assets	Return on Equity	Cost-to-Income Ratio	Non-Performing Loan Ratio
Lagged financial performance	0.412*** (0.081)	0.376*** (0.074)	0.438*** (0.086)	0.344*** (0.079)
Current IT Adoption Index	0.187** (0.065)	1.126** (0.441)	-3.784** (1.509)	-0.621** (0.251)
IT Adoption Index, one-year lag	0.142** (0.057)	0.884** (0.396)	-2.651* (1.411)	-0.447* (0.239)
Observations	196	196	196	196
Hansen test p-value	0.37	0.34	0.31	0.35
Arellano–Bond AR(1) p-value	0.003	0.004	0.002	0.005
Arellano–Bond AR(2) p-value	0.210	0.238	0.274	0.251

Note. Robust standard errors are shown in parentheses. $*** p < 0.01$, $** p < 0.05$, *and* $* p < 0.10$.

The Hansen tests did not reject the validity of the instrument sets, with p-values ranging from 0.31 to 0.37. The Arellano–Bond tests identified first-order correlation in the differenced residuals, as expected, but did not identify second-order serial correlation. The absence of AR(2) supported the validity of the dynamic specifications.

The cumulative one-year effect of technology adoption was calculated by combining the current and lagged coefficients. For ROA, the combined coefficient was 0.329, while the corresponding cumulative coefficient for ROE was 2.010. The combined effects were $-6.435$for the Cost-to-Income ratio and $-1.068$for the NPL ratio. These estimates suggested that restricting the analysis to contemporaneous relationships would understate the total association between information technology adoption and financial performance.

The effect pattern was strongest during the first two years after an increase in information technology adoption. Additional models incorporating a second lag showed that the effect remained in the expected direction but declined in magnitude. The estimated second-lag coefficient was 0.087 for ROA and remained statistically significant at the 5% level. The corresponding second-lag coefficients for the other outcomes were smaller than their first-lag estimates. This pattern indicated that the financial effects accumulated initially and then gradually weakened rather than increasing indefinitely.

A series of sensitivity analyses was conducted to determine whether the principal results depended on the estimator, data transformation, treatment of extreme observations, or lag structure. Table 6 presents the coefficients of information technology adoption under six alternative specifications.

The baseline fixed-effects model produced coefficients of 0.389 for ROA, 2.174 for ROE, $-7.351$for the Cost-to-Income ratio, and $-1.286$for the NPL ratio. When Driscoll–Kraay standard errors were used, the point estimates were unchanged because this procedure modified the covariance estimates rather than the coefficients. All four effects remained statistically significant.

Winsorizing the variables at the first and ninety-ninth percentiles produced slightly smaller coefficients, but the direction and significance of the effects were retained. The coefficient was 0.374 for ROA, 2.086 for ROE, $-7.064$for the Cost-to-Income ratio, and $-1.219$for the NPL ratio.

The first-difference models also supported the principal findings. Changes in information technology adoption were positively associated with changes in ROA and ROE and negatively associated with changes in the Cost-to-Income and NPL ratios. This finding reduced concern that the level-based results reflected common trends rather than substantive within-bank relationships.

The component-specific analyses showed that both the Digital Banking and IT Infrastructure indices were independently associated with financial performance. Digital banking had coefficients of 0.268 for ROA, 1.472 for ROE, $-4.386$for the Cost-to-Income ratio, and $-0.731$for the NPL ratio. Technology infrastructure produced somewhat larger coefficients of 0.301, 1.681, -5.218, and -0.846, respectively. The stronger Cost-to-Income coefficient for IT infrastructure indicated that infrastructure adoption was especially closely associated with operating efficiency.

Table 6

Robustness and Sensitivity of Information Technology Adoption Effects

Model specification	ROA coefficient	ROE coefficient	Cost-to-Income coefficient	NPL coefficient
Baseline fixed effects	0.389***	2.174***	-7.351***	-1.286**
Fixed effects with Driscoll–Kraay SE	0.389***	2.174***	-7.351***	-1.286**
Winsorized fixed-effects model	0.374***	2.086***	-7.064***	-1.219**
First-difference model	0.341**	1.938**	-6.482**	-1.107**
Digital Banking Index model	0.268***	1.472***	-4.386***	-0.731**
IT Infrastructure Index model	0.301***	1.681***	-5.218***	-0.846**

Note. $***\ p < 0.001$; $**\ p < 0.01$. *Robust or bank-clustered standard errors were used as appropriate.*

The stability of the coefficients across the alternative models demonstrated that the principal findings were not artifacts of a single operationalization of information technology adoption. The relationship remained statistically significant when the overall adoption index was replaced by either the Digital Banking Index or the IT Infrastructure Index. It also remained significant when the distributions were winsorized, when common cross-sectional dependence was addressed through alternative standard errors, and when changes rather than levels were analyzed.

The findings consistently demonstrated that information technology adoption was associated with stronger financial performance among Iraqi banking institutions. Higher levels of adoption were related to higher ROA and ROE and to lower Cost-to-Income and NPL ratios. These relationships were evident in descriptive correlations, pooled regression, fixed-effects estimation, random-effects estimation, and dynamic System GMM models.

The fixed-effects findings indicated that the relationship remained significant after stable differences among banking institutions were controlled. This result was particularly important because it showed that increases in information technology adoption within the same bank were associated with subsequent improvements in that bank's financial performance. The Hausman test further established fixed effects as the more appropriate static estimator.

The dynamic findings showed that the relationship was not limited to the year in which technology adoption occurred. Current adoption and one-year-lagged adoption both contributed significantly to financial performance. The lagged effects were smaller than the contemporaneous effects but remained economically and statistically meaningful. Financial performance itself also displayed significant persistence, confirming that banking outcomes followed a dynamic process.

The results for the individual technology dimensions showed that both digital banking and information technology infrastructure contributed to the overall pattern. Digital banking was associated with improved profitability and lower cost and loan-performance ratios. Information technology infrastructure produced similar relationships and showed a particularly strong association with the Cost-to-Income ratio. Consequently, the positive financial effects observed for the overall Information Technology Adoption Index reflected contributions from both externally visible digital services and underlying technological infrastructure.

Taken together, the six sets of results supported the study's central proposition. Information technology adoption had a positive relationship with banking profitability and a negative relationship with operating costs and non-performing loans. The direction of the coefficients remained stable across outcome measures, estimators, lag structures, data treatments, and alternative measures of technology adoption.

Discussion and Conclusion

The present study examined the impact of information technology adoption on the financial performance of banking institutions in Iraq over the 2012–2026 period. The findings consistently showed that higher levels of information technology adoption were associated with stronger financial performance. Specifically, information technology adoption had a positive and statistically significant relationship with Return on Assets and Return on Equity, while it had a negative and statistically significant relationship with the Cost-to-Income ratio and the Non-Performing Loan ratio. These patterns were stable across pooled ordinary least squares, fixed-effects, random-effects, and dynamic System Generalized Method of Moments estimations. The results therefore indicate that the financial benefits of technology adoption were not confined to a single performance measure or a particular estimation method. Instead, technology adoption was associated with higher profitability, greater operating efficiency, and improved loan-portfolio performance.

The positive relationship between information technology adoption and Return on Assets suggests that banks with more advanced technological capabilities were able to generate greater net income from their asset bases. This result is consistent with the argument that information technology increases the productive capacity of banking assets by accelerating transactions, reducing processing delays, and improving the scale at which services can be delivered. The finding aligns with evidence that financial technology adoption improves bank profitability and enhances the productive use of banking resources [1]. It is also consistent with research from an emerging economy showing that bank digitalization contributes positively to profitability [17]. The present result extends this evidence to Iraq, indicating that the adoption of information technology can improve the capacity of banking institutions to convert their available resources into financial returns.

The positive coefficient for Return on Equity further demonstrates that information technology adoption increased the returns generated from shareholders' invested capital. This finding implies that technological investment was not merely associated with a larger volume of banking activity but also with a more effective use of equity resources. Banks with higher technology adoption may be better positioned to process transactions efficiently, offer scalable digital services, and generate additional income without a proportionate increase in the resources committed by shareholders. Similar findings have been reported in research examining the contribution of electronic banking to financial performance in Rwanda, where greater use of electronic banking services was linked to improved bank outcomes [9]. Studies of digital financial services in Nigerian commercial banks have likewise found that technology-enabled banking is associated with stronger performance [10]. The consistency of these findings suggests that technology adoption can create financial leverage by increasing the efficiency with which institutional resources are transformed into earnings.

The results also support evidence from studies of financial technology adoption in traditional banking. Bian et al. found that fintech adoption created measurable value for conventional banks, indicating that technological integration can strengthen rather than merely disrupt established banking institutions [24]. Similarly, research in China found that financial innovations significantly influenced bank performance [18]. More recent evidence from Chinese banking also confirms that financial technology is closely connected to the performance of traditional banks [19]. Although the Iraqi banking environment differs from the Chinese context, the present findings demonstrate a comparable underlying relationship: banks that adopt information technology more extensively tend to achieve better financial outcomes.

The negative relationship between information technology adoption and the Cost-to-Income ratio indicates that technology adoption improved operational efficiency. A lower Cost-to-Income ratio means that banks required fewer operating expenses to generate each unit of operating income. This finding is economically plausible because banking technology can automate repetitive tasks, reduce manual processing, accelerate settlement procedures, and expand service capacity without requiring equivalent increases in branch-based expenditure. The finding is in line with research on digital transformation in banking, which suggests that technology-intensive business models can improve efficiency by reorganizing banking operations around digital channels and automated systems [3]. It is also consistent with evidence concerning neobanks, where digital transformation has been linked to enhanced operational efficiency [4].

The efficiency result is further supported by research on strategic technological innovations in Kenyan commercial banks, which found that technological investment contributed to improved institutional performance [15]. Evidence from selected

West African countries similarly showed that technological innovation influenced bank performance over an extended period [14]. The present study adds to this literature by showing that the efficiency effect remained statistically significant after controlling for stable differences among Iraqi banks through fixed-effects estimation. This means that the result was not simply driven by technologically advanced banks being inherently different from less advanced banks. Rather, increases in technology adoption within the same institution were associated with reductions in its Cost-to-Income ratio over time.

The IT Infrastructure Index produced a particularly strong negative association with the Cost-to-Income ratio. This result indicates that underlying technological systems, rather than only customer-facing digital channels, play a central role in operational efficiency. Core banking platforms, network capacity, data-processing systems, and integrated information infrastructure can reduce duplication, improve transaction speed, and enable banks to process a greater volume of financial activity at a lower average cost. This interpretation is consistent with research emphasizing that technological adoption must be embedded in the operational structure of a bank to generate sustainable performance gains [25]. It also corresponds with studies showing that the performance value of fintech depends on the depth and effectiveness of its integration into traditional banking operations [24].

The negative association between information technology adoption and the Non-Performing Loan ratio is another important finding. This relationship indicates that banks with higher levels of technology adoption tended to have a smaller proportion of loans classified as non-performing. Although information technology does not eliminate credit risk, it can improve the speed, organization, and accuracy of financial information processing. Better technological systems may allow banks to maintain more consistent records, identify repayment problems earlier, monitor loan accounts more effectively, and process borrower information more systematically. The result is therefore consistent with the broader view that technological innovation can improve banking performance not only through income generation but also through stronger management of financial assets.

This finding has particular importance because the NPL ratio reflects the quality of a bank's lending portfolio. Poor loan performance reduces interest income, requires greater loss recognition, and limits the productive use of financial resources. Research concerning lending and the financial performance of commercial banks has shown that the quality and outcomes of lending activity are central determinants of bank performance [7]. The present study suggests that information technology adoption may support improved loan performance by strengthening the informational and operational processes through which loans are administered. The negative relationship between technology adoption and NPLs therefore helps explain why the same adoption index was positively associated with ROA and ROE.

The Digital Banking Index also showed significant relationships with all four financial performance indicators. Higher digital banking adoption was associated with greater ROA and ROE and with lower Cost-to-Income and NPL ratios. This result supports the proposition that customer-facing digital services contribute to financial performance by expanding access to banking services and increasing the volume of transactions processed through lower-cost channels. The finding is consistent with evidence that mobile money and related financial technologies can improve banking performance in East African economies [12]. It also aligns with studies showing that mobile banking performance effects are economically meaningful, although their magnitude may vary across banking institutions [13].

The positive performance effect of digital banking is further supported by evidence from Nigeria, where financial technology has transformed the delivery of banking services [11]. The expansion of online, mobile, and electronic channels can reduce customers' dependence on branch-based services and permit banks to conduct a larger number of transactions through standardized digital processes. Research on digital financial innovation in Kenya also indicates that digitally enabled financial activities can support improved financial outcomes [16]. The present findings suggest that these mechanisms are relevant in the Iraqi banking sector, where variation in digital banking adoption was associated with measurable differences in profitability, efficiency, and loan performance.

The results also showed that information technology adoption had both contemporaneous and lagged effects on financial performance. Current adoption significantly affected all four performance indicators, while one-year-lagged adoption remained statistically significant after current adoption and prior financial performance were considered. This finding indicates that the benefits of technology adoption were not fully realized in the year of implementation. Instead, part of the financial effect emerged in subsequent periods. This delayed pattern is consistent with the nature of technological investment, which often requires implementation, institutional adjustment, system integration, and gradual utilization before its full economic value becomes visible.

The lagged findings help explain why some previous studies have reported varying magnitudes of financial technology effects. Short observation periods may underestimate the value of adoption when the costs are recognized immediately but the benefits accumulate over time. Research on cost estimation in banking and fintech projects demonstrates that technology initiatives involve substantial initial and continuing expenditure [8]. At the same time, studies of fintech profitability indicate that technological investment becomes financially beneficial when institutions successfully convert innovation into sustained operational and revenue advantages [23]. The current and lagged coefficients observed in the present study reflect this temporal sequence, with technology producing immediate benefits as well as additional financial improvements in later periods.

The significant lagged dependent-variable coefficients also showed that financial performance was persistent. Banks with stronger performance in one year tended to maintain part of that advantage in the following year. This persistence is important because it indicates that technology adoption operates within an ongoing financial trajectory rather than producing isolated annual changes. The dynamic estimates suggest that technology adoption can reinforce positive performance paths by generating improvements that continue beyond the initial period. Evidence on the relationship between information technology adoption, peer influence, and bank performance similarly suggests that technology decisions have strategic implications that extend over time [25].

The robustness analyses strengthened confidence in the principal findings. The direction and significance of the coefficients remained stable when alternative estimators, transformed variables, winsorized data, first differences, and separate technology indices were used. These results reduce the likelihood that the conclusions were produced by extreme observations, common trends, or a single definition of information technology adoption. The similarity between pooled, fixed-effects, random-effects, and GMM findings also indicates that the relationship was not highly sensitive to alternative assumptions concerning institutional heterogeneity and temporal dependence.

The overall pattern is consistent with research from several emerging markets. Technological innovations have been linked to banking performance in Africa [2], digitalization has been associated with profitability in emerging-country banks [17], and fintech growth has influenced bank performance in the Gulf region [20]. Studies from Egypt have also shown that the adoption of information-based technologies can improve banking profitability [26, 27]. Evidence concerning fintech adoption and bank profitability likewise supports the positive relationship identified in the present research [28].

The results are also compatible with the view that financial technology can complement established banking institutions. Research from Ghana suggests that technology may function as a complement to domestic financial institutions when it expands their capacity to provide financial services [21]. Similarly, research on traditional African banks emphasizes that financial technology development creates both competitive pressure and opportunities for institutional improvement [22]. The Iraqi evidence indicates that technology adoption was predominantly associated with performance enhancement, suggesting that digital systems and conventional banking activities can operate complementarily when technological capabilities are incorporated into institutional operations.

The findings concerning profitability also correspond with research showing that technology-related banking practices contribute to financial outcomes [30]. Studies of financial inclusion and bank performance further suggest that the expansion of technology-enabled financial activity can strengthen the economic position of banking institutions [29]. In addition, emerging artificial intelligence applications indicate that the technological transformation of banking is likely to continue, with AI-supported services becoming increasingly relevant to bank operations and customer interactions [5]. Strategic blockchain adoption may similarly expand the range of information technologies used in financial activities [6]. The present study therefore captures a relationship that is likely to remain important as Iraqi banks adopt increasingly advanced technologies.

Taken together, the findings show that information technology adoption was a significant determinant of financial performance in Iraqi banking institutions. The effects were multidimensional: profitability increased, operating efficiency improved, and the proportion of non-performing loans declined. The results also demonstrated that both digital banking and IT infrastructure contributed to these outcomes and that part of the effect materialized with a time lag. The study therefore provides empirical support for treating information technology as a productive banking resource whose financial value develops through both immediate operational improvements and cumulative institutional use.

This study has several limitations. First, the analysis relied on publicly available annual reports, audited financial statements, and regulatory disclosures, and the detail and consistency of technology-related reporting differed across banking institutions and years. The Information Technology Adoption Index therefore depended on observable and documented indicators and may not have captured every aspect of actual technology use. Second, the panel was unbalanced because complete information was not available for every bank in every year, particularly toward the end of the study period. Third, although fixed-effects and dynamic GMM estimations reduced bias arising from unobserved institutional differences, persistence, and reverse relationships, the observational design does not provide the same degree of causal certainty as an experimental design. Finally, the study focused on Iraqi banking institutions, so the magnitude of the estimated effects may not be directly generalizable to banking systems with substantially different technological, operational, and financial structures.

Future studies should construct more detailed measures of information technology adoption using standardized institution-level disclosures and should distinguish among successive stages of technological implementation. Researchers could extend the observation period as additional audited data become available and compare the Iraqi results with those of other emerging economies using harmonized measures of technology adoption and financial performance. Further research should also investigate whether the financial effects of technology are linear or whether diminishing returns emerge after banks attain high levels of adoption. Studies using quarterly data could identify shorter adjustment periods, while longer longitudinal designs could examine whether the effects on profitability, operating efficiency, and non-performing loans persist beyond the initial implementation years. Qualitative or mixed-method investigations could also clarify why similar levels of technology adoption produce different financial outcomes across institutions.

Banking institutions should approach information technology adoption as a sustained financial investment rather than a one-time modernization project. Priority should be given to technologies that can be integrated directly into transaction processing, financial reporting, loan administration, and digital service delivery because the findings indicate that both infrastructure and digital banking contribute to performance. Managers should evaluate technology projects through multiple financial indicators instead of relying only on immediate profitability, since improvements may also appear as lower operating costs and reduced non-performing loans. Performance assessment should continue for several years after implementation because part of the financial return emerges with a lag. Banks should also develop consistent internal reporting systems that connect technology adoption measures with ROA, ROE, the Cost-to-Income ratio, and the NPL ratio so that investment decisions can be based on documented financial outcomes.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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