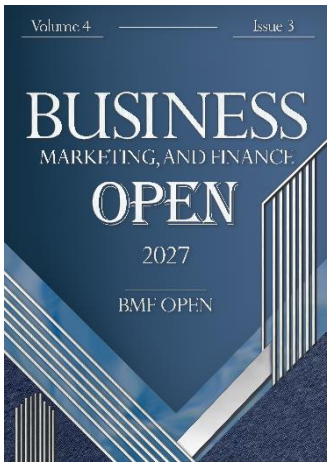
Dynamic Modeling of Financial Health in Emerging Banking Systems: Evidence from Iraqi Banks Using GMM and Panel Data Techniques

Hussein Kamel Hussein [1], Ezatollah Abbasian [2,*] and Islam Fakher [3]



[1] Ph.D. student in Finance– Banking, Aras International Campus, University of Tehran, Jolfa, Iran, and Head of a Supervisory Commission in the Federal Board of Supreme Audit, Iraq;
[2] Professor of Financial Economics, Department of Financial Engineering, Faculty of Management, University of Tehran, Tehran, Iran;
[3] Associate Professor, Department of Financial Management, Shahid Chamran University of Ahvaz, Ahvaz, Iran;

* Correspondence: e.abbasian@ut.ac.ir

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Abstract: This study aimed to develop and empirically test a dynamic econometric model for evaluating the financial health of Iraqi banks by integrating bank-specific financial indicators and macroeconomic determinants within a panel data framework. The study employed a quantitative, applied, and longitudinal panel-data design using balanced annual data from Iraqi commercial banks over the period 2010–2024. Financial health was proxied primarily through credit-risk indicators, particularly the non-performing loan ratio. The explanatory variables included bank-level indicators such as capital adequacy, profitability, liquidity, and portfolio concentration, together with macroeconomic variables including inflation, GDP growth, and oil price volatility. To ensure robust estimation, the analysis applied Pooled Ordinary Least Squares, Fixed Effects, Random Effects, and Generalized Method of Moments models. The GMM approach was used to control for dynamic persistence, unobserved heterogeneity, simultaneity, and potential endogeneity in the relationship between banking indicators and financial health. The inferential results indicated that financial health in Iraqi banks is dynamically persistent, as the lagged dependent variable remained statistically significant in the GMM model. Non-performing loans had a significant negative effect on financial stability, confirming the central role of credit risk in weakening banking soundness. Capital adequacy and profitability showed significant positive effects, suggesting that better capitalization and stronger earnings capacity improve bank resilience. Macroeconomic variables, particularly oil price volatility, significantly improved the explanatory power of the model, demonstrating the vulnerability of Iraqi banks to external macroeconomic shocks. Overall, the dynamic GMM model provided stronger inferential performance than static panel models. The findings confirm that financial health in Iraqi banks cannot be adequately assessed through static accounting indicators alone. A dynamic panel-data approach provides a more accurate and forward-looking understanding of banking fragility in oil-dependent emerging economies. The results highlight the need for Iraqi regulators and bank managers to strengthen credit-risk monitoring, enhance capital buffers, improve profitability, and incorporate macroeconomic stress indicators into supervisory frameworks.

Keywords: Financial Health; Iraqi Banks; Dynamic Panel Data; Generalized Method of Moments; Credit Risk; Emerging Economies

1. Introduction

Financial health is a central concept in banking research because banks function as the primary institutions through which savings are mobilized, credit is allocated, payment systems are maintained, and macroeconomic shocks are transmitted across the real economy. In emerging banking systems, the assessment of financial health is particularly important because banks often operate within environments characterized by institutional fragility, unstable macroeconomic conditions, limited capital-market depth, weak information infrastructure, and high exposure to government spending cycles. Unlike mature financial systems, where market discipline, regulatory transparency, and diversified sources of funding may support early detection of financial distress, emerging systems frequently require more contextualized and forward-looking models capable of integrating bank-specific indicators with broader economic risk factors. In this regard, financial health should not be understood merely as the absence of immediate insolvency, but as the capacity of a bank to maintain asset quality, absorb losses, generate sustainable earnings, manage liquidity pressures, and continue intermediation under changing economic conditions. Standard banking theory emphasizes that sound bank management depends on the coordinated evaluation of capital adequacy, asset quality, management efficiency, earnings, liquidity, and sensitivity to market risk, because weaknesses in one dimension can quickly affect the entire financial condition of a bank [1].

The importance of financial health assessment has grown as banking systems have become more interconnected and exposed to systemic risk. The global financial crisis demonstrated that financial institutions can appear individually stable while collectively transmitting fragility through credit markets, liquidity channels, asset-price correlations, and confidence effects. Systemic risk research has therefore shifted attention from static balance-sheet indicators toward dynamic and interdependent measures of vulnerability. Acharya et al. argued that systemic risk cannot be evaluated solely by observing individual institutional weakness, because the contribution of each institution to system-wide fragility depends on its exposure, capitalization, and interaction with broader market conditions [2]. This perspective is highly relevant for banking systems in oil-dependent economies, where the financial sector is often linked to fiscal expenditure, public-sector deposits, construction cycles, trade financing, and borrower repayment capacity. When oil prices fluctuate, the shock may affect government liquidity, public investment, household income, corporate cash flows, and ultimately loan portfolio quality. Therefore, financial health modeling in such contexts requires dynamic tools that can capture persistence, feedback effects, and macro-financial linkages rather than relying exclusively on contemporaneous accounting ratios.

The relationship between banking-sector health and macroeconomic conditions has been widely documented in financial stability literature. Bank profitability, credit quality, and solvency are affected not only by internal managerial decisions but also by industry structure and the macroeconomic environment. Athanasoglou et al. showed that bank profitability is shaped by bank-specific, industry-specific, and macroeconomic determinants, suggesting that financial performance cannot be separated from the wider environment in which banks operate [3]. Similarly, Love and Turk Ariss demonstrated that macroeconomic shocks influence loan portfolio quality, showing that adverse economic conditions can weaken borrower repayment capacity and increase non-performing loans [4]. These findings are especially important for the Iraqi banking sector because Iraq's economy remains highly dependent on oil revenues, public expenditure, and import-related financial flows. In such an environment, a decline in oil revenues may generate liquidity constraints, reduce economic activity, delay payments to contractors and suppliers, and weaken the quality of bank assets. Consequently, any empirical model of financial health in

Iraqi banks should incorporate macroeconomic variables such as inflation, GDP growth, and oil price volatility in addition to internal banking indicators.

Financial health also depends on the institutional and legal environment that governs financial contracting. The law and finance tradition argues that financial development is shaped by legal protections, enforcement mechanisms, investor rights, and institutional quality [5]. Strong legal systems reduce information asymmetry, improve contract enforcement, and support creditor protection, while weak legal environments increase uncertainty in lending relationships and reduce the reliability of repayment expectations. In emerging economies, institutional weakness may amplify credit risk because banks face difficulties in collateral recovery, borrower screening, bankruptcy resolution, and financial disclosure verification. These institutional concerns are reinforced by research on deposit insurance and banking stability, which shows that poorly designed safety nets may increase moral hazard if they are not accompanied by strong supervision and regulatory discipline [6]. For countries such as Iraq, where the banking system has been shaped by post-conflict reconstruction, regulatory transition, and uneven institutional capacity, financial health assessment must therefore consider the interaction between bank behavior, macroeconomic exposure, and the supervisory environment.

Traditional approaches to bank soundness measurement often rely on accounting ratios, supervisory ratings, or failure-prediction models. These approaches are useful because they transform complex financial statements into interpretable indicators of solvency, profitability, liquidity, and asset quality. However, static models may be insufficient when financial health is persistent over time. A bank with high non-performing loans in one year may continue to experience elevated credit risk in subsequent years due to delayed recovery, inadequate provisioning, borrower restructuring, or weak credit administration. This means that current financial health is partly determined by past financial health. Barr et al. contributed to this literature by showing that bank failure can be forecast using non-parametric frontier estimation, highlighting the importance of efficiency and performance-based evaluation in predicting distress [7]. Flannery also emphasized the role of market information in prudential supervision, arguing that supervisory assessment can benefit from signals beyond traditional regulatory reports [8]. Although market-based indicators may be less available or less informative in underdeveloped capital markets, the broader implication remains important: supervisory models should use richer and more forward-looking information rather than depend only on backward-looking accounting data.

Financial health measurement has also evolved across non-bank sectors, demonstrating the broad relevance of financial distress prediction and organizational sustainability assessment. Altman-type bankruptcy models, balance analysis, and financial health indices have been applied to transportation firms, agricultural enterprises, small and medium-sized enterprises, sport organizations, and listed companies. Aidi et al. used the Z-score method to evaluate the financial health of transportation companies, showing the practical value of combining multiple financial indicators to classify distress risk [9]. Fachrudin developed insolvency and financial health prediction models for listed firms, emphasizing that financial distress prediction requires systematic integration of accounting information [10]. Karpac and Bartošová verified the predictive ability of sector-specific balance analysis using ROC procedures, reinforcing the need to test whether financial health models perform reliably in specific economic contexts [11]. Vavrek et al. evaluated agricultural enterprises using bankruptcy models, demonstrating that sectoral conditions influence the interpretation of financial health indicators [12]. Clarkson et al. extended the concept to professional women's football clubs, showing that financial health is not limited to banking or corporate finance but is relevant wherever organizational survival depends on revenue stability, cost control, and debt capacity [13].

These studies collectively suggest that financial health is a multidimensional and context-sensitive construct, and that models developed in one sector or country may not be directly transferable to another without adaptation.

Recent scholarship has further expanded the concept of financial health beyond traditional insolvency prediction. Parker et al. proposed multiple ways to measure financial health, emphasizing that financial condition involves resilience, planning capacity, management of obligations, and ability to withstand shocks [14]. Klontz et al. also framed financial health as a practical and behavioral construct relevant to planners, coaches, and therapists, showing that financial well-being includes both measurable outcomes and decision-making processes [15]. Pinder-Ayres discussed financial health planning in professional practice, indicating that financial health assessment can guide strategic decisions before distress becomes irreversible [16]. Although these works are not limited to banks, they are useful because they demonstrate that financial health should be assessed as a forward-looking capacity rather than a single static result. In the banking sector, this implies that regulators and managers should not wait until insolvency indicators become severe; instead, they should identify early warning patterns in credit risk, profitability, liquidity, capital adequacy, and macroeconomic exposure.

Governance has also become an important dimension of financial health. Barati et al. identified financial health indicators based on good governance in government organizations, showing that transparency, accountability, and governance quality are closely related to financial sustainability [17]. Papík and Papíková examined the impact of gender-diverse boards on the financial health of small and medium-sized enterprises, suggesting that board composition and governance structure may influence financial outcomes [18]. Zhang et al. analyzed differences in financial health between female-headed and male-headed households in China, further showing that financial health is shaped by structural, demographic, and institutional conditions rather than only by income or assets [19]. Mom and Linh examined the role of financial health in predicting long-term performance in selected industries in Thailand, supporting the argument that financial health has predictive relevance for future outcomes and organizational sustainability [20]. These contributions reinforce the theoretical justification for modeling financial health dynamically, because financial conditions influence future performance and are themselves shaped by prior decisions, governance quality, and external constraints.

In banking systems, credit risk is often the most visible symptom of deteriorating financial health. The non-performing loan ratio is particularly important because it reflects the quality of a bank's loan portfolio and the ability of borrowers to fulfill contractual obligations. High non-performing loans reduce interest income, increase provisioning costs, weaken profitability, erode capital, restrict new lending, and may create liquidity pressure. In emerging economies, credit risk can be amplified by weak credit registries, politically connected lending, sectoral concentration, collateral enforcement problems, and macroeconomic volatility. Aggarwal et al. showed that foreign institutional investors' portfolio preferences are shaped by country and firm characteristics, implying that financial systems with weaker transparency, governance, or stability may face constraints in attracting stable capital [21]. Beck et al. questioned whether more finance is always better and distinguished between financial intermediation and financial system size, suggesting that financial deepening contributes to stability only when intermediation is efficient and productive [22]. For Iraq, this distinction is critical: expanding bank assets or credit volume does not necessarily indicate stronger financial health if loan quality, capital adequacy, and risk management do not improve simultaneously.

The Iraqi banking sector provides a highly relevant setting for studying dynamic financial health. Iraq is an emerging, oil-dependent economy in which the financial system operates under conditions of macroeconomic volatility, regulatory transition, institutional constraints, and uneven private-sector development. Commercial

banks are exposed to fluctuations in oil revenue through multiple channels, including public spending, contractor payments, liquidity creation, deposit growth, foreign exchange demand, and borrower solvency. At the same time, banks differ in capitalization, profitability, liquidity management, and portfolio concentration. These differences create heterogeneous financial health trajectories across institutions. A static model may identify associations between banking indicators and non-performing loans, but it cannot adequately capture persistence, endogeneity, or feedback effects. For example, profitability may reduce credit risk by improving internal resilience, but high credit risk may also reduce profitability through provisioning and lost interest income. Similarly, capital adequacy may protect banks from distress, but deteriorating asset quality may erode capital over time. These reciprocal relationships justify the use of dynamic panel-data techniques, especially the Generalized Method of Moments, which is designed to address lagged dependence, unobserved heterogeneity, simultaneity, and potential endogeneity in panel datasets.

A contextualized econometric model of financial health in Iraqi banks is therefore needed for both theoretical and policy reasons. Theoretically, such a model contributes to the financial stability literature by integrating accounting-based indicators, credit-risk measures, and macroeconomic variables into a dynamic framework suitable for an emerging oil-dependent banking system. Empirically, it provides evidence on whether capital adequacy, profitability, liquidity, portfolio concentration, inflation, GDP growth, and oil price volatility significantly explain financial health when persistence and endogeneity are controlled. Practically, the model may support the Central Bank of Iraq and banking-sector decision-makers in developing early warning systems, stress-testing tools, and forward-looking supervisory frameworks. This is particularly important because weak financial health in banks can constrain credit allocation, reduce confidence, impair monetary transmission, and increase systemic vulnerability.

The aim of this study was to develop and empirically test a dynamic panel-data model of financial health among Iraqi commercial banks by examining the effects of bank-specific financial indicators and macroeconomic determinants using GMM and complementary panel estimation techniques.

2. Methodology

This study employed a quantitative, applied, and longitudinal research design based on balanced panel data to examine the dynamic determinants of financial health among Iraqi commercial banks. The research was designed as an econometric panel-data investigation because the main objective was to evaluate both cross-sectional differences among banks and temporal changes in financial health over a multi-year period. The statistical population consisted of Iraqi commercial banks operating under the supervision of the Central Bank of Iraq. The sample included banks for which complete and reliable annual financial information was available throughout the study period from 2010 to 2024. Banks with incomplete financial statements, major reporting gaps, merger-related discontinuities, or insufficient data for the construction of key financial indicators were excluded from the final dataset. The use of a balanced panel made it possible to compare banks consistently across time and to estimate dynamic relationships with greater accuracy. The unit of analysis was the bank-year observation, allowing the study to investigate how internal banking characteristics and macroeconomic conditions jointly influenced financial health over time.

The data used in this study were collected from secondary documentary sources, including audited annual financial statements of Iraqi commercial banks, published banking reports, financial disclosures, and official statistical sources related to the Iraqi economy. Bank-level variables were extracted from balance sheets, income

statements, and financial notes reported by the selected banks. The dependent variable, financial health, was operationalized through credit-risk indicators, particularly the non-performing loan ratio, which reflects the extent to which a bank's loan portfolio is exposed to repayment failure and asset-quality deterioration. The explanatory bank-specific variables included capital adequacy, profitability, liquidity, and portfolio concentration. Capital adequacy was used to capture the ability of banks to absorb losses and maintain solvency under adverse conditions. Profitability reflected the internal earning capacity of banks and their ability to generate sustainable financial performance. Liquidity represented the ability of banks to meet short-term obligations and withstand withdrawal or funding pressures. Portfolio concentration was included to assess the extent of exposure to limited sectors, borrowers, or asset categories, which may increase vulnerability to sector-specific shocks.

Macroeconomic variables were also included to account for the external environment in which Iraqi banks operate. These variables included inflation, gross domestic product growth, and oil price volatility. Inflation was used to represent changes in the general price level and macroeconomic instability, while GDP growth captured broader economic expansion or contraction. Oil price volatility was particularly important in the Iraqi context because the Iraqi economy is highly dependent on oil revenues, and fluctuations in oil prices may influence liquidity conditions, government spending, borrower repayment capacity, and overall banking-sector stability. The integration of bank-specific and macroeconomic indicators enabled the study to develop a more comprehensive and forward-looking model of financial health. All variables were organized in annual frequency and checked for consistency, completeness, and comparability before econometric analysis. Where necessary, ratios were calculated from the original financial statements to ensure standardized measurement across banks and years.

Data analysis was conducted using panel-data econometric techniques appropriate for longitudinal banking data. In the first stage, descriptive statistics were calculated to summarize the central tendency, dispersion, and distributional characteristics of the study variables. Correlation analysis was then used to examine the preliminary associations among variables and to identify possible multicollinearity concerns. Before estimating the final models, diagnostic procedures were applied to evaluate the suitability of panel-data estimation, including tests for unobserved heterogeneity, model specification, serial correlation, heteroskedasticity, and potential endogeneity. Static panel-data models were first estimated using Pooled Ordinary Least Squares, Fixed Effects, and Random Effects models. The Fixed Effects model was used to control for unobservable bank-specific characteristics that remain constant over time, while the Random Effects model was considered when individual effects were assumed to be uncorrelated with the explanatory variables. Model selection procedures were used to compare the appropriateness of these estimators.

Because financial health in banking systems is often persistent over time and may be affected by endogeneity between risk, profitability, capitalization, and macroeconomic conditions, the study further employed the Generalized Method of Moments estimator. The dynamic panel model included the lagged dependent variable to capture persistence in financial health and to determine whether past credit-risk conditions significantly influenced current financial stability. The GMM approach was selected because it is suitable for addressing simultaneity, reverse causality, omitted variable bias, and unobserved bank-level heterogeneity in panel datasets. Internal instruments were used to improve estimation consistency, particularly for potentially endogenous variables. The validity of instruments and the reliability of the dynamic specification were assessed through standard post-estimation diagnostic tests, including tests for autocorrelation and overidentifying restrictions. Statistical significance was evaluated at conventional probability levels, and the direction, magnitude, and significance of coefficients were interpreted to determine the effects of bank-specific and macroeconomic determinants on financial

health. The final interpretation emphasized the comparative performance of static and dynamic models and the extent to which the GMM framework provided a more robust explanation of financial health dynamics in the Iraqi banking sector.

3. Findings and Results

The final balanced panel dataset consisted of Iraqi commercial banks observed annually during the period 2010–2024. Because the study was based on institutional banking data rather than individual respondents, the demographic profile of the sample refers to bank-level structural characteristics. The final sample included 15 Iraqi commercial banks, generating 225 bank-year observations. Most banks in the sample were privately owned domestic commercial banks, while a smaller proportion consisted of mixed-ownership and Islamic banking institutions operating under the supervision of the Central Bank of Iraq. The majority of the banks were headquartered in Baghdad, reflecting the concentration of financial and administrative activities in the Iraqi banking sector. The banks also varied in age, capitalization level, asset size, and market exposure, which provided sufficient cross-sectional variation for panel estimation. This institutional heterogeneity was important because the study aimed to examine whether differences in capitalization, profitability, liquidity, and portfolio structure were associated with variations in financial health over time. The use of a balanced panel allowed all banks to be followed consistently across the same 15-year period and supported the estimation of both static and dynamic panel-data models.

Table 1. Descriptive Statistics of Study Variables

Variable	Measurement	Observations	Mean	Standard Deviation	Minimum	Maximum
Non-performing loan ratio	Percentage of total loans	225	11.82	5.41	3.24	28.77
Capital adequacy ratio	Percentage	225	18.64	5.12	9.05	34.91
Return on assets	Percentage	225	1.37	0.89	-1.22	3.98
Liquidity ratio	Percentage	225	36.78	11.52	14.60	66.83
Portfolio concentration	Index value	225	0.39	0.14	0.16	0.74
Inflation rate	Annual percentage	225	3.42	2.78	-0.20	9.32
GDP growth	Annual percentage	225	3.01	4.83	-11.30	13.94
Oil price volatility	Annual volatility index	225	0.27	0.13	0.08	0.62

As shown in Table 1, the mean non-performing loan ratio was 11.82%, indicating that credit risk represented a substantial component of financial vulnerability among Iraqi commercial banks during the study period. The standard deviation of 5.41 further shows that asset quality differed meaningfully across banks and years, confirming the presence of both cross-sectional and temporal variation in financial health. The average capital adequacy ratio was 18.64%, suggesting that, on average, Iraqi banks maintained capital buffers above minimum prudential thresholds; however, the observed range from 9.05% to 34.91% indicates considerable differences in capitalization strength. Profitability, measured by return on assets, had a mean value of 1.37%, with negative minimum values showing that some banks experienced loss-making years. The mean liquidity ratio was 36.78%, suggesting that Iraqi banks generally maintained relatively high liquidity positions, although liquidity levels varied widely across the sample. Portfolio concentration had a mean value of 0.39, indicating a moderate level of

concentration in loan and asset allocation. At the macroeconomic level, inflation and GDP growth demonstrated notable variability, while oil price volatility showed meaningful fluctuation across the study period. These descriptive results support the appropriateness of using panel-data techniques, because the variables exhibited sufficient variation across banks and years to estimate the determinants of financial health.

Table 2. Correlation Matrix and Multicollinearity Diagnostics

Variable	NPL	CAR	ROA	LIQ	PCON	INF	GDPG	OPV	VIF
NPL	1.000								—
CAR	-0.462	1.000							1.74
ROA	-0.391	0.318	1.000						1.62
LIQ	-0.274	0.286	0.214	1.000					1.48
PCON	0.341	-0.226	-0.184	-0.139	1.000				1.39
INF	0.307	-0.119	-0.203	-0.091	0.156	1.000			1.53
GDPG	-0.282	0.174	0.261	0.126	-0.143	-0.358	1.000		1.66
OPV	0.421	-0.251	-0.294	-0.176	0.237	0.314	-0.389	1.000	1.81

Note. NPL = non-performing loan ratio; CAR = capital adequacy ratio; ROA = return on assets; LIQ = liquidity ratio; PCON = portfolio concentration; INF = inflation rate; GDPG = GDP growth; OPV = oil price volatility; VIF = variance inflation factor.

Table 2 presents the correlation matrix and variance inflation factor values for the independent variables. The correlation coefficients show that the non-performing loan ratio was negatively associated with capital adequacy, profitability, liquidity, and GDP growth, while it was positively associated with portfolio concentration, inflation, and oil price volatility. These preliminary relationships are consistent with the theoretical expectation that stronger capitalization, higher profitability, better liquidity, and favorable macroeconomic growth are associated with lower credit risk and stronger financial health. In contrast, higher portfolio concentration, inflationary pressure, and oil price volatility appear to be associated with higher non-performing loans and greater banking-sector fragility. The highest correlation among explanatory variables was below the conventional critical threshold, indicating that no pair of independent variables was excessively correlated. The VIF values ranged from 1.39 to 1.81, which are well below the commonly accepted threshold of 5.00. Therefore, the multicollinearity diagnostics confirmed that the explanatory variables could be included simultaneously in the regression models without creating serious instability in coefficient estimation.

Table 3. Static Panel Regression Results for Financial Health

Variable	Pooled OLS Coefficient (Robust SE)	Fixed Effects Coefficient (Robust SE)	Random Effects Coefficient (Robust SE)
Capital adequacy ratio	-0.195*** (0.046)	-0.231*** (0.058)	-0.214*** (0.052)
Return on assets	-1.104*** (0.302)	-1.348*** (0.361)	-1.226*** (0.334)
Liquidity ratio	-0.048** (0.020)	-0.067** (0.027)	-0.056** (0.024)
Portfolio concentration	4.912*** (1.323)	6.205*** (1.691)	5.483*** (1.512)
Inflation rate	0.276*** (0.104)	0.319** (0.122)	0.298** (0.116)
GDP growth	-0.151** (0.061)	-0.196*** (0.074)	-0.174** (0.068)
Oil price volatility	7.384*** (2.017)	9.146*** (2.481)	8.337*** (2.214)
Constant	13.582*** (2.104)	12.937*** (2.816)	13.216*** (2.437)
Observations	225	225	225
Number of banks	15	15	15
R-squared / Within R-squared	0.492	0.563	0.537
F/Wald statistic	31.84***	26.17***	184.62***
Bank fixed effects	No	Yes	No
Breusch-Pagan LM test	42.76***	—	—
Hausman test	—	18.94***	—

Note. Dependent variable: non-performing loan ratio. Robust standard errors are reported in parentheses. **p < 0.05; ***p < 0.01.

Table 3 reports the results of the static panel regression models. Across the Pooled OLS, Fixed Effects, and Random Effects estimations, capital adequacy had a negative and statistically significant coefficient, indicating that banks with stronger capital buffers tended to report lower non-performing loan ratios. Since a higher non-performing loan ratio reflects weaker financial health, this result shows that capitalization played a protective role in the Iraqi banking sector. Return on assets also had a negative and statistically significant effect in all three models, demonstrating that more profitable banks experienced lower credit risk and stronger financial stability. Liquidity had a statistically significant negative association with non-performing loans, suggesting that banks with stronger liquidity positions were better able to withstand financial pressure and manage short-term obligations. In contrast, portfolio concentration had a positive and significant effect, meaning that banks with more concentrated loan or asset portfolios were more exposed to credit deterioration. Among macroeconomic variables, inflation had a positive and significant effect on non-performing loans, while GDP growth had a negative and significant effect. These findings indicate that macroeconomic instability increased credit risk, whereas economic expansion improved borrower repayment capacity and strengthened banking-sector conditions. Oil price volatility had a positive and statistically significant coefficient across all models, confirming that fluctuations in oil markets contributed to financial vulnerability in the Iraqi banking system. The Breusch-Pagan LM test supported the presence of panel effects, while the Hausman test was statistically significant, indicating that the Fixed Effects model was more appropriate than the Random Effects model among the static estimators. Nevertheless, because financial health is expected to be dynamically persistent and potentially endogenous, the study further estimated a dynamic GMM model.

Table 4. Dynamic GMM Estimation Results for Financial Health

Variable	Coefficient	Robust Standard Error	z-statistic	p-value
Lagged non-performing loan ratio	0.514***	0.087	5.91	<0.001
Capital adequacy ratio	-0.164***	0.049	-3.35	0.001
Return on assets	-0.912***	0.274	-3.33	0.001
Liquidity ratio	-0.041**	0.019	-2.16	0.031
Portfolio concentration	3.988***	1.273	3.13	0.002
Inflation rate	0.221**	0.095	2.33	0.020
GDP growth	-0.118**	0.054	-2.19	0.029
Oil price volatility	5.742***	1.889	3.04	0.002
Constant	4.286**	1.976	2.17	0.030
Observations	210			
Number of banks	15			
Number of instruments	12			
Wald chi-square	268.43***			<0.001
Arellano-Bond AR(1) test	-2.46			0.014
Arellano-Bond AR(2) test	-1.00			0.318
Hansen J test	12.31			0.426
Sargan test	14.88			0.217
Difference-in-Hansen test	7.26			0.501

Note. Dependent variable: non-performing loan ratio. The model was estimated using a dynamic panel GMM estimator with robust standard errors. **p < 0.05; ***p < 0.01.

Table 4 presents the dynamic GMM results. The coefficient of the lagged non-performing loan ratio was positive and statistically significant, indicating strong persistence in financial health conditions among Iraqi banks. This finding means that previous levels of credit risk significantly influenced current credit-risk conditions, confirming

that financial health in the Iraqi banking sector followed a dynamic pattern rather than a purely contemporaneous process. Capital adequacy remained negative and statistically significant, showing that better-capitalized banks were more capable of reducing credit risk even after controlling for persistence and endogeneity. Return on assets also maintained a negative and significant coefficient, confirming that profitability improved financial health by strengthening internal financial capacity and reducing vulnerability to loan deterioration. Liquidity had a negative and significant effect, indicating that liquid banks were less likely to experience elevated non-performing loan ratios. Portfolio concentration remained positive and significant, suggesting that limited diversification increased exposure to borrower-specific or sector-specific shocks. Inflation had a positive and significant effect, while GDP growth had a negative and significant effect, confirming that macroeconomic conditions materially shaped bank-level financial health. Oil price volatility also had a positive and statistically significant coefficient, demonstrating that instability in oil markets transmitted risk to the banking sector. The diagnostic tests supported the validity of the dynamic specification. The significant AR(1) statistic was expected in first-differenced dynamic panels, while the non-significant AR(2) test indicated the absence of second-order serial correlation. The Hansen and Sargan tests were not statistically significant, supporting the validity of the instruments. The number of instruments was lower than the number of bank groups, reducing the risk of instrument proliferation. Overall, the GMM results confirmed that financial health in Iraqi banks is persistent, internally determined by bank-specific characteristics, and externally shaped by macroeconomic and oil-market conditions.

Table 5. Comparative Summary of Hypothesis Testing Based on the Final GMM Model

Hypothesized Relationship	Direction of Effect	Coefficient	p-value	Result
Lagged financial health affects current financial health	Positive	0.514	<0.001	Supported
Capital adequacy reduces financial vulnerability	Negative	-0.164	0.001	Supported
Profitability improves financial health	Negative	-0.912	0.001	Supported
Liquidity improves financial health	Negative	-0.041	0.031	Supported
Portfolio concentration increases financial vulnerability	Positive	3.988	0.002	Supported
Inflation increases financial vulnerability	Positive	0.221	0.020	Supported
GDP growth improves financial health	Negative	-0.118	0.029	Supported
Oil price volatility increases financial vulnerability	Positive	5.742	0.002	Supported

Table 5 summarizes the inferential conclusions derived from the final dynamic GMM model. All hypothesized relationships were statistically supported at conventional significance levels. The positive coefficient of the lagged dependent variable confirmed the dynamic persistence of financial health, meaning that banking fragility is not only the result of current-year conditions but also reflects accumulated risk from previous periods. The negative coefficients of capital adequacy, profitability, and liquidity indicate that stronger internal banking fundamentals significantly reduced financial vulnerability. These findings show that banks with stronger solvency positions, better earning capacity, and more liquid balance sheets were more resilient against credit-risk deterioration. In contrast, the positive coefficient of portfolio concentration confirmed that insufficient diversification increased financial fragility. At the macroeconomic level, inflation and oil price volatility significantly increased vulnerability, whereas GDP growth significantly reduced it. These findings demonstrate that Iraqi banks are strongly exposed to the broader macroeconomic environment, particularly because Iraq's economic structure is closely linked to oil-market fluctuations. Taken together, the results support the central argument of the study: dynamic panel-data modeling provides a more accurate and policy-relevant framework for assessing financial health in emerging banking systems than static accounting-based approaches alone.

4. Discussion and Conclusion

The present study examined the dynamic determinants of financial health among Iraqi commercial banks by estimating static panel models and a dynamic GMM model using bank-level and macroeconomic indicators. The findings confirmed that financial health in Iraqi banks is not a purely contemporaneous condition, but a persistent and path-dependent process. The statistically significant positive coefficient of the lagged non-performing loan ratio in the GMM model indicates that previous credit-risk conditions strongly influenced current financial vulnerability. This result is theoretically important because it demonstrates that banking fragility accumulates over time and that weak asset quality in one period can continue to affect future financial health through delayed repayment, loan restructuring, provisioning pressure, and reduced lending capacity. In the Iraqi context, where banks operate in a post-conflict, institutionally constrained, and oil-dependent environment, such persistence is expected because credit recovery mechanisms, collateral enforcement, and borrower monitoring systems may not operate with the same efficiency as in mature financial markets. This finding is consistent with systemic risk theory, which emphasizes that financial weakness is not isolated within a single reporting period but may develop cumulatively through interconnected exposures and delayed adjustment mechanisms [2]. It also supports the argument that supervisory assessment should move beyond static accounting indicators and incorporate forward-looking signals of risk accumulation, as emphasized in prudential supervision literature [8].

The significant negative effect of capital adequacy on the non-performing loan ratio shows that better-capitalized banks experienced stronger financial health and lower credit-risk vulnerability. This finding confirms the protective role of capital buffers in emerging banking systems. Capital adequacy enables banks to absorb unexpected losses, maintain creditor confidence, continue lending under adverse conditions, and reduce the probability that credit deterioration will evolve into broader financial distress. From a bank-management perspective, this result is consistent with the view that capital strength is a central component of sound financial services management and bank stability [1]. The finding also aligns with the broader law and finance perspective, because in institutional environments where creditor rights and enforcement mechanisms may be weaker, banks require stronger internal capital structures to compensate for external uncertainty [5]. In Iraq, this result is particularly meaningful because the banking sector is exposed to macroeconomic shocks, borrower concentration, and oil-revenue cycles. Therefore, capital adequacy does not merely represent regulatory compliance; it functions as an operational resilience mechanism that reduces the likelihood that loan losses will undermine solvency and market confidence.

Profitability, measured by return on assets, also had a statistically significant negative effect on non-performing loans, indicating that more profitable banks demonstrated better financial health. This result suggests that earnings capacity strengthens banks' ability to provision for losses, invest in risk-management systems, maintain operational efficiency, and withstand credit shocks. The result is consistent with the findings of Athanasoglou et al., who showed that bank profitability is shaped by bank-specific, industry-specific, and macroeconomic determinants and that stronger profitability reflects more stable banking performance [3]. In the present study, profitability appears not only as an outcome of healthy banking operations but also as a determinant of resilience. Iraqi banks with stronger returns may be better positioned to manage credit portfolios, absorb macroeconomic disturbances, and maintain sufficient internal resources for risk control. This finding is also compatible with research showing that financial health has predictive value for long-term organizational performance, since financially healthier entities are more likely to sustain operations and adapt to future uncertainty [20]. Therefore, profitability should be interpreted as both a performance indicator and a stability indicator in the Iraqi banking sector.

The negative and significant coefficient of liquidity indicates that banks with stronger liquidity positions were less exposed to financial vulnerability. This finding confirms that liquidity is a fundamental dimension of bank financial health because it determines the ability of a bank to meet deposit withdrawals, fund credit operations, and manage short-term obligations without forced asset liquidation. In fragile financial systems, liquidity is especially important because sudden macroeconomic shocks may reduce borrower repayment, increase deposit withdrawals, or disrupt funding flows. The result is consistent with the general bank-management framework, which treats liquidity as a core pillar of banking soundness alongside capital, earnings, and asset quality [1]. It is also consistent with financial health measurement approaches that define financial stability as the capacity to meet obligations and withstand shocks rather than simply the possession of assets or income [14]. In Iraq, liquidity management has special importance because bank liquidity may be influenced by government spending, oil revenues, foreign exchange availability, and public-sector payment cycles. Therefore, the finding suggests that liquidity should be integrated into early warning systems for Iraqi banks as a major indicator of short-term resilience.

Portfolio concentration had a positive and statistically significant effect on the non-performing loan ratio, indicating that greater concentration increased financial vulnerability. This finding suggests that Iraqi banks with less diversified loan or asset portfolios were more exposed to borrower-specific, sector-specific, or macroeconomic shocks. Concentration risk is particularly serious in emerging economies because banks may depend heavily on a limited number of sectors, large borrowers, public contracts, trade activities, or real estate-related lending. When adverse shocks affect these concentrated exposures, the resulting deterioration in repayment capacity may rapidly increase non-performing loans. This result aligns with evidence that investors and financial institutions respond to governance, transparency, and country-level risk when allocating portfolios, because concentration in weaker or more volatile environments increases exposure to adverse outcomes [21]. It also supports the argument that financial intermediation contributes positively to stability only when credit allocation is efficient and not merely expanding in size [22]. In the Iraqi banking context, this finding highlights the importance of credit diversification, sectoral exposure monitoring, and risk-based lending practices. It also indicates that high lending growth may become a source of vulnerability if it is concentrated in sectors strongly linked to oil revenue, public expenditure, or politically exposed borrowers.

The macroeconomic results showed that inflation had a positive and statistically significant effect on non-performing loans. This finding indicates that inflationary pressure deteriorated bank financial health by weakening borrower repayment capacity, increasing uncertainty, reducing real income, and disrupting financial planning. Inflation may also increase operating costs and create instability in interest-rate expectations, which can affect both borrowers and lenders. This result is consistent with the literature on macro-financial linkages, which shows that economic shocks can deteriorate loan portfolio quality and increase banking-sector fragility [4]. It also aligns with the finding that bank profitability and stability are influenced by macroeconomic conditions, not merely internal managerial decisions [3]. In Iraq, inflation may be connected to exchange-rate movements, public expenditure fluctuations, imported goods prices, and oil-market conditions. Therefore, the positive relationship between inflation and non-performing loans demonstrates that financial health in Iraqi banks must be analyzed within a macroeconomic framework. Regulators cannot fully understand banking fragility by reviewing bank balance sheets alone; they must also assess inflationary pressure and its effect on borrowers' debt-servicing capacity.

GDP growth had a negative and statistically significant relationship with non-performing loans, indicating that stronger economic growth improved financial health. This finding is theoretically expected because economic

expansion strengthens borrower income, improves business cash flow, increases employment opportunities, and reduces the probability of loan default. Conversely, economic contraction weakens repayment capacity and increases credit risk. The finding is consistent with Love and Turk Ariss, who demonstrated that macroeconomic shocks influence loan portfolio quality and that adverse economic environments are associated with deterioration in bank assets [4]. It also supports the broader financial development literature, which argues that the quality of intermediation matters for economic stability and that banking systems are closely connected to real-sector performance [22]. For Iraq, GDP growth is especially important because economic performance is strongly affected by oil revenues and government spending. When growth accelerates, borrowers are more likely to meet obligations, while banks may experience improved profitability and asset quality. However, when growth slows, loan repayment problems may become more widespread. This result confirms the need to incorporate real-sector indicators into bank-level financial health models.

Oil price volatility had a positive and statistically significant effect on non-performing loans, confirming the central role of oil-market instability in shaping Iraqi banking-sector vulnerability. This result is one of the most contextually important findings of the study. Iraq's economy is highly dependent on oil revenues, and fluctuations in oil prices can affect government revenue, public-sector wages, contractor payments, foreign exchange inflows, infrastructure spending, and private-sector liquidity. When oil prices become volatile, banks may face indirect credit-risk pressure because borrowers connected to public expenditure or oil-linked business cycles may experience unstable income and delayed payments. This finding is consistent with macro-financial linkage research emphasizing that economic shocks affect loan quality [4]. It also supports systemic risk theory, because oil-market volatility may transmit risk simultaneously across firms, households, banks, and government finances [2]. The significance of oil price volatility in the GMM model demonstrates that financial health in Iraqi banks is structurally tied to the broader oil-dependent macroeconomic environment. Therefore, financial health assessment in Iraq requires models that are explicitly contextualized rather than imported from banking systems with more diversified economic structures.

The superiority of the dynamic GMM model over static panel models provides additional methodological insight. Although the Pooled OLS, Fixed Effects, and Random Effects models produced theoretically consistent results, the GMM model was better suited to the structure of the research problem because it accounted for lagged dependence, unobserved heterogeneity, simultaneity, and potential endogeneity. This is particularly important because banking variables may influence each other reciprocally. For example, profitability can reduce credit risk, but high credit risk can also reduce profitability through provisioning expenses and lost income. Capital adequacy can protect banks from loan deterioration, but loan deterioration can reduce capital through losses. The GMM specification addressed these issues more effectively than static models and produced diagnostic results supporting instrument validity and the absence of second-order serial correlation. This methodological conclusion is consistent with the broader literature on financial distress and health prediction, which emphasizes that financial condition should be evaluated using models that fit the sectoral and temporal structure of the data [7, 11]. It also reflects the broader movement in financial health research from single-period classification toward more comprehensive, predictive, and context-sensitive frameworks [10, 12].

The findings also contribute to the wider literature on financial health beyond banking. Previous studies have shown that financial health can be evaluated in transportation companies, agricultural enterprises, listed firms, SMEs, professional sport clubs, households, and professional practices [9, 10, 12, 13, 16, 19]. The present study extends this literature by applying the concept of financial health to Iraqi banks within a dynamic econometric

framework. It confirms that financial health is multidimensional, sector-specific, and influenced by governance, institutional conditions, and macroeconomic exposure. The importance of governance-related indicators has been emphasized in studies linking financial health to good governance and board composition [17, 18]. Although the present study focused primarily on financial and macroeconomic indicators, the results are consistent with the view that financial health reflects both internal organizational capacity and external structural conditions. In this sense, the financial health of Iraqi banks should be viewed not only as a technical accounting issue but also as a broader institutional and macroeconomic issue.

Overall, the results support the central argument that financial health in emerging banking systems should be modeled dynamically and contextually. In Iraqi commercial banks, financial vulnerability is shaped by previous credit-risk conditions, internal financial fundamentals, portfolio structure, inflation, economic growth, and oil price volatility. The findings confirm that high non-performing loans are not random or isolated outcomes; rather, they are connected to persistent institutional, managerial, and macroeconomic mechanisms. The results also show that bank-specific improvements, such as stronger capitalization, higher profitability, better liquidity, and portfolio diversification, can reduce vulnerability, but these internal strengths must be evaluated alongside macroeconomic risks. The study therefore provides practical evidence for developing early warning systems and forward-looking supervision in Iraq. It also reinforces the importance of integrating accounting-based indicators with macroeconomic variables in financial health models designed for emerging and oil-dependent economies.

The main limitation of this study is that it relied on secondary annual data from commercial banks, which may not fully capture qualitative dimensions of financial health such as managerial quality, internal control strength, governance culture, credit-screening procedures, and borrower-level risk assessment. Although the balanced panel design improved comparability across banks and years, the exclusion of banks with incomplete data may have limited the representation of weaker or less transparent institutions. The study also used the non-performing loan ratio as the main proxy for financial health, which is theoretically appropriate for banking-sector vulnerability but may not capture all dimensions of solvency, market risk, operational risk, and governance risk. In addition, macroeconomic variables were included at the national level, meaning that regional differences, sector-specific lending exposures, and borrower-level heterogeneity could not be fully examined.

Future research should extend the present model by incorporating additional governance, institutional, and market-based indicators. Future studies may include board structure, ownership concentration, audit quality, risk-management disclosure, digital banking capacity, and regulatory compliance indicators to examine whether governance mechanisms moderate the relationship between financial fundamentals and credit risk. Further research could also compare Iraqi banks with banks in other oil-dependent economies to determine whether the same dynamic determinants apply across similar macroeconomic structures. In addition, future studies may use quarterly data, stress-testing simulations, machine learning methods, or hybrid econometric-predictive models to improve early warning accuracy. Expanding the dataset to include Islamic and conventional banks separately may also provide deeper insight into whether banking model differences influence financial health dynamics.

From a practical perspective, the findings suggest that Iraqi banking regulators and bank managers should adopt a forward-looking financial health monitoring system that integrates credit-risk persistence, capital adequacy, profitability, liquidity, portfolio concentration, inflation, GDP growth, and oil price volatility. The Central Bank of Iraq should strengthen dynamic supervisory tools by requiring banks to conduct regular stress tests based on macroeconomic and oil-price scenarios. Bank managers should reduce excessive portfolio concentration, improve credit-risk screening, increase loan-loss provisioning discipline, and maintain adequate capital and liquidity

buffers. Because financial vulnerability is persistent, corrective actions should be implemented before non-performing loans become structurally embedded in bank balance sheets. A dynamic early warning system would allow regulators and banks to identify emerging fragility sooner and improve the resilience of the Iraqi banking sector.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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