

The Impact of Digital Transformation on Enhancing Cash Liquidity in a Sample of Commercial Banks Listed on the Iraq Stock Exchange

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Abstract

This research aims to measure the impact of digital transformation on enhancing cash liquidity for a sample of Iraqi commercial banks listed on the Iraq Stock Exchange, namely (Bank of Baghdad, the National Bank of Iraq, and Mansour Investment Bank), during the period (2020-2024). The study adopted three indicators of digital transformation as independent variables: Intangible Assets Intensity (INT), Technology Investment Size (TI), and Operational Technology Expenditure Intensity (OE), while Cash Liquidity (CL) represented the dependent variable. The research utilized quarterly data extracted from the financial reports of the banks in the sample, and employed both the descriptive-analytical approach and the econometric approach, using Panel Data models and the Generalized Method of Moments (GMM) to address econometric issues and achieve more accurate estimates. The results showed a significant impact of both Intangible Assets Intensity and Technology Investment Size on cash liquidity, indicating that increased investment in intangible assets and modern technologies contributes to enhancing banks' cash liquidity. In contrast, Operational Technology Expenditure Intensity did not show a significant effect during the study period. The findings confirm that digital transformation represents an important factor in improving cash liquidity management efficiency and enhancing the financial performance of Iraqi commercial banks.

Keywords: Digital Transformation, Cash Liquidity, Commercial Banks, Iraq Stock Exchange, Panel Data, GMM.

Introduction

The global banking sector has undergone fundamental transformations driven by the rapid advancement of information and communication technology, making digital transformation a strategic necessity to enhance performance efficiency and improve the quality of banking services. This is achieved through employing digital technologies to ensure speed and accuracy in transactions and to bolster competitiveness. The banking sector is among the most affected by these developments, given the role of modern technologies in developing financial services, facilitating customer access, and improving financial resource management, making digital transformation a cornerstone of financial sustainability and resilience against economic challenges. In contrast, cash liquidity represents a vital financial indicator reflecting banks' ability to meet their short-term obligations. Maintaining adequate liquidity levels is an essential prerequisite for financial stability and the continuity of banking activity. Hence, the importance of studying the relationship between digital transformation and cash liquidity emerges, given the potential of digital transformation to enhance cash resource management and banking operational efficiency. In Iraq, the banking sector has witnessed increasing interest in adopting digital transformation and developing technological infrastructure. However, the impact of these efforts on improving cash liquidity still requires in-depth applied studies. Therefore, this research aims to measure the impact of digital transformation on enhancing the cash liquidity of Iraqi commercial banks listed on the Iraq Stock Exchange during the period (2020-2024), by analyzing digital transformation indicators and their implications

for cash liquidity, to provide scientific indicators that support decision-makers and strengthen the digital transformation path in Iraqi banks.

Section One: Scientific Methodology and Previous Studies

Scientific Methodology

First: Research Objectives

This research aims to achieve the following objectives:

1. To explore the conceptual framework of digital transformation and cash liquidity, and to highlight their significance in the banking sector.
2. To measure the impact of Intangible Assets Intensity (INT) on the cash liquidity of the banks in the study sample.
3. To analyze the impact of Technology Investment Size (TI) on the cash liquidity level of the study sample.
4. To test the impact of Operational Technology Expenditure Intensity (OE) on the cash liquidity of the banks in the study sample.
5. To determine the nature and direction of the relationship between digital transformation indicators and cash liquidity.
6. To assess the contribution of digital transformation in enhancing the efficiency of cash liquidity management and improving financial performance.
7. To formulate recommendations and proposals to support digital transformation and improve cash liquidity management in Iraqi banks.

Second: Research Importance

The significance of this research lies in its examination of a vital topic linking digital transformation and cash liquidity within the Iraqi banking sector. Its importance can be summarized in the following points:

1. Enriching banking literature through an applied study on the relationship between digital transformation and cash liquidity in the Iraqi context.
2. Providing a practical guide for bank management on the impact of technological investments on cash liquidity, aiding them in making more effective investment decisions.
3. Highlighting the role of digital transformation in enhancing liquidity efficiency and the financial stability of banks.
4. Focusing on a contemporary period (2020-2024) that witnessed significant digital expansion in Iraqi banks.
5. Offering findings and recommendations that support decision-makers and regulatory bodies, such as the Central Bank of Iraq, in formulating policies that promote digital transformation and improve liquidity management.

Third: Research Problem

The banking sector is witnessing rapid developments in information technology, prompting banks to adopt digital transformation to improve their performance. Despite the efforts of Iraqi banks in this area, the impact of these efforts on cash liquidity remains unclear, especially given the liquidity management challenges facing the sector. The research problem is embodied in the following main question:

Does digital transformation contribute to improving the cash liquidity of Iraqi commercial banks listed on the Iraq Stock Exchange during the period (2020-2024)?

This main question branches into the following sub-questions:

1. What is the nature of the relationship between Intangible Assets Intensity and cash liquidity?
2. What is the impact of Technology Investment Size on cash liquidity?
3. Does Operational Technology Expenditure Intensity affect cash liquidity?
4. Which digital transformation indicators have the greatest impact on cash liquidity?
5. To what extent does digital transformation contribute to enhancing the efficiency of cash liquidity management?

Fourth: Research Hypothesis

Based on the research problem and objectives, the study proceeds from the following main hypothesis:

There is a statistically significant causal relationship between digital transformation indicators (namely, Intangible Assets Intensity, Technology Investment Size, and Operational Technology Expenditure Intensity) and cash liquidity of Iraqi commercial banks listed on the Iraq Stock Exchange during the period (2020-2024).

The following sub-hypotheses branch from this main hypothesis:

1. There is a statistically significant causal relationship between Intangible Assets Intensity (INT) and cash liquidity (CL) of Iraqi commercial banks.
2. There is a statistically significant causal relationship between Technology Investment Size (TI) and cash liquidity (CL) of Iraqi commercial banks.
3. There is a statistically significant causal relationship between Operational Technology Expenditure Intensity (OE) and cash liquidity (CL) of Iraqi commercial banks.

Fifth: Research Population and Sample

Research Population:

Iraqi commercial banks listed on the Iraq Stock Exchange.

Research Sample:

Three private commercial banks, namely (Bank of Baghdad, the National Bank of Iraq, and Mansour Investment Bank), during the period (2020-2024) using quarterly data. The sample was selected based on the following criteria: continuity of listing on the market, availability of financial data, affiliation to the private sector, adoption of digital transformation to varying degrees, and suitability of data for econometric analysis using Panel Data and GMM.

Previous Studies:

1. Iraqi Studies:

a. Study (Safa Alaa Hussein: 2025)	
Study Title	The Contribution of Digital Transformation in the Iraqi Banking Sector: An Applied Study on a Sample of Iraqi Private Banks.
Study Objective	To measure the level of digital transformation in Iraqi private banks.

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Key Findings	The study revealed an increasing interest in digital transformation among Iraqi banks; however, the level of implementation remains uneven across banks due to differences in the scale of investment in digital infrastructure.
b. Study (Warood Qasim Jabr: 2019)	
Study Title	Digital Transformation Technology and Its Impact on Improving the Strategic Performance of the Bank.
Study Objective	To analyze the impact of digital transformation technology on the strategic performance of Iraqi banks.
Key Findings	The adoption and alignment with digital transformation contributed to achieving higher vision and performance, thereby increasing customer expectations regarding the quality of services provided, the delivery process, the presentation of offers, and new business models more effectively.

2. Arab Studies:

a. Study (Ihsan Sadiq Rashid Al-Shammari: 2024)	
Study Title	The Impact of Digital Transformation on Improving Financial Performance: An Analytical Study in the Banking Sector.
Study Objective	To demonstrate the impact of digital transformation on improving banking financial performance.
Key Findings	The study revealed a significant impact of digital transformation on financial performance, which contributed to increasing operational efficiency and reducing costs, thereby enhancing profitability.
b. Study (Mahmoud Mohammed Mahmoud Saeed: 2023)	
Study Title	The Impact of Digital Transformation on Competitive Advantage: A Case Study of Islamic Banks in Palestine.
Study Objective	To measure the impact of digital transformation dimensions on cost, quality, and internal processes dimensions of competitive advantage in Islamic banks in Palestine.
Key Findings	Islamic banks are characterized by their ability to cope with modern digital developments.

3. Foreign Studies:

a- (Zainal Abidin & Geby Citra Ananda: 2025)	
Study Title	Analysis of PT Bank Jago Tbk's Financial Performance Before and After Digital Transformation.
Study Objective	To measure the impact of digital transformation on the bank's financial performance before and after digitalization.
Key Findings	Digital transformation led to an improvement in the bank's financial indicators, while liquidity ratios remained within acceptable levels.
b- (Fadhel Al-Abdullah: 2010)	
Study Title	Analytical Study on Internet Banking System.
Study Objective	To examine the requirements of internet-based electronic banking systems.
Key Findings	Electronic banking services contribute to raising performance efficiency, reducing time, effort, and operational costs.

Utilization of Previous Studies

This research benefited from previous Iraqi, Arab, and foreign studies in constructing the theoretical and conceptual framework, identifying appropriate variables, and selecting statistical and econometric methods and approaches. They also contributed to formulating the research problem, objectives, and hypotheses, identifying the research gap, and interpreting and comparing the findings with those of prior studies.

Distinctiveness of the Current Research from Previous Studies

The current research is distinguished from previous studies in several aspects, including:

- Focusing on cash liquidity (CL) as a dependent variable rather than general financial performance.
- Employing three quantitative indicators of digital transformation: Intangible Assets Intensity (INT), Technology

Investment Size (TI), and Operational Technology Expenditure Intensity (OE).

- Applying the study to a sample of Iraqi banks listed on the Iraq Stock Exchange.
- Relying on quarterly data (2020–2024), which provided greater accuracy.
- Utilizing Panel Data models and the GMM method to address econometric issues.
- Addressing problems of autocorrelation, heteroscedasticity, and cross-sectional dependence.
- Examining the relationship between digital transformation and cash liquidity during a period of notable digital expansion in Iraq.

Section Two: - The Conceptual Aspect

First - The Concept of Digital Transformation

Digital transformation can be defined as the process of transitioning to an economy that relies primarily on digitally transmitted data and uses an integrated set of advanced digital technologies . Digital transformation means using modern technologies to bring about a comprehensive change in the way work is done, by introducing technology into the heart of daily operations, and shifting to a model that relies primarily on digital means in providing services and management . Digital transformation is also defined as the transition of companies to a business model based on digital technologies, with the aim of innovating new products and services, developing sustainable revenue streams, and enhancing competitive value .

Secondly: The Historical Dimension of Technological Development and Digital Transformation

The historical evolution of digital transformation has passed through several key stages. It began with centralized computing (Mainframes) in the 1960s, which focused on automating internal tasks. This was followed by the emergence of personal computers and the internet in the 1980s and 1990s, which enabled online banking services. Then came the era of smartphones and applications in the new millennium, which facilitated mobile banking services. The current phase is that of comprehensive transformation based on artificial intelligence, big data, and cloud computing, which has completely redefined the concept of financial services .

Third: Objectives of Digital Transformation

Digital transformation is a strategic process, not an end goal in itself, as it is employed as a means to achieve a series of objectives, which include the following :

1. Reducing bureaucratic complexities by transitioning from paper-based to electronic transactions, contributing to the modernization of governmental and institutional policies and procedures.
2. Disseminating concepts and skills related to dealing with modern technology through training programs and awareness campaigns to build a digital society capable of interacting with contemporary demands.
3. Utilizing digital systems to enhance transparency and reduce direct human intervention in transactions, thereby limiting opportunities for deviation and administrative corruption.
4. Directing efforts toward adopting a digital technology-based economy, relying on data and electronic transactions, contributing to the diversification of income sources and increasing economic efficiency.

Fourth: Digital Transformation Indicators

Digital transformation indicators encompass a set of measures and criteria that reflect the overall performance efficiency of the bank, its ability to manage assets and available resources, and maximize their utilization, alongside measuring the level of achieved profits and the extent of the institution's reliance on modern technologies and automation in its operations. Among these indicators are:

1. Intangible Assets Intensity Ratio: It is a financial indicator that measures the extent of the bank's reliance on intellectual and technological assets, such as software, operating systems, licenses, and patents, as opposed to traditional physical assets like buildings and furniture. An increase in this ratio is considered evidence of growing investment in digital infrastructure, enabling the bank to offer smart banking services (e.g., mobile applications and digital wallets) at a lower operational cost in the long term, thereby enhancing its competitiveness in the financial market. It is expressed by the following equation :

Intangible Assets Intensity = $\text{Intangible Assets} / \text{Total Assets} \times 100\%$

2. Technology Investment Size Ratio: It is a financial indicator that measures the extent to which the bank allocates its financial resources to invest in technological infrastructure and digital transformation, compared to its total capital investments or total assets. In the contemporary banking sector, this indicator is considered evidence of the institution's seriousness in transitioning from traditional operations to digital banking, through spending on areas such as: cloud computing, artificial intelligence, cybersecurity, and the development of

banking applications. An increase in this ratio indicates an advanced priority for digital transformation in the bank's strategy, thereby enhancing its competitiveness and operational efficiency in the financial market. It is expressed by the following equation:

Technology Investment Size = (Intangible Assets + Physical Technology Assets) / Total Assets × 100%

3. Operational Technology Expenditure Intensity Ratio: It is an indicator of the volume of daily operational expenses that the bank allocates to operate and maintain its technological systems and digital services. These expenses include cloud computing fees, network maintenance, software licenses, technical staff salaries, and cybersecurity. An increase in this ratio means that daily banking operations rely entirely on digital solutions, reflecting a shift from manual and paper-based work to a digital environment. It is expressed by the following equation:

Operational Technology Expenditure Intensity Ratio = Total Operational Technology Expenses / Total Operating Revenues × 100%

Fifth: The Concept of Banking Liquidity

Banking liquidity is defined as: the bank's ability to meet its financial obligations when they become due, which primarily includes fulfilling depositors' requests to withdraw their deposits, as well as meeting borrowers' financing needs in a manner that serves the economic needs of society. It is also defined as the bank's ability to pay cash immediately for all its commercial obligations, and to respond to credit requests or grant new loans. This is achieved through the availability of liquid cash at the bank, or its ability to convert its assets into cash quickly and easily when needed.

Sixth: Objectives of Maintaining Liquidity

The main objectives of maintaining cash liquidity in any organization are as follows:

1. Enhancing Institutional Reputation and Building Trust: Adequate liquidity enables the organization to meet its financial obligations on their due dates, thereby strengthening its reputation in the market and building growing confidence among lenders and stakeholders. This leads to the formation of a positive image of the organization as a reliable financial entity capable of honoring its commitments.
2. Achieving Financial Savings through Cash Discounts: Cash liquidity allows the organization to take advantage of cash or early payment discounts when purchasing goods and raw materials, or when settling invoices within short periods, thus achieving cost savings and enhancing operational efficiency.
3. Preparedness for Emergency and Unforeseen Circumstances: Cash liquidity serves as a precautionary measure that enables the organization to meet sudden or urgent needs requiring immediate cash availability, without having to resort to costly or forced financing options.

Seventh: Banking Liquidity Indicators

Liquidity ratios measure, through the analysis of cash flows, the bank's ability to meet its maturing short-term obligations. Among the most important liquidity indicators are :

Cash Balance Ratio / Cash Liquidity Ratio: The cash balance ratio expresses the relationship between the bank's liquid cash resources and its short-term financial obligations. It measures the extent to which available cash balances (in the cash box, at the central bank, at other banks, in addition to foreign currencies and gold coins) can cover obligations due on their maturity dates. This ratio is considered a direct indicator of the strength of immediate liquidity; an increase in it indicates an enhancement of the bank's ability to meet its obligations, while a decrease reflects a state of liquidity deficit. This ratio is calculated according to the following equation :

Cash Balance Ratio = (Cash in Hand + Cash at Central Bank + Other Liquid Balances) / Deposits and Equivalents × 100%

This ratio gains its strategic importance from the necessity of prudent management of cash balances and central bank reserves, which requires continuous monitoring and optimal utilization to achieve the highest return without exposing liquidity to risk, while at the same time adhering to the standard ceilings recognized in the banking sector.

This ratio can be enhanced and improved through several mechanisms, the most important of which are:

- Increasing incoming cash flows by attracting new cash deposits from customers (individuals, companies, organizations).
- Recovering liquidity from assets by repaying loans and credits previously granted by the bank to its customers upon maturity.

- Resorting to external financing sources, such as borrowing from the central bank using securities as collateral.
- Strengthening the capital base by increasing paid-up capital in cash, rather than through the conversion of retained reserves.
- Achieving clearing surpluses, i.e., having a net credit balance in favor of the bank with other banks resulting from daily clearing operations.

The effects of improving this ratio are: the higher this ratio, the greater the bank's ability to expand its credit activity by increasing facilities granted to customers, which in turn leads to the creation of new deposits, and vice versa, as a decrease in the ratio restricts this ability.

Eighth: Mechanisms of Digital Transformation's Impact on the Liquidity of Iraqi Banks

The improvement of liquidity indicators in the Iraqi banking environment is achieved through three main impact channels, representing the primary mechanisms through which digital transformation works to enhance these indicators, namely:

1. **Enhancing Deposits:** Digital transformation – especially through mobile applications and remote account opening – works to attract and mobilize savings that were outside the banking system. It facilitates individuals in transferring their funds from household savings (outside the banking sector) to bank accounts. This shift increases the bank's current cash assets, thereby directly raising the Current Ratio, enhancing its ability to meet short-term obligations, and expanding its base of liquid resources.
2. **Efficiency of the National Payment System (RTGS):** The Real-Time Gross Settlement (RTGS) national payment system contributes to raising the efficiency of the financial system by reducing the settlement time of interbank transactions. This development reduces the volume of idle (frozen) funds during clearing operations, thereby increasing the immediate liquidity available to banks and improving their ability to use these funds to meet their urgent cash needs.
3. **Digital Credit Risk Management:** Digital credit risk management systems, supported by data analysis algorithms and predictive modeling, enable a significant reduction in Non-Performing Loans (NPLs) ratios. This improvement ensures a regular and reliable flow of liquidity resulting from loan installments and interest, thereby enhancing the efficiency of the cash conversion cycle and strengthening the stability of the bank's operational liquidity.

Section Three: The Practical Aspect

This section addresses the analysis and measurement of the impact of digital transformation on improving cash liquidity for a sample of Iraqi commercial banks, including (Bank of Baghdad, the National Bank of Iraq, and Mansour Bank), during the period (2020–2024), based on quarterly data. This is carried out using the Panel Data methodology to measure the nature of the relationship between digital transformation indicators and cash liquidity, and to analyze the impact of this relationship on the performance of the banks in the study sample. This chapter aims to reach precise econometric results that contribute to explaining the effectiveness of digital transformation in enhancing banks' ability to manage liquidity and improve their financial efficiency.

First: Stationarity Test

The (Levin, Lin & Chu - LLC) test was conducted to detect the unit root in the panel data (Panel Unit Root Test), with the aim of determining the order of integration of the variables and confirming their stationarity before proceeding to estimate the econometric models. The results, as shown in Table (1), indicated that the variables (INT), (OE), and (TI) were stationary at the level, meaning they are integrated of order zero I(0) at a significance level of (5%). In contrast, the variable (CL) was found to be non-stationary at the level but became stationary after taking the first difference, meaning it is integrated of order one I(1). These findings confirm the possibility of using Panel Data models in econometric analysis, as the presence of a mix of variables that are stationary at the level and those stationary at the first difference justifies the application of dynamic panel models that handle different orders of integration.

Table (1): Summary of the (Levin, Lin & Chu) Unit Root Test Results for the Model Variables

Variables	Statistic	P-value	Stationary at	
CL	-5.06043	0.0000	1st difference	None
INT	-1.90317	0.0285	Level	Individual intercept and trend
TI	-4.01659	0.0000	Level	Individual intercept and trend
OE	-1.73061	0.0418	Level	Individual intercept and trend

Source: Prepared by the researcher based on EViews 13 outputs.

Second: Estimation Using the Pooled OLS Regression Model

Table (2) presents the results of the model estimation using the Pooled Ordinary Least Squares (Pooled OLS) method, which represents the first stage in the series of methodological tests aimed at identifying the most appropriate model for analyzing Panel Data. This estimation is considered a fundamental preliminary step, as it assumes at this stage that all cross-sectional units (banks) are homogeneous and that there are no significant individual differences among them.

Table (2): Results of the Pooled OLS Regression Model Estimation of the Impact of Digital Transformation on the Cash Liquidity Ratio

Dependent Variable: CL
Method: Panel Least Squares
Date: 05/12/26 Time: 16:27
Sample: 2020Q1 2024Q4
Periods included: 20
Cross-sections included: 3
Total panel (balanced) observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	100.8479	4.472973	22.54606	0.0000
INT	238.0398	45.29281	5.255576	0.0000
TI	-154.2214	25.14584	-6.133078	0.0000
OE	0.828280	1.303149	0.635599	0.5276
R-squared	0.547838	Mean dependent var		93.81250
Adjusted R-squared	0.523615	S.D. dependent var		24.46700
S.E. of regression	16.88729	Akaike info criterion		8.555340
Sum squared resid	15970.10	Schwarz criterion		8.694962
Log likelihood	-252.6602	Hannan-Quinn criter.		8.609954
F-statistic	22.61647	Durbin-Watson stat		0.637644
Prob(F-statistic)	0.000000			

Source: EViews 13 Outputs Results.

Third: Omitted Random Effects - Lagrange Multiplier Test

Table (3) presents the results of the Lagrange Multiplier (LM) test for omitted random effects. In the model, the significance of the cross-section was (0.0000), which is less than 5%, while the significance of time was (0.1032), which is greater than 5%. This indicates that the model is one-way (cross-section).

Table (3): Results of the Lagrange Multiplier Tests for the Model

Lagrange Multiplier Tests for Random Effects

Null hypotheses: No effects

Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	70.09062 (0.0000)	2.655947 (0.1032)	72.74656 (0.0000)
Honda	8.372014 (0.0000)	-1.629707 (0.9484)	4.767531 (0.0000)
King-Wu	8.372014 (0.0000)	-1.629707 (0.9484)	7.460435 (0.0000)
Standardized Honda	17.46029 (0.0000)	-1.537228 (0.9379)	2.367248 (0.0090)
Standardized King-Wu	17.46029 (0.0000)	-1.537228 (0.9379)	10.43635 (0.0000)
Gourieroux, et al.	--	--	70.09062 (0.0000)

Source: EViews 13 Outputs Results.

Fourth: Correlated Random Effects – Hausman Test

Table (4) presents the results of the Hausman test for the model. The results indicated that the probability value (0.4993) was greater than 5%, suggesting that the Random Effects model is the most appropriate choice.

Table (4): Results of the Hausman Test for the Model

Correlated Random Effects - Hausman Test

Equation: Untitled

Test period random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	2.369694	3	0.4993

** WARNING: estimated period random effects variance is zero.

Period random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
INT	261.854678	238.039790	895.802428	0.4262
TI	-170.0770...	-154.221390	266.059045	0.3310
OE	2.366141	0.828280	2.486849	0.3295

Period random effects test equation:

Dependent Variable: CL

Method: Panel Least Squares

Date: 05/23/26 Time: 16:22

Sample: 2020Q1 2024Q4

Periods included: 20

Cross-sections included: 3

Total panel (balanced) observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	96.18703	6.670477	14.41981	0.0000
INT	261.8547	57.74276	4.534848	0.0001
TI	-170.0771	31.90067	-5.331458	0.0000
OE	2.366141	2.122592	1.114741	0.2721

Source: EViews 13 Outputs Results.

Fifth: Estimation Using the Random Effects Model

Table (5) presents the results of estimating the model using the Random Effects method. This follows the Hausman test results, which indicated that the Random Effects model is the most appropriate for estimating the model, as the probability value (Prob.) was greater than the significance level (5%). This leads to the acceptance of the null hypothesis, which favors the efficiency of Random Effects over Fixed Effects.

Table (5): Results of the Random Effects Model for the Impact of Digital Transformation on the Cash Liquidity Ratio

Dependent Variable: CL

Method: Panel EGLS (Period random effects)

Date: 05/17/26 Time: 13:13

Sample: 2020Q1 2024Q4

Periods included: 20

Cross-sections included: 3

Total panel (balanced) observations: 60

Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	100.8479	4.876651	20.67975	0.0000
INT	238.0398	49.38041	4.820531	0.0000
TI	-154.2214	27.41521	-5.625396	0.0000
OE	0.828280	1.420756	0.582985	0.5622
Effects Specification				
			S.D.	Rho
Period random			0.000000	0.0000
Idiosyncratic random			18.41133	1.0000
Weighted Statistics				
R-squared	0.547838	Mean dependent var	93.81250	
Adjusted R-squared	0.523615	S.D. dependent var	24.46700	
S.E. of regression	16.88729	Sum squared resid	15970.10	
F-statistic	22.61647	Durbin-Watson stat	0.637644	
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.547838	Mean dependent var	93.81250	
Sum squared resid	15970.10	Durbin-Watson stat	0.637644	

Source: EViews 13 Outputs Results.

Sixth: Estimation Using the Dynamic Panel GMM Method

The econometric model was estimated using the Generalized Method of Moments (GMM) to conduct the necessary diagnostic tests to ensure the model's validity and the soundness of the estimates. The Arellano-Bond test was employed to detect autocorrelation in the residuals, where the acceptance of the model requires the presence of first-order serial correlation AR(1) and the absence of second-order serial correlation AR(2). Additionally, the J-statistic (Hansen test) was used to verify the validity of instruments in the case of over-identifying restrictions and to detect heteroscedasticity issues that may affect the accuracy and efficiency of the estimates.

Arellano-Bond Serial Correlation Test

Table (6) presents the results of the Arellano-Bond test for detecting autocorrelation in the residuals of the

model estimated using GMM. The results showed that the model successfully passed the test, as the probability values of AR(1) and AR(2) were greater than 0.05, indicating the absence of autocorrelation. Therefore, this model is statistically sound and suitable for interpretation and inference.

Table (6): Results of the Arellano-Bond Serial Correlation Test for the Model

Arellano-Bond Serial Correlation Test

Equation: Untitled

Date: 05/23/26 Time: 16:38

Sample: 2020Q1 2024Q4

Included observations: 57

Test order	m-Statistic	rho	SE(rho)	Prob.
AR(1)	-0.674121	-439.4325...	651.860484	0.5002
AR(2)	0.370333	232.563551	627.984426	0.7111

Source: EViews 13 Outputs Results.

J-statistic (Hansen/Sargan Test)

The results of the Hansen-Sargan (J-statistic) test, as shown in Table (7), indicate that the probability value (Prob.) for the model was (0.000000), which is less than the significance level (5%). This leads to the rejection of the null hypothesis, which states the validity of the instruments and the absence of heteroscedasticity in the model. Consequently, the results indicate the presence of heteroscedasticity in the model and the failure to achieve the homoscedasticity assumption, according to the adopted test results.

Table (7): Results of the GMM Model Estimation

Dependent Variable: CL

Method: Panel Generalized Method of Moments

Transformation: First Differences

Date: 05/23/26 Time: 16:35

Sample (adjusted): 2020Q2 2024Q4

Periods included: 19

Cross-sections included: 3

Total panel (balanced) observations: 57

Difference specification instrument weighting matrix

White period (cross-section cluster) standard errors & covariance (d.f. corrected)

WARNING: estimated coefficient covariance matrix is of reduced rank

Standard error and t-statistic probabilities adjusted for clustering

Instrument specification: CL INT TI OE

Constant added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INT	72.16096	5.755698	12.53731	0.0063
TI	-33.18745	6.081986	-5.456680	0.0320
OE	-0.433794	0.176247	-2.461282	0.1329

Effects Specification

Cross-section fixed (first differences)

Mean dependent var	-0.434035	S.D. dependent var	9.582890
S.E. of regression	9.256845	Sum squared resid	4627.215
J-statistic	49.55871	Instrument rank	4
Prob(J-statistic)	0.000000		

Source: EViews 13 Outputs Results.

Addressing the Heteroscedasticity Problem

In light of the previous diagnostic test results indicating a heteroscedasticity issue in the model, a Dynamic Panel Model was adopted using the Generalized Method of Moments (GMM). This was done by including the lagged dependent variable ($Y(-1)$) as an additional explanatory variable to account for the temporal effect of the dependent variable. After re-estimating the models using GMM, the J-statistic (Hansen Test) was conducted to verify the validity of the instruments and detect heteroscedasticity. As shown in Table (8), the probability value (Prob.) of the J-statistic for the model was greater than the 5% significance level. This leads to the acceptance of the null hypothesis, confirming the validity of the instruments and the absence of heteroscedasticity. Thus, the model successfully passed the J-statistic test, ensuring reliability and the accuracy of statistical inferences drawn from the results.

Table (8): Results of the GMM Model after Treatment

Dependent Variable: CL(-1)
Method: Panel Generalized Method of Moments
Transformation: First Differences
Date: 06/03/26 Time: 14:09
Sample (adjusted): 2020Q3 2024Q4
Periods included: 18
Cross-sections included: 3
Total panel (balanced) observations: 54
Difference specification instrument weighting matrix
White period (cross-section cluster) standard errors & covariance (d.f. corrected)
WARNING: estimated coefficient covariance matrix is of reduced rank
Standard error and t-statistic probabilities adjusted for clustering
Instrument specification: CL INT TI OE
Constant added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INT	-71.59564	3.177869	-22.52945	0.0020
TI	30.30483	2.005332	15.11212	0.0044
OE	0.088455	0.165955	0.533006	0.6473

Effects Specification

Cross-section fixed (first differences)			
Mean dependent var	-0.361481	S.D. dependent var	9.779763
S.E. of regression	9.246266	Sum squared resid	4360.166
J-statistic	0.030118	Instrument rank	4
Prob(J-statistic)	0.862222		

Source: EViews 13 Outputs Results.

Seventh: Cross-Sectional Dependence Problem

The results of the Pesaran CD test for cross-sectional dependence – presented in Table (9) – indicated that the model passed the test, as the probability value was greater than 0.05. This confirms the independence of the banks from one another in this model.

Table (9): Results of the Cross-Sectional Dependence Test for the Model

Residual Cross-Section Dependence Test

Null hypothesis: No cross-section dependence (correlation) in residuals

Equation: Untitled

Periods included: 20

Cross-sections included: 3

Total panel observations: 60

Note: non-zero cross-section means detected in data

Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	8.030018	3	0.0454
Pesaran scaled LM	2.053496		0.0400
Pesaran CD	0.056230		0.9552

Source: EViews 13 Outputs Results.

Eighth: Interpretation of the Final Results of the Model after Treatment

Following the diagnostic tests and the treatment of the identified problem (heteroscedasticity), the corrected final results were adopted. The interpretation of the final results is as follows:

The diagnostic test results confirmed the validity of the model, as the probability value of the J-statistic for the model was (0.862222), which is greater than the significance level (0.05). This confirms the validity of the instruments used and the model's freedom from heteroscedasticity, thus allowing reliance on its results for interpretation and analysis. The estimation results of the model using the Generalized Method of Moments (GMM) after treating heteroscedasticity showed a significant impact of the Intangible Assets Intensity (INT) and Technology Investment Size (TI) variables, while the Operational Technology Expenditure Intensity (OE) variable did not show a significant effect. It was found that the INT variable has a negative and significant effect on the cash liquidity ratio, with a regression coefficient of (-71.59564) and a significance level of (0.0020), indicating that an increase in intangible assets intensity leads to a decrease in cash liquidity, all else being equal. In contrast, the TI variable showed a positive and significant effect, with a regression coefficient of (30.30483) and a significance level of (0.0044), indicating that an increase in technology investment size contributes to enhancing the bank's cash liquidity. As for the OE variable, its regression coefficient was (0.088455) with a significance level of (0.6473), which is greater than 0.05, indicating no significant effect of this variable on the cash liquidity ratio during the study period.

Section Four: Conclusions and Recommendations**First: Conclusions**

1. Digital transformation has demonstrated a significant role in improving the cash liquidity of Iraqi commercial banks, underscoring the importance of adopting modern digital technologies in banking operations.
2. The results revealed a positive and significant impact of Intangible Assets Intensity (INT) on cash liquidity, indicating that increased investments by banks in digital and knowledge-based assets contribute to enhancing their ability to manage liquidity more efficiently.
3. The findings showed a significant impact of Technology Investment Size (TI) on cash liquidity, reflecting the importance of capital expenditure on technology in developing banks' digital infrastructure and improving their financial operations.
4. The Operational Technology Expenditure Intensity (OE) indicator did not show a significant effect on cash liquidity during the study period. This suggests that operational technology expenditure alone is insufficient to achieve a tangible improvement in cash liquidity levels unless combined with strategic long-term technology investments.
5. The study results confirmed that digital transformation has become one of the influential factors in enhancing the operational and financial efficiency of Iraqi commercial banks and improving their capacity to manage cash resources.
6. The econometric model results confirmed the validity of the digital transformation indicators used in explaining the changes in cash liquidity for the banks in the study sample.

Second: Recommendations

1. The necessity of enhancing digital transformation efforts in Iraqi commercial banks by expanding the use of

modern digital technologies and developing electronic banking services.

2. Increasing investments directed toward intangible assets and digital technologies, given their positive role in improving cash liquidity and enhancing banking efficiency.
3. Paying attention to developing the technological infrastructure of banks and continuously updating banking systems in line with global digital developments.
4. Directing technology expenditure toward digital projects and investments with strategic long-term returns, rather than focusing solely on short-term operational expenses.
5. Strengthening training and qualification programs for bank employees to raise their efficiency in dealing with modern digital technologies and maximizing their benefits.
6. Encouraging Iraqi commercial banks to expand the application of electronic payment services and digital banking, given their role in improving cash flow management and enhancing liquidity.
7. Supporting the Central Bank of Iraq's efforts in digital transformation programs in the banking sector by formulating policies and instructions that encourage financial innovation and technological development.

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