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Developing a Composite Financial Health Index for Banking Stability: A PCA-Based Approach in an Oil-Dependent Economy

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ABSTRACT

This study aimed to develop and validate a Principal Component Analysis (PCA)-based Composite Financial Health Index (CFHI) for Iraqi commercial banks and to examine its association with oil price volatility, economic growth, and inflation during 2010–2024. A quantitative longitudinal design was employed using a balanced panel of 18 Iraqi commercial banks observed over 15 years, yielding 270 bank-year observations. The core CFHI was constructed from capital adequacy ratio, non-performing loans, return on assets, liquidity ratio, and portfolio concentration. Variables were winsorized, directionally harmonized, standardized using z-scores, and subjected to PCA. Sampling adequacy was assessed using the Kaiser–Meyer–Olkin statistic and Bartlett's test of sphericity. Components were retained based on eigenvalues greater than one, cumulative explained variance, and scree-plot inspection. Component scores were weighted according to explained variance to construct the CFHI. Fixed-effects panel regression was then used to assess the effects of oil price volatility, GDP growth, and inflation on financial health. Validity and robustness were examined through correlations, alternative PCA specifications, sensitivity tests, and predictive analysis. PCA adequacy was confirmed by a KMO value of 0.742 and a significant Bartlett's test, ($chi^2(10)=512.684$, $p<0.001$). Two components were retained and explained 71.18% of total variance. CFHI was positively associated with capital adequacy ($r=0.674$, $p<0.001$), profitability ($r=0.698$, $p<0.001$), and liquidity ($r=0.533$, $p<0.001$), and negatively associated with non-performing loans ($r=-0.721$, $p<0.001$) and portfolio concentration ($r=-0.586$, $p<0.001$). Fixed-effects estimates showed that oil price volatility negatively affected CFHI (beta=-0.031, $p<0.001$), GDP growth had a positive effect (beta=0.047, $p<0.001$), and inflation had a negative effect (beta=-0.058, $p=0.006$). A one-standard-deviation increase in CFHI reduced subsequent distress odds by 46% (OR=0.54, 95% CI: 0.39–0.75). The PCA-based CFHI provides a statistically robust and economically interpretable measure of multidimensional banking stability in Iraq and demonstrates that bank financial health is materially influenced by oil-market volatility and broader macroeconomic conditions.

Keywords: *Composite Financial Health Index; Principal Component Analysis; Banking Stability; Oil Price Volatility; Financial Health; Iraqi Banks; Macroeconomic Conditions*

1. Introduction

The stability of the banking sector is a central prerequisite for sustainable economic development because banks perform several functions that directly affect capital allocation, liquidity creation, payment-system continuity, investment financing, and the transmission of monetary and fiscal policies. In economies where financial markets are relatively shallow and bank-based intermediation dominates corporate and household financing, the soundness of commercial banks becomes particularly important for maintaining macroeconomic stability. The financial condition of a bank, however, cannot be assessed adequately through a single accounting measure because banking stability reflects the interaction of capitalization, asset quality, profitability, liquidity, risk exposure, portfolio composition, and broader economic conditions. Bank management therefore requires an integrated assessment of several dimensions of financial performance rather than isolated interpretation of individual ratios (Rose & Hudgins, 2015). This multidimensional perspective is particularly relevant to emerging and resource-dependent economies, where banking performance can be influenced simultaneously by institution-specific characteristics and large external macroeconomic shocks.

The concept of financial health generally refers to the capacity of an economic entity to maintain solvency, generate adequate returns, meet short- and long-term obligations, absorb adverse shocks, and sustain its operations without experiencing severe financial distress. Although the term has been applied to individuals, firms, public organizations, and financial institutions, its underlying logic is inherently multidimensional. Financial health frameworks frequently combine indicators relating to liquidity, solvency, savings or capital buffers, debt burden, income generation, and resilience to unexpected events (Klontz et al., 2016; Parker et al., 2016). The concept has also increasingly been used as a forward-looking construct because healthier financial conditions are generally expected to improve the ability of an organization to withstand disturbances and maintain long-term performance. Evidence from non-financial industries similarly suggests that financial health contains information relevant to future organizational performance and sustainability (Mom & Linh, 2025). Consequently, the assessment of financial health should not be limited to contemporaneous profitability but should encompass the broader capacity of an institution to remain resilient over time.

A substantial body of research has attempted to operationalize financial health through accounting ratios and financial-distress prediction models. Traditional approaches frequently rely on bankruptcy scoring systems, discriminant-analysis models, balance-analysis techniques, or combinations of solvency and profitability indicators. Studies applying Altman-type Z-score frameworks demonstrate that composite measures can offer a more informative representation of financial condition than an isolated financial ratio (Aidi et al., 2022). Similarly, insolvency and financial-health prediction research has shown that models combining several financial indicators can distinguish financially healthy firms from entities facing an elevated probability of distress (Fachrudin, 2021). Bankruptcy-model applications in agricultural enterprises have also demonstrated the usefulness of combining multiple financial dimensions when evaluating enterprise sustainability under heterogeneous operating conditions (Vavrek et al., 2021). Predictive assessment based on balance analysis further indicates that financial-health models can be evaluated not only on descriptive grounds but also according to their discriminatory and forecasting performance (Karpac & Bartošová, 2021). These approaches collectively support the argument that financial health is best interpreted as a composite rather than a univariate phenomenon.

Nevertheless, direct application of corporate bankruptcy models to banks is problematic because banking institutions have distinctive balance-sheet structures, regulatory requirements, liquidity characteristics, and systemic functions. A high level of leverage, for instance, may be considered problematic in a conventional non-financial corporation but is an inherent feature of commercial banking. Likewise, bank soundness depends heavily on regulatory capital, credit quality, liquidity buffers, and the capacity to generate earnings while managing maturity transformation and funding risks. For this reason, the assessment of bank financial health requires indicators that reflect the specific economics of financial intermediation. Capital adequacy represents the capacity to absorb unexpected losses; asset quality reflects the risk embedded in the loan portfolio; profitability supports capital accumulation and provides an internal buffer against adverse developments; and liquidity determines the ability of banks to meet withdrawal and funding obligations. These dimensions are interrelated, and deterioration in one area can spread to others, particularly during periods of systemic stress (Rose & Hudgins, 2015).

The importance of multidimensional assessment is further reinforced by the literature on bank failure and prudential supervision. Early-warning research has shown that deteriorating financial characteristics can provide useful signals before institutional failure occurs. Non-parametric frontier techniques, for example, have demonstrated that bank efficiency and financial-condition information can contribute to forecasting bank failure (Barr et al., 2002). Market-based information has likewise been proposed as a supplementary source of evidence for prudential supervisors because accounting measures alone may not capture the full evolution of banking risk (Flannery, 1998). At the systemic level, bank-specific weakness can generate broader financial externalities when distress spreads through interconnected institutions or common exposures. Measures of systemic risk therefore emphasize that the social and macroeconomic consequences of financial distress may considerably exceed the losses observed at a single institution (Acharya et al., 2010). A composite bank-health indicator can consequently serve not only as a measure of individual institutional strength but also as an input into broader assessments of banking-sector vulnerability.

The relationship between financial development and economic performance also underscores the need to distinguish healthy intermediation from excessive or inefficient expansion of the financial system. Financial systems can contribute to growth through improved resource allocation and intermediation, yet a larger financial sector does not automatically imply stronger economic performance or greater stability (Beck et al., 2013). The quality and resilience of financial intermediation therefore matter as much as its scale. Similarly, institutional and legal environments influence financial development by shaping investor protection, creditor rights, enforcement mechanisms, and the incentives faced by financial intermediaries (La Porta et al., 1998). This institutional perspective is relevant to banking stability because banks do not operate independently of governance arrangements, regulatory frameworks, disclosure quality, or legal enforcement. Financial-health measurement must therefore be sufficiently flexible to capture differences in internal performance while remaining interpretable within the institutional environment in which banks operate.

A further limitation of relying on individual banking ratios is that such indicators frequently move in different directions and may convey conflicting signals. A bank may, for example, maintain strong capital adequacy while simultaneously experiencing deteriorating loan quality, declining profitability, or excessive portfolio concentration. Similarly, high liquidity may enhance resilience to short-term funding shocks but can also reflect limited lending opportunities or inefficient deployment of assets. This ambiguity creates a weighting problem when researchers and regulators attempt to combine several indicators into a single measure. Equal weighting assumes that every indicator contributes identically to financial health, whereas expert-based weighting introduces an element of subjectivity. Data-driven dimensionality-reduction methods provide an alternative because they derive weights from the covariance structure of observed indicators. Principal Component Analysis (PCA), in particular, transforms correlated variables into orthogonal components that retain the largest possible proportion of the variance in the original data. Such an approach is especially suitable when the objective is to summarize several interrelated financial ratios in a single index while reducing arbitrary assumptions concerning relative importance.

The logic of constructing a composite financial-health measure is supported by studies in several organizational contexts. Research on public-sector entities has emphasized the importance of identifying a broader set of financial-health indicators rather than relying on a single measure, particularly where governance quality and institutional performance are intertwined (Barati et al., 2024). Financial-health assessment has also been used to investigate organizational characteristics such as governance and board composition, suggesting that financial condition can operate as an outcome through which structural and managerial characteristics are evaluated (Papík & Papíková, 2023). In professional sports organizations, financial-health analysis has revealed how persistent financial weakness can coexist with organizational growth and market expansion, again demonstrating that revenue generation alone does not guarantee financial sustainability (Clarkson et al., 2023). The relationship between financial health and investment efficiency further indicates that healthier firms may be better positioned to allocate resources productively and avoid distortions arising from financing constraints (Hoseini Soreh & Molaei Qolanjie, 2021). Even in professional practice management, systematic financial-health planning has been presented as an essential component of organizational continuity and long-term decision-making (Pinder-Ayres, 2019). Collectively, these studies illustrate the conceptual versatility of financial-health assessment while reinforcing the necessity of adapting measurement frameworks to the specific characteristics of the institution under investigation.

For banks, the macroeconomic environment represents an additional source of variation that cannot be ignored. Bank profitability and stability are shaped not only by institution-specific characteristics but also by industry structure and macroeconomic conditions. Empirical evidence has demonstrated that profitability is influenced jointly by internal bank factors, banking-sector conditions, and broader economic variables (Athanasoglou et al., 2008). Economic contractions can weaken borrower repayment capacity, increase credit risk, suppress loan demand, reduce profitability, and amplify non-performing loans, whereas periods of strong economic growth generally improve repayment performance and support financial intermediation. The connection between macroeconomic shocks and loan portfolio quality is particularly important because deterioration in the macroeconomic environment can rapidly translate into worsening asset quality. Panel evidence on macro-financial linkages has shown that adverse economic shocks materially affect loan portfolio performance and consequently banking-sector stability (Love & Turk Ariss, 2014). Such findings support the incorporation of macroeconomic conditions into any comprehensive assessment of bank financial health.

Inflation represents another important external factor because it affects nominal interest rates, real returns, operating expenses, household purchasing power, and the repayment capacity of borrowers. Although moderate and predictable inflation may be manageable, large or unstable price changes can complicate asset-liability management and increase uncertainty. Macroeconomic instability may also interact with institutional safeguards such as deposit insurance. While deposit insurance can reduce the probability of destabilizing runs, excessively generous protection can generate moral hazard and increase risk-taking incentives when regulatory and institutional arrangements are weak (Demirguc-Kunt & Detragiache, 2002). Therefore, the stability of banks depends on a broader policy architecture in which prudential supervision, capital regulation, risk monitoring, institutional quality, and macroeconomic conditions jointly influence financial behavior.

Portfolio composition is also central to bank financial health. Concentrated exposure to specific borrowers, industries, or economic sectors can increase vulnerability because a negative shock affecting one major segment may simultaneously deteriorate a substantial portion of the loan portfolio. Diversification, by contrast, may reduce idiosyncratic risk when exposures are distributed across economically distinct activities. The broader financial literature has demonstrated that portfolio allocation and investor preferences depend on information, institutional characteristics, transparency, and risk considerations (Aggarwal et al., 2009). Although this literature is not limited to banking loan portfolios, the underlying principle is directly relevant to bank stability: concentration magnifies exposure to common shocks, whereas diversification can reduce the dependence of overall financial performance on a narrow set of economic activities. Portfolio concentration is therefore an important complement to traditional measures such as capital adequacy, asset quality, profitability, and liquidity in constructing a multidimensional financial-health index.

The relevance of these macro-financial mechanisms becomes even greater in an oil-dependent economy such as Iraq. Oil revenues play a dominant role in government finances, foreign-exchange receipts, liquidity creation, aggregate demand, public investment, and private-sector activity. Consequently, large changes in international oil prices can affect the banking system through multiple channels. Falling or highly volatile oil prices may reduce fiscal resources, constrain government expenditure, weaken contractor and household cash flows, lower deposit growth, increase uncertainty, and deteriorate borrowers' ability to service debt. Conversely, favorable oil-market conditions may strengthen public spending, liquidity, and economic activity. This dependence creates the possibility that apparently bank-specific financial outcomes partly reflect common oil-driven macroeconomic shocks. A financial-health framework for Iraq therefore requires explicit recognition of oil price volatility alongside conventional macroeconomic indicators such as GDP growth and inflation.

The importance of distinguishing internal financial strength from external economic conditions also has methodological implications. If macroeconomic variables are mechanically incorporated into the same composite index as bank-specific accounting variables, a bank may appear financially stronger merely because it operates during a favorable macroeconomic year. On the other hand, omitting macroeconomic variables altogether risks ignoring a major source of financial-health variation. A more informative framework is therefore to construct a core index from bank-level indicators and subsequently examine its relationship with macroeconomic variables, while using an expanded specification as a robustness analysis. Such an approach permits the composite index to retain a clear institutional interpretation while simultaneously recognizing that financial stability is embedded in a broader macro-financial environment.

Another important consideration is that composite measures should demonstrate validity beyond statistical convenience. An index should exhibit theoretically consistent relationships with its constituent indicators, distinguish stronger institutions from vulnerable ones, respond meaningfully to known periods of stress, and demonstrate stability under alternative specifications. The literature on financial-health prediction supports the evaluation of classification accuracy and forecasting ability rather than relying solely on contemporaneous fit (Fachrudin, 2021; Karpac & Bartošová, 2021). Furthermore, recent research on financial health across households and organizations indicates that financial-health conditions reflect multiple dimensions that may vary according to demographic, governance, institutional, or structural characteristics (Papík & Papíková, 2023; Zhang et al., 2024). This reinforces the need for transparent validation procedures when composite financial-health measures are applied to a new institutional setting.

Despite extensive research on bank profitability, financial distress, bankruptcy prediction, systemic risk, and macro-financial linkages, an important methodological gap remains in relation to emerging oil-dependent banking systems. Much of the banking literature focuses on individual outcomes such as profitability, non-performing loans, failure probability, or capital adequacy, while studies of financial health in other fields commonly use predefined scoring systems that may not be transferable to banks. Moreover, conventional composite indexes frequently depend on predetermined weights, potentially imposing assumptions that are not supported by the observed structure of the data. In the context of Iraq, this limitation is particularly important because banks operate under substantial heterogeneity in capitalization, asset quality, profitability, liquidity, and portfolio exposure while simultaneously facing common shocks originating from oil-market volatility and domestic macroeconomic conditions. A PCA-based Composite Financial Health Index can address these limitations by extracting the dominant latent dimensions of financial health from correlated banking indicators, assigning weights according to explained variance, and generating a standardized score that facilitates comparison across institutions and over time.

Such an index has direct regulatory and policy relevance. A transparent CFHI can support macroprudential surveillance by allowing regulators to track the evolution of financial strength across banks, identify institutions exhibiting persistent weakness, compare sector-wide conditions across macroeconomic cycles, and determine whether deteriorating bank health coincides with changes in oil-market volatility, GDP growth, or inflation. Because the approach reduces a set of multidimensional indicators to an interpretable composite measure, it can also improve communication of financial-stability conditions to policymakers. At the same time, its construction from observable financial data makes it reproducible and potentially adaptable to other oil-dependent or resource-intensive economies. The usefulness of such a measure ultimately depends on whether it preserves sufficient information from the underlying indicators, generates economically coherent loadings, remains robust to alternative specifications, and exhibits meaningful relationships with subsequent financial vulnerability.

Accordingly, the aim of this study is to develop and validate a PCA-based Composite Financial Health Index for Iraqi commercial banks over 2010–2024 and to examine how the resulting measure of banking stability is associated with oil price volatility, economic growth, and inflation in an oil-dependent economy.

2. Methods and Materials

This study adopted a quantitative longitudinal research design to develop a Composite Financial Health Index (CFHI) for assessing banking stability in Iraq through Principal Component Analysis (PCA). The empirical setting was selected because Iraq represents a strongly oil-dependent economy in which banking-sector conditions are closely connected not only to bank-specific financial characteristics but also to fluctuations in oil revenues, economic growth, and domestic price conditions. The unit of analysis was the individual commercial bank observed annually over the period 2010–2024. A balanced panel structure was used so that each bank included in the final sample had continuous and sufficiently complete observations for all study years and for the financial variables required to construct the index. The observation period was sufficiently long to capture heterogeneous macro-financial conditions, including periods of relatively favorable oil-market conditions, major declines in international oil prices, domestic fiscal pressures, pandemic-related disruptions, inflationary episodes, and subsequent economic recovery. This temporal coverage was particularly important because a financial-health measure developed for an oil-dependent economy should remain informative under both normal conditions and periods of substantial external volatility.

The study population consisted of Iraqi commercial banks operating under the supervision of the Central Bank of Iraq during the study period. Banks were eligible for inclusion when annual reports, audited financial statements, balance-sheet information, income statements, and the financial ratios or underlying accounting items necessary to calculate the selected indicators were consistently available. Banks with substantial discontinuities in reporting, prolonged periods of missing financial statements, material changes that prevented intertemporal comparability, or insufficient observations for the selected indicators were excluded from the balanced analytical panel. Accordingly, the study did not employ respondent-based sampling because the observations represented institutional bank-year records rather than individual participants. The sampling procedure was instead based on data completeness and longitudinal comparability. Each bank-year therefore represented one observation in the analytical dataset, producing a panel in which cross-sectional differences between banks and temporal changes within banks could jointly contribute to the estimation of financial-health components.

The conceptual specification of financial health was multidimensional. Rather than defining banking stability through a single accounting ratio, the study treated financial health as a latent empirical condition reflected simultaneously in capitalization, asset quality, profitability, liquidity, portfolio structure, and the macroeconomic environment. The bank-specific indicators consisted of the capital adequacy ratio (CAR), non-performing loan ratio (NPL), return on assets (ROA), liquid-assets-to-total-assets ratio (LIQ), and portfolio concentration (PC). Capital adequacy captured the capacity of a bank to absorb unexpected losses, asset quality represented exposure to credit deterioration, profitability measured the ability to generate sustainable earnings from the asset base, liquidity reflected short-term funding resilience, and portfolio concentration represented sensitivity to sector-specific credit shocks. Because the Iraqi economy is highly dependent on hydrocarbon revenues, three macroeconomic variables—oil price volatility (OPV), real GDP growth (GDP), and inflation (INF)—were incorporated into the broader analytical framework to capture external conditions capable of affecting banking stability. The methodological design therefore distinguished between the construction of the core bank-level CFHI and the examination of macroeconomic influences on that index. This distinction avoided mechanically interpreting favorable macroeconomic conditions as an intrinsic improvement in a bank's balance-sheet quality while still allowing the oil-dependent environment to be incorporated explicitly into the stability analysis.

The study used secondary quantitative data obtained from institutional and internationally recognized sources. Bank-level financial information was collected from audited annual reports, financial statements, balance sheets, income statements, statistical disclosures of individual Iraqi commercial banks, and publications of the Central Bank of Iraq. Where ratios were not directly reported in a comparable form, they were calculated from the corresponding accounting items. Macroeconomic data were obtained from internationally comparable databases, particularly the World Bank and the International Monetary Fund, while oil-price information was compiled from established international energy and commodity-price series. Data from different sources were cross-checked by bank and year before inclusion in the analytical dataset to reduce inconsistencies arising from reporting revisions, changes in units, or differences in accounting presentation.

Capital adequacy was operationalized through the ratio of regulatory capital to risk-weighted assets. For bank $i$in year t, capital adequacy was defined as

$$CAR_{it} = \frac{\text{Regulatory Capital}_{it}}{\text{Risk-Weighted Assets}_{it}} \times 100.$$

Higher values of CARwere interpreted as indicating greater loss-absorbing capacity and therefore stronger financial health. Asset quality was measured by the non-performing loan ratio,

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

Unlike capital adequacy, a higher NPL ratio represents poorer financial health because it reflects deterioration in credit quality and an increased probability of loan losses. Profitability was measured by return on assets,

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

with higher positive values indicating stronger earnings generation and a greater internal capacity to absorb adverse shocks. Liquidity was measured as

$$LIQ_{it} = \frac{\text{Liquid Assets}_{it}}{\text{Total Assets}_{it}} \times 100,$$

where liquid assets comprised cash and other readily realizable short-term assets according to the available reporting classifications. Higher liquidity was generally interpreted as strengthening resilience to withdrawal and funding shocks, although excessively high liquidity was recognized as potentially reflecting inefficient asset allocation.

Portfolio concentration was used to represent the extent to which lending was concentrated across economic sectors or major portfolio categories. When sufficiently disaggregated sectoral lending data were available, concentration was measured using a Herfindahl-type concentration index:

$$PC_{it} = \sum_{s=1}^{S} q_{sit}^2,$$

where q_{sit}represents the share of lending to sector $s$in the total loan portfolio of bank $i$in year t, and Sdenotes the number of lending categories. Higher values indicate greater concentration and weaker diversification and were therefore treated as adverse to financial health. If an equivalent concentration measure was reported consistently in the original bank disclosures, the reported series was harmonized to preserve comparability across institutions and years.

Oil price volatility was included because the transmission of oil-market shocks to public revenues, liquidity, credit conditions, and aggregate demand is especially important in Iraq. Oil-price volatility was derived from the variation in international oil prices within each year rather than from the annual price level alone. Where P_{tm}represents the oil price observed in month $m$of year t, annual volatility was calculated as

$$OPV_t = \sqrt{\frac{1}{M-1}\sum_{m=1}^{M}(P_{tm} - \bar{P}_t)^2},$$

where $M$is the number of monthly observations and $\bar{P}_t$is the annual mean oil price. As a robustness specification, volatility could also be calculated from logarithmic oil-price returns when monthly price information was sufficiently complete. GDP growth was measured as the annual percentage change in real gross domestic product,

$$GDP_t = \frac{RGDP_t - RGDP_{t-1}}{RGDP_{t-1}} \times 100,$$

while inflation was measured as the annual percentage change in the consumer price index,

$$INF_t = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \times 100.$$

Before PCA estimation, the database was subjected to a systematic preprocessing procedure. Observations were checked for missing values, inconsistent units, impossible values, duplication, and extreme observations. Continuous bank-level variables were winsorized at the 1st and 99th percentiles to reduce the disproportionate influence of extreme observations without deleting economically meaningful bank-year records. Because PCA is sensitive to both measurement scale and variance, all variables entering the component extraction procedure were standardized using z-scores. For variable j, bank i, and year t, standardization was performed as

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

where X_{ijt}denotes the observed value, $\bar{X}_j$denotes the sample mean of variable j, and $s_j$is its sample standard deviation. This transformation generated variables with approximately zero mean and unit variance and prevented indicators expressed in large numerical units from dominating the PCA solution.

The directional interpretation of the indicators was also harmonized before the composite score was finalized. Variables for which larger values implied poorer financial health, particularly NPL and portfolio concentration, were reverse-coded so that the final CFHI consistently increased with financial health. For an adverse indicator, the direction-adjusted standardized score was defined as

$$Z_{ijt}^{*} = -Z_{ijt}.$$

For indicators in which larger values represented stronger financial conditions, the standardized value was retained unchanged. Oil-price volatility was likewise interpreted as an adverse external condition because greater volatility increases macroeconomic uncertainty in an oil-dependent economy. The treatment of inflation depended on the macroeconomic specification, although persistently higher inflation was generally interpreted as an adverse environmental condition. This directional alignment was essential for giving the resulting index a clear substantive interpretation: larger CFHI scores represent stronger financial health, whereas smaller or negative values indicate comparatively weaker conditions.

Data analysis was conducted in several sequential stages consisting of descriptive examination, assessment of PCA suitability, principal-component extraction, index construction, validation, and macroeconomic assessment. Initially, descriptive statistics were computed for all bank-specific and macroeconomic variables, including the mean, standard deviation, minimum, maximum, and distributional characteristics. Pairwise correlation coefficients were then examined to determine whether the indicators exhibited sufficient common variation to justify dimensionality reduction while also identifying possible near-redundancy. PCA is meaningful when variables are related but not perfectly collinear; consequently, both extremely weak and near-perfect correlation structures were evaluated before component extraction. Sampling adequacy was assessed using the Kaiser–Meyer–Olkin statistic, and Bartlett's test of sphericity was used to test whether the correlation matrix differed significantly from an identity matrix. A statistically significant Bartlett test and an acceptable KMO coefficient were treated as evidence that the dataset contained sufficient shared covariance for PCA.

Let the standardized analytical data matrix be denoted by

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1p} \\ z_{21} & z_{22} & \cdots & z_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ z_{N1} & z_{N2} & \cdots & z_{Np} \end{bmatrix},$$

where $N$is the total number of bank-year observations and $p$is the number of standardized financial indicators included in the core index. Because the variables were standardized, PCA was performed on the correlation matrix, which is equivalent to the covariance matrix of standardized observations. The matrix was calculated as

$$R = \frac{1}{N-1} Z'Z.$$

Principal components were derived by solving the eigenvalue problem

$$Rv_m = \lambda_m v_m,$$

where $\lambda_m$represents the eigenvalue associated with principal component $m$and $v_m$is the corresponding eigenvector. The eigenvalues were ordered so that

$$\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p,$$

which ensures that the first principal component captures the largest possible proportion of total standardized variance, the second captures the largest remaining orthogonal variance, and subsequent components successively explain smaller portions of residual variation. The proportion of variance explained by component $m$was computed as

$$EV_m = \frac{\lambda_m}{\sum_{j=1}^{p} \lambda_j}.$$

The cumulative variance explained by the first $k$components was consequently defined as

$$CEV_k = \frac{\sum_{m=1}^{k} \lambda_m}{\sum_{j=1}^{p} \lambda_j}.$$

The number of components retained for constructing the CFHI was determined jointly using the Kaiser criterion, visual inspection of the scree plot, cumulative explained variance, and substantive interpretability of the component loadings. Components with eigenvalues greater than one were treated as primary candidates for retention, but the final solution was not based mechanically on this criterion when the scree structure or cumulative variance suggested a more parsimonious representation. The objective was to preserve the dominant dimensions of banking financial health while avoiding the inclusion of components representing only minor statistical noise.

For every bank-year observation, the score of retained component $m$was computed as a linear combination of the standardized, directionally harmonized variables:

$$PC_{m,it} = v_{m1} Z_{1,it}^{*} + v_{m2} Z_{2,it}^{*} + \cdots + v_{mp} Z_{p,it}^{*},$$

or, equivalently,

$$PC_{m,it} = \sum_{j=1}^{p} v_{mj} Z_{j,it}^{*}.$$

The core Composite Financial Health Index was then calculated by weighting the retained principal-component scores according to the amount of variance explained by each component. For $k$retained components, normalized component weights were calculated as

$$w_m = \frac{\lambda_m}{\sum_{r=1}^{k} \lambda_r},$$

such that

$$\sum_{m=1}^{k} w_m = 1.$$

The raw composite financial-health score for bank $i$in year $t$was therefore obtained from

$$CFHI_{it}^{Raw} = \sum_{m=1}^{k} w_m PC_{m,it}.$$

This weighting procedure is entirely data-driven and reduces the subjectivity associated with assigning arbitrary equal or expert-determined weights to individual banking indicators. Components explaining a larger proportion of common variation make a correspondingly larger contribution to the index.

Because the algebraic sign of a PCA eigenvector is mathematically arbitrary, the orientation of each retained component was checked against the theoretically favorable indicators before calculating the final index. If a retained component was negatively oriented relative to financial health, its score and corresponding loading vector were multiplied by -1. Consequently, the completed CFHI was oriented so that higher values consistently represented stronger capitalization, better asset quality, stronger profitability, adequate liquidity, and greater portfolio resilience. For easier interpretation and longitudinal comparison, the raw index was also transformed into a standardized score,

$$CFHI_{it}^{Z} = \frac{CFHI_{it}^{Raw} - \bar{CFHI}^{Raw}}{s_{CFHI}},$$

where positive values indicate financial health above the sample average and negative values indicate financial health below the sample average. For graphical presentation and robustness analysis, the index could additionally be transformed to a 0–100 scale using

$$CFHI_{it}^{100} = 100 \left[\frac{CFHI_{it}^{Raw} - CFHI_{\min}^{Raw}}{CFHI_{\max}^{Raw} - CFHI_{\min}^{Raw}} \right],$$

where values closer to 100 represent comparatively stronger financial health and values closer to zero represent comparatively greater financial vulnerability.

The principal specification constructed the CFHI from bank-specific financial indicators and subsequently incorporated macroeconomic variables through a separate explanatory framework. This approach was adopted to maintain a conceptual distinction between the intrinsic financial condition of individual banks and the external environment in which they operate. Specifically, the standardized CFHI was modeled as a function of oil-price volatility, GDP growth, and inflation:

$$CFHI_{it} = \alpha + \beta_1 OPV_t + \beta_2 GDP_t + \beta_3 INF_t + \mu_i + \varepsilon_{it},$$

where $\alpha$is the intercept, β_1, β_2, and $\beta_3$represent the effects of the macroeconomic variables, $\mu_i$denotes unobserved bank-specific heterogeneity, and $\varepsilon_{it}$is the idiosyncratic error term. Because OPV, GDP growth, and inflation vary primarily over time rather than across banks, this panel formulation enabled assessment of whether changes in the macroeconomic environment were systematically associated with changes in bank financial health. Fixed-effects and alternative panel specifications could be compared as robustness checks, with heteroskedasticity- and serial-correlation-robust standard errors used where necessary.

A supplementary specification was estimated in which standardized macroeconomic variables were entered jointly with bank-specific indicators in an expanded PCA. This alternative specification was used as a robustness analysis rather than as the principal CFHI because direct inclusion of common annual macroeconomic variables in the same component extraction process can cause the index to combine bank quality with economy-wide conditions. The expanded index can be represented as

$$CFHI_{it}^{Expanded} = \sum_{m=1}^{k^*} w_m^* PC_{m,it}^*,$$

where $PC_{m,it}^*$denotes the components extracted from the combined microeconomic and macroeconomic indicator matrix. Consistency between the core and expanded indexes was assessed through rank correlations, temporal co-movement, and the stability of bank classifications.

The validity and robustness of the CFHI were assessed using several complementary procedures. Construct validity was examined through the signs and magnitudes of PCA loadings and the extent to which retained components corresponded to economically interpretable dimensions of bank resilience. Convergent validity was evaluated by examining the relationship between the CFHI and conventional indicators such as CAR, NPL, ROA, and LIQ. A valid index was expected to correlate positively with favorable indicators such as capitalization and profitability and negatively with adverse indicators such as non-performing loans and concentration risk. Spearman rank correlation was additionally employed because the policy usefulness of a composite index depends partly on its ability to preserve meaningful relative rankings across banks.

Criterion-related validity was evaluated by determining whether lower CFHI scores coincided with observable episodes of financial weakness, including deterioration in capital positions, exceptionally high credit impairment, persistent losses, liquidity pressure, or other documented bank-level distress events where such information was available. The predictive specification was expressed generally as

$$Distress_{i,t+h} = \alpha + \delta CFHI_{it} + \gamma' M_t + \mu_i + \varepsilon_{it},$$

where $Distress_{i,t+h}$represents a subsequent measure or indicator of banking vulnerability, $M_t$represents the vector of macroeconomic controls, and $h$denotes the forecast horizon. A negative relationship between the CFHI and future distress would provide evidence that the index possesses early-warning content beyond contemporaneous accounting ratios.

Internal consistency was examined cautiously because PCA-based composite indicators need not satisfy the same assumptions as reflective psychometric scales. Cronbach's alpha was therefore treated as a supplementary diagnostic rather than as the primary criterion for index validity. Where reported, the coefficient was calculated as

$$\alpha = \frac{p}{p-1}\left(1 - \frac{\sum_{j=1}^{p} \sigma_j^2}{\sigma_T^2}\right),$$

where $p$denotes the number of indicators, $\sigma_j^2$is the variance of indicator j, and $\sigma_T^2$is the variance of the aggregate standardized score. Greater emphasis was placed on PCA adequacy, loading coherence, explained variance, ranking stability, and external validity.

Sensitivity analysis was finally performed to assess whether the CFHI depended excessively on individual indicators, extreme observations, or a specific component-retention rule. The PCA was re-estimated after alternative winsorization treatments, exclusion of individual indicators, alternative component-retention thresholds, and the use of a first-principal-component-only index. The resulting scores were compared with the baseline CFHI using Pearson and Spearman correlations and changes in bank rankings. A robust financial-health index was defined as one whose broad cross-sectional rankings and temporal dynamics remained stable across these alternative specifications. This analytical framework allowed the CFHI to function as a multidimensional, empirically weighted measure of banking stability while retaining explicit sensitivity to the macroeconomic characteristics of an oil-dependent economy such as Iraq.

3. Findings and Results

The final analytical sample consisted of 18 Iraqi commercial banks observed continuously over the 15-year period from 2010 to 2024, yielding a balanced panel of 270 bank-year observations. In terms of institutional characteristics, 15 banks, representing 83.3% of the sample, were privately owned, whereas 3 banks, representing 16.7%, were state-owned commercial institutions. Thirteen banks, equivalent to 72.2% of the sample, operated primarily under conventional banking arrangements, while 5 banks, or 27.8%, operated under Islamic banking principles while maintaining sufficiently comparable financial disclosures for inclusion in the analysis. All banks included in the final sample had complete observations for the five bank-specific indicators used in construction of the core Composite Financial Health Index (CFHI), namely capital adequacy ratio, non-performing loan ratio, return on assets, liquidity ratio, and portfolio concentration. The balanced structure therefore generated 270 observations for each bank-level indicator. The macroeconomic variables—oil price volatility, real GDP growth, and inflation—were observed annually and matched to the corresponding bank-year records, resulting in the same 270 observations after merging. Inspection of the longitudinal data indicated substantial heterogeneity across both institutions and years, which was desirable for the construction of a composite financial-health measure because the index was intended to distinguish relatively resilient banks from institutions displaying weaker capitalization, poorer asset quality, lower profitability, tighter liquidity positions, or greater concentration risk. The period also contained considerable macroeconomic variation, including years characterized by sharp oil-market disturbances and weaker economic activity, thereby providing an appropriate environment in which to examine whether the CFHI captured meaningful changes in banking stability.

Table 1

Descriptive Statistics of Bank-Specific and Macroeconomic Variables

Variable	N	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
Capital adequacy ratio (CAR), %	270	21.84	6.47	10.92	41.36	0.71	0.58
Non-performing loans (NPL), %	270	12.63	7.18	2.14	34.72	0.94	0.77
Return on assets (ROA), %	270	1.76	1.21	-2.18	4.96	-0.24	0.81
Liquidity ratio (LIQ), %	270	37.42	10.86	17.25	65.93	0.31	-0.42
Portfolio concentration (PC)	270	0.286	0.094	0.118	0.538	0.52	-0.17
Oil price volatility (OPV)	270	14.38	8.67	4.12	37.85	1.03	0.39
Real GDP growth (GDP), %	270	3.21	6.14	-11.33	13.94	-0.47	0.16
Inflation (INF), %	270	3.86	2.74	-0.19	9.68	0.69	-0.21

Table 1 presents the descriptive properties of the variables used in the analysis. The average capital adequacy ratio was 21.84% with a standard deviation of 6.47 percentage points, indicating that capitalization differed substantially across Iraqi banks and over time. The minimum CAR of 10.92% showed that some bank-year observations operated relatively close to lower capital positions, whereas the maximum of 41.36% reflected institutions maintaining substantial capital buffers. The non-performing loan ratio averaged 12.63%, with a comparatively large standard deviation of 7.18 percentage points and values ranging from 2.14% to 34.72%. This dispersion demonstrated marked variation in credit quality and constituted one of the clearest sources of heterogeneity in financial health across the sample. Because higher NPL values represent weaker asset quality, this variable was reverse-oriented before PCA so that larger standardized values consistently represented better financial health. Mean ROA was 1.76%, with values between -2.18% and 4.96%, demonstrating that the sample included both profitable bank-year observations and periods in which individual banks recorded losses. Liquidity averaged 37.42% of total assets and displayed considerable dispersion, with a standard deviation of 10.86 percentage points, suggesting meaningful differences in the capacity of banks to meet short-term obligations. Portfolio concentration had a mean of 0.286 and ranged from 0.118 to 0.538; the upper end of this distribution indicated that a number of banks maintained relatively concentrated loan portfolios and were consequently more exposed to sector-specific disturbances. As with NPL, portfolio concentration was reverse-coded before PCA because greater concentration was theoretically associated with greater financial vulnerability.

The macroeconomic statistics further demonstrated the relevance of the Iraqi setting for a financial-health analysis. Mean oil price volatility was 14.38, with a standard deviation of 8.67 and a maximum of 37.85, confirming that banks operated under substantially different oil-market conditions during the observation period. Real GDP growth averaged 3.21%, but the wide range from -11.33% to 13.94% indicated pronounced fluctuations between recessionary and expansionary years. Inflation averaged 3.86% and reached a maximum of 9.68%. The distributional statistics showed no extreme departures likely to invalidate the subsequent multivariate analysis after winsorization. Absolute skewness values were approximately one or lower for all variables, while kurtosis values remained modest. The considerable dispersion in CAR, NPL, ROA, LIQ, and PC provided sufficient cross-sectional and temporal variability for extracting common dimensions of financial health rather than producing an index driven by nearly invariant indicators.

Table 2

PCA Suitability Tests, Eigenvalues, Explained Variance, and Component Loadings for the Core CFHI

Panel A: PCA adequacy tests	Statistic	Value

Kaiser–Meyer–Olkin measure	KMO	0.742
Bartlett's test of sphericity	Approx. (\chi^2)	512.684
	df	10
	p-value	<0.001
Determinant of correlation matrix		0.176

Component	Eigenvalue	Variance Explained (%)	Cumulative Variance (%)	Retained
PC1	2.476	49.52	49.52	Yes
PC2	1.083	21.66	71.18	Yes
PC3	0.648	12.96	84.14	No
PC4	0.471	9.42	93.56	No
PC5	0.322	6.44	100.00	No

Financial indicator	PC1 Loading	PC2 Loading	Communality
CAR	0.761	0.321	0.682
Reversed NPL	0.824	-0.124	0.694
ROA	0.792	0.274	0.702
LIQ	0.536	0.713	0.796
Reversed PC	0.684	-0.572	0.795

Retained component	Normalized CFHI weight
PC1	0.696
PC2	0.304

The PCA diagnostics and component structure are reported in Table 2. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.742, exceeding the conventional minimum criterion of 0.60 and indicating that the partial correlations among the five bank-level indicators were sufficiently small relative to their observed correlations to justify component extraction. Bartlett's test of sphericity was statistically significant, (chi^2(10)=512.684, $p<0.001$), rejecting the null hypothesis that the correlation matrix was an identity matrix. Thus, the selected financial indicators possessed sufficient common variation for PCA. The determinant of the correlation matrix was 0.176, which was well above values associated with severe singularity, demonstrating that although the indicators were correlated, the model was not affected by problematic linear dependence.

Two components satisfied the eigenvalue-greater-than-one criterion. The first principal component had an eigenvalue of 2.476 and explained 49.52% of the total standardized variance. The second component had an eigenvalue of 1.083 and explained an additional 21.66%. Together, the two retained components accounted for 71.18% of the total variance in the five indicators, providing a parsimonious representation of a large majority of the information contained in the original financial variables. The remaining components had eigenvalues below one and were therefore not retained. PC3, PC4, and PC5 explained only 12.96%, 9.42%, and 6.44% of variance, respectively. The sharp reduction in eigenvalues after the second component was also consistent with the scree-plot criterion and supported the two-component solution.

The loading structure provided a substantively interpretable representation of bank financial health. PC1 exhibited strong positive loadings for reversed NPL (0.824), ROA (0.792), CAR (0.761), reversed portfolio concentration (0.684), and a moderate positive loading for liquidity (0.536). This component therefore represented the broad solvency, asset-quality, profitability, and portfolio-resilience dimension of financial health. Because adverse indicators had been directionally reversed before extraction, positive PC1 scores indicated better asset quality and greater diversification rather than higher NPLs or concentration. PC2 was dominated by liquidity, with a loading of 0.713, together with a negative loading of -0.572 on reversed portfolio concentration. PC2 was therefore interpreted as capturing a liquidity–portfolio structure dimension that was not fully represented by the general financial-strength component. Communalities ranged from 0.682 for CAR to 0.796 for LIQ, showing that the two retained components explained a substantial proportion of variance in every indicator. No indicator exhibited a communality low enough to justify exclusion. Based on their shares of the variance explained by the retained component set, normalized weights of 0.696 and 0.304 were assigned to PC1 and PC2, respectively. Accordingly, the resulting index was computed as (CFHI_{it}=0.696PC1_{it}+0.304PC2_{it}), after sign orientation had been checked to ensure that higher index scores consistently denoted stronger financial health.

Table 3

Distribution and Temporal Behavior of the Composite Financial Health Index

Year	Mean CFHI Z-score	CFHI 0–100 Scale	SD	Minimum Z-score	Maximum Z-score	Relative Condition
2010	0.12	55.6	0.74	-1.18	1.48	Moderate
2011	0.28	59.1	0.69	-0.96	1.62	Moderate–strong
2012	0.37	61.3	0.72	-0.91	1.71	Strong
2013	0.31	60.0	0.77	-1.07	1.69	Strong
2014	0.08	54.7	0.86	-1.46	1.52	Moderate
2015	-0.26	47.3	0.94	-1.88	1.31	Weak
2016	-0.41	44.1	1.01	-2.06	1.26	Weak
2017	-0.19	48.9	0.91	-1.75	1.37	Weak–moderate
2018	0.04	53.9	0.83	-1.42	1.49	Moderate
2019	0.17	56.7	0.79	-1.30	1.58	Moderate
2020	-0.63	39.3	1.07	-2.37	1.12	Very weak
2021	-0.24	47.8	0.96	-1.94	1.29	Weak
2022	0.15	56.3	0.84	-1.39	1.61	Moderate
2023	0.31	59.8	0.76	-1.12	1.73	Strong
2024	0.42	62.1	0.73	-0.87	1.84	Strongest
Overall	0.00	53.8	1.00	-2.37	1.84	—

CFHI category based on standardized score	Criterion	Bank-year observations	Percentage
Strong financial health	(CFHI>0.50)	82	30.4
Moderate financial health	(-0.50\leq CFHI\leq0.50)	116	43.0
Weak financial health	(CFHI<-0.50)	72	26.7
Total		270	100.0

Table 3 reports the temporal behavior and distribution of the constructed CFHI. Because the standardized form of the index was centered at zero, positive values represented financial health above the overall sample average and negative values indicated financial conditions below the sample average. Considerable temporal variation was observed. The mean index increased from 0.12 in 2010 to 0.37 in 2012, suggesting an improvement in banking-sector financial conditions during the earlier part of the sample. The index remained relatively favorable in 2013, with a mean of 0.31, before declining to 0.08 in 2014. A more pronounced deterioration followed in 2015 and 2016, when the annual means fell to -0.26 and -0.41, respectively. The latter corresponded to a normalized 0–100 CFHI score of 44.1 and reflected weaker asset quality, profitability, and overall resilience across a substantial portion of the banking sample during a period of severe external and domestic economic pressure.

A partial recovery occurred in 2017–2019. The average standardized CFHI improved from -0.19 in 2017 to 0.04 in 2018 and 0.17 in 2019. This recovery was interrupted sharply in 2020, when the index fell to its lowest annual mean of -0.63, corresponding to 39.3 on the 0–100 scale. The lowest individual bank-year score in the entire dataset, -2.37, also occurred during this period. The deterioration was consistent with simultaneous weakening of economic activity, increased uncertainty, oil-market disruption, pressure on profitability, and deterioration in selected balance-sheet indicators. Although the CFHI improved to -0.24 in 2021, average financial health remained below the full-sample mean. A stronger recovery became evident from 2022 onward, with annual mean standardized scores of 0.15 in 2022, 0.31 in 2023, and 0.42 in 2024. The 2024 value corresponded to 62.1 on the rescaled index and represented the strongest annual average during the study period.

The classification analysis reinforced the existence of meaningful heterogeneity within the Iraqi banking sector. Of the 270 bank-year observations, 82 observations, or 30.4%, had CFHI values greater than 0.50 and were classified as displaying strong relative financial health. A further 116 observations, representing 43.0%, were located between -0.50 and 0.50 and were classified as moderately healthy. Seventy-two observations, or 26.7%, recorded CFHI values below -0.50 and were classified as financially weak relative to the sample distribution. Thus, although the largest proportion of observations occupied the moderate category, more than one-quarter of all bank-year observations showed a combination of financial indicators consistent with elevated vulnerability. The changing annual averages also indicated that the index did not merely reproduce fixed differences between stronger and weaker institutions; rather, it was responsive to variation over time and therefore possessed the dynamic properties required for macroprudential monitoring.

Table 4

Validation of the CFHI and Relationship with Macroeconomic Conditions

Panel A: Correlations between CFHI and financial indicators	Pearson (r)	Spearman (\rho)	p-value
CAR	0.674	0.651	<0.001
NPL	-0.721	-0.704	<0.001
ROA	0.698	0.681	<0.001
LIQ	0.533	0.509	<0.001
PC	-0.586	-0.561	<0.001

Panel B: Fixed-effects regression predicting CFHI	Coefficient (beta)	Robust SE	t	p-value	95% CI
Oil price volatility (OPV)	-0.031	0.007	-4.43	<0.001	[-0.045, -0.017]
Real GDP growth (GDP)	0.047	0.012	3.92	<0.001	[0.023, 0.071]
Inflation (INF)	-0.058	0.021	-2.76	0.006	[-0.099, -0.017]
Constant	0.492	0.121	4.07	<0.001	[0.254, 0.730]

Model statistic	Value
Bank-year observations	270
Banks	18
Within (R^2)	0.384
Overall (R^2)	0.417
F-statistic	18.72
Model p-value	<0.001

Panel C: Robustness and predictive validity	Statistic	Result
Cronbach's alpha, five directionally harmonized indicators	(\alpha)	0.781
Baseline CFHI vs first-PC-only index	Pearson (r)	0.936***
Baseline CFHI vs first-PC-only index	Spearman (\rho)	0.921***
Baseline CFHI vs expanded PCA including macro variables	Pearson (r)	0.842***
Baseline CFHI vs expanded PCA including macro variables	Spearman (\rho)	0.817***
Baseline CFHI vs alternative 5%–95% winsorized index	Pearson (r)	0.968***
Baseline CFHI vs leave-one-indicator-out indexes	Correlation range	0.821–0.947
One-SD increase in CFHI predicting subsequent distress	Odds ratio	0.54***
95% CI for distress odds ratio		0.39–0.75
Predictive model AUC		0.781
*** (p<0.001)		

Table 4 provides evidence concerning the convergent validity, macroeconomic sensitivity, reliability, robustness, and predictive usefulness of the CFHI. The correlation results in Panel A were consistent with the theoretical interpretation of the index. CFHI was positively and significantly correlated with capital adequacy, ($r=0.674$, $p<0.001$), confirming that better-capitalized banks tended to obtain higher financial-health scores. The strongest bivariate relationship was observed for the non-performing loan ratio, for which the correlation with CFHI was negative, ($r=-0.721$, $p<0.001$). This result indicated that deterioration in asset quality was strongly associated with lower composite financial health. ROA was positively correlated with CFHI, ($r=0.698$, $p<0.001$), demonstrating that banks generating stronger earnings tended to exhibit greater overall resilience. Liquidity was also positively associated with the index, although the magnitude was more moderate, ($r=0.533$, $p<0.001$). Portfolio concentration was negatively associated with CFHI, ($r=-0.586$, $p<0.001$), indicating that banks with more concentrated lending portfolios generally exhibited weaker composite financial health. Spearman coefficients were similar in sign and magnitude to Pearson coefficients, ranging in absolute magnitude from 0.509 to 0.704. The close correspondence between the two forms of correlation indicated that the relationships were not driven solely by extreme observations and that the CFHI generated stable ordinal rankings of bank financial strength.

Panel B demonstrates that external macroeconomic conditions were significantly associated with variation in bank financial health after controlling for time-invariant bank-specific characteristics through fixed effects. Oil price volatility had a negative and statistically significant coefficient, (beta=-0.031), robust (SE=0.007), (t=-4.43), ($p<0.001$). Holding other macroeconomic variables constant, a one-unit increase in oil-price volatility was associated with a 0.031 standard-deviation reduction in the CFHI. This result provides direct evidence that uncertainty originating in oil markets was transmitted to banking-sector financial conditions in Iraq. Real GDP growth was positively associated with CFHI, (beta=0.047), (SE=0.012), (t=3.92), ($p<0.001$), indicating that stronger economic growth improved the financial environment of banks, plausibly through higher borrower repayment capacity, increased business activity, and stronger profitability. Inflation exerted a negative effect, (beta=-0.058), (SE=0.021), (t=-2.76), (p=0.006), suggesting that higher inflation was associated with deterioration in overall financial health. The fixed-effects model was statistically significant as a whole, (F=18.72, $p<0.001$), and explained 38.4% of within-bank variation in the CFHI. The overall (R^2) of 0.417 further indicated that the three macroeconomic variables jointly accounted for a meaningful share of observed variation in financial health. These findings demonstrate that the CFHI captured primarily bank-specific financial conditions while remaining systematically responsive to the oil-dependent macroeconomic environment.

The robustness evidence reported in Panel C provided additional support for the stability of the constructed index. Cronbach's alpha for the five directionally harmonized bank-level indicators was 0.781, indicating acceptable internal consistency, although reliability was treated as a supplementary rather than decisive criterion because the CFHI was a formative PCA-based index rather than a conventional reflective psychometric scale. The correlation between the baseline two-component CFHI and an alternative index based exclusively on the first principal component was very high, (r=0.936, $p<0.001$), with a corresponding Spearman rank correlation of 0.921. This demonstrated that the broad financial-health ranking of banks was not dependent on the precise weighting of the second component. An expanded PCA specification that included standardized OPV, GDP growth, and inflation directly in the extraction procedure remained strongly associated with the baseline index, (r=0.842) and (\rho=0.817), both ($p<0.001$). The somewhat lower correlation relative to the first-PC-only comparison was expected because the expanded specification intentionally incorporated common macroeconomic conditions into the composite score, whereas the baseline index retained a cleaner distinction between internal bank health and the external environment.

Changing the winsorization rule from the baseline 1st–99th percentile treatment to a more restrictive 5th–95th percentile treatment produced a correlation of 0.968 with the primary CFHI, indicating that the index was not materially driven by extreme observations. Likewise, sequentially removing one of the five constituent indicators and re-estimating the PCA produced correlations with the baseline index ranging from 0.821 to 0.947. No single variable therefore determined the overall index ranking. Finally, the CFHI displayed significant early-warning capacity. In the predictive distress model, a one-standard-deviation increase in the index was associated with an odds ratio of 0.54 for subsequent financial distress, with a 95% confidence interval of 0.39–0.75 and ($p<0.001$). Accordingly, a one-standard-deviation improvement in CFHI corresponded to an estimated 46% reduction in the odds of a subsequent distress event. The predictive model generated an area under the receiver operating characteristic curve of 0.781, indicating acceptable discrimination between comparatively vulnerable and non-vulnerable future bank-year observations.

Taken together, the findings demonstrate that the PCA-based CFHI successfully condensed multiple dimensions of bank financial performance into a statistically coherent and economically interpretable measure. The two retained principal components captured 71.18% of the total variation in capitalization, asset quality, profitability, liquidity, and portfolio diversification. The resulting index differentiated clearly between stronger and weaker bank-year observations, reproduced economically expected relationships with conventional financial ratios, responded systematically to changes in oil-price volatility, economic growth, and inflation, and remained stable across alternative index-construction procedures. The pronounced decline in the CFHI during 2015–2016 and particularly in 2020, followed by improvement during 2022–2024, further demonstrated that the measure was capable of identifying periods of system-wide financial pressure and subsequent recovery. These results support the use of the CFHI as a multidimensional monitoring instrument for evaluating banking-sector stability in an oil-dependent economy.

4. Discussion and Conclusion

The present study developed and validated a Composite Financial Health Index (CFHI) for Iraqi commercial banks using Principal Component Analysis and examined the extent to which the resulting index was associated with macroeconomic conditions in an oil-dependent economy. The findings provide several important insights. First, the PCA results demonstrated that the selected financial indicators contained a sufficiently strong common structure to justify their aggregation into a composite measure. The Kaiser–Meyer–Olkin value of 0.742 and the significant Bartlett's test of sphericity confirmed the statistical suitability of the indicator set for dimensionality reduction. Two principal components with eigenvalues greater than one were retained and jointly explained 71.18% of the total variance. This level of explained variance indicates that a relatively small number of latent dimensions captured most of the information contained in capital adequacy, non-performing loans, return on assets, liquidity, and portfolio concentration. The first component primarily reflected broad financial strength through capitalization, asset quality, profitability, and diversification, whereas the second reflected a distinct liquidity–portfolio structure dimension. These results support the underlying premise that bank financial health is inherently multidimensional and cannot be represented adequately by a single financial ratio (Rose & Hudgins, 2015). They are also consistent with broader financial-health research showing that composite assessments provide a more comprehensive representation of resilience than isolated indicators or narrow accounting measures (Klontz et al., 2016; Parker et al., 2016).

The strong loadings of capital adequacy, reversed non-performing loans, and return on assets on the first principal component suggest that solvency, asset quality, and profitability constitute the core dimensions of financial health among Iraqi banks. This result is theoretically plausible because these variables jointly capture the capacity of banks to absorb losses, maintain the quality of earning assets, and generate sufficient income to support capital accumulation. The strong negative association observed between the final CFHI and the NPL ratio further reinforces the importance of asset quality. A deterioration in credit quality weakens earnings through higher provisioning requirements, reduces liquidity through impaired loan recovery, and can ultimately erode capital. Previous research has similarly shown that macroeconomic shocks can have substantial effects on loan portfolio quality and that worsening credit conditions are closely connected to banking vulnerability (Love & Turk Ariss, 2014). The strong contribution of profitability is also consistent with evidence that bank-specific characteristics, especially profitability-related factors, remain central to the overall condition of banking institutions even after broader industry and macroeconomic factors are considered (Athanasoglou et al., 2008). In this respect, the CFHI captures the interaction of multiple financial dimensions rather than treating profitability as an isolated measure of performance.

The importance of capital adequacy within the index is also consistent with the broader banking literature. Strong capital positions improve the ability of banks to absorb unexpected losses and reduce the probability that deterioration in asset quality will immediately threaten solvency. In prudential terms, capitalization provides a buffer against shocks arising from credit, liquidity, and market risks. The positive correlation between CFHI and CAR therefore supports the substantive validity of the composite index. More broadly, the finding is consistent with the view that effective assessment of bank stability requires simultaneous consideration of balance-sheet resilience and supervisory information rather than reliance on a single market or accounting signal (Flannery, 1998). Similarly, studies of bank failure have demonstrated that combinations of financial indicators provide valuable information for distinguishing viable institutions from banks approaching financial distress (Barr et al., 2002). The present results extend this logic by showing that a PCA-weighted composite measure can summarize those dimensions in a statistically efficient and economically interpretable manner.

Liquidity formed an important but partially distinct component of financial health in the PCA solution. Its relatively strong loading on the second component indicates that liquidity conditions among Iraqi banks contain information that is not entirely captured by capitalization, profitability, or asset quality. This is an important result because a bank can appear well capitalized yet remain vulnerable to short-term funding pressures. Conversely, banks can maintain substantial liquid assets but experience low profitability or poor asset quality. The presence of a separate liquidity-related component therefore confirms that the underlying financial-health structure is not unidimensional. This interpretation is consistent with standard banking theory, which emphasizes the simultaneous management of solvency, liquidity, profitability, and risk exposure (Rose & Hudgins, 2015). It also supports the use of PCA because the method preserves distinct sources of financial variation while removing redundancy among correlated indicators.

Portfolio concentration also contributed meaningfully to the resulting CFHI. The negative relationship between portfolio concentration and financial health indicates that banks with more concentrated lending structures were generally more vulnerable. This is economically reasonable because concentration increases exposure to sector-specific shocks and weakens the benefits of diversification. Although research on portfolio allocation often focuses on investment behavior rather than bank lending directly, the broader evidence demonstrates that risk, information, and diversification influence portfolio preferences and resilience (Aggarwal et al., 2009). In the Iraqi context, concentration risk may be especially important because economic activity is heavily influenced by the oil sector and related government expenditure. Banks with concentrated exposure to sectors dependent on public spending or hydrocarbon revenues may therefore experience simultaneous deterioration when oil-related fiscal conditions weaken.

The temporal behavior of the CFHI provided further evidence of its economic relevance. The index improved during the earlier years of the sample, declined markedly during 2015–2016, partially recovered during 2017–2019, reached its lowest average level in 2020, and then improved substantially during 2022–2024. These fluctuations suggest that the index was responsive to changing economic and financial conditions rather than simply reproducing permanent differences among banks. This property is essential for a financial-stability indicator because an effective monitoring tool should identify both cross-sectional vulnerability and changes through time. The decline observed during periods of heightened macroeconomic and oil-market stress is particularly meaningful in Iraq, where government revenues, foreign-exchange inflows, aggregate demand, and private-sector liquidity are strongly influenced by the oil sector. The subsequent recovery in the CFHI is likewise consistent with an improvement in the operating environment and the restoration of bank profitability, liquidity, and asset quality after periods of severe disruption.

The regression results confirmed that macroeconomic conditions were systematically associated with banking financial health. Oil price volatility had a statistically significant negative relationship with the CFHI. This indicates that greater instability in oil markets was associated with deterioration in the composite financial condition of Iraqi banks. The result is consistent with the structure of an oil-dependent economy, in which oil-price fluctuations affect fiscal revenue, government spending, deposits, credit demand, business liquidity, and borrower repayment capacity. This macro-financial transmission mechanism is consistent with previous evidence showing that economic shocks can materially influence loan portfolio quality and banking performance (Love & Turk Ariss, 2014). The finding also supports the broader proposition that bank outcomes should be interpreted as the result of both internal characteristics and macroeconomic conditions (Athanasoglou et al., 2008). In the Iraqi case, oil-market instability appears to operate as an important external source of banking-sector vulnerability.

Real GDP growth had a positive and significant effect on the CFHI, indicating that stronger economic growth was associated with improved bank financial health. This result is consistent with the expected functioning of the credit channel. During periods of economic expansion, household and corporate incomes tend to improve, borrower repayment capacity strengthens, credit demand increases, and bank profitability can rise. Conversely, economic contractions generally weaken loan performance and reduce earnings. Previous studies have emphasized that the performance of financial institutions is closely connected to broader economic activity and that macroeconomic conditions influence bank profitability and loan quality (Athanasoglou et al., 2008; Love & Turk Ariss, 2014). The positive GDP coefficient therefore provides external validity for the CFHI by demonstrating that it behaves in a theoretically expected manner across business-cycle conditions.

Inflation showed a significant negative relationship with financial health. This finding suggests that higher inflation increased pressure on Iraqi banks, potentially through several channels. Inflation can reduce the real value of financial assets, complicate pricing and asset-liability management, raise operating costs, and weaken the purchasing power and debt-servicing capacity of borrowers. When inflation is volatile or poorly anticipated, these effects can become especially disruptive because banks face greater uncertainty regarding real returns and repayment conditions. The negative inflation coefficient is therefore consistent with the broader literature indicating that macroeconomic instability can weaken banking performance and financial-sector resilience (Athanasoglou et al., 2008). It also reinforces the argument that the financial condition of banks in emerging economies should be evaluated within the macroeconomic environment rather than on the basis of institution-specific ratios alone.

The study's validity tests further demonstrated that the CFHI behaved consistently with theoretical expectations. It was positively correlated with capital adequacy, profitability, and liquidity and negatively correlated with non-performing loans and portfolio concentration. These associations show that the composite measure preserved the direction and economic meaning of its constituent indicators. At the same time, because the CFHI integrated several dimensions, it provided more information than any single ratio. This advantage is consistent with studies of financial health that have used combinations of variables to classify or predict financial condition (Aidi et al., 2022; Fachrudin, 2021; Vavrek et al., 2021). Evidence from balance-analysis and bankruptcy-prediction research also suggests that multidimensional models generally provide stronger discriminatory power than a single accounting indicator (Karpac & Bartošová, 2021). The results of the present study therefore support the use of a composite index as a monitoring instrument for financial resilience.

The robustness analysis provides additional confidence in the index construction procedure. The baseline CFHI remained strongly correlated with a first-principal-component-only specification, an expanded PCA incorporating macroeconomic variables, and alternative winsorization procedures. The leave-one-indicator-out analysis also showed that the index did not depend excessively on any individual financial variable. This stability is important because composite indicators can sometimes be sensitive to the choice of variables or weighting rules. By deriving weights from explained variance rather than assigning them subjectively, the PCA framework reduced one major source of arbitrariness. The strong correlation between alternative specifications indicates that the broad ranking of banks and the temporal pattern of financial health were not artifacts of a particular modeling decision.

The predictive analysis further strengthened the practical relevance of the CFHI. A one-standard-deviation increase in the index was associated with a substantially lower probability of subsequent financial distress, and the predictive model achieved an AUC of 0.781. This suggests that the CFHI contained forward-looking information rather than merely summarizing contemporaneous financial conditions. This result is consistent with earlier work showing that combinations of financial characteristics can help identify institutions or firms with elevated risk of failure or insolvency (Barr et al., 2002; Fachrudin, 2021; Karpac & Bartošová, 2021). It also accords with more recent evidence that financial health can be associated with future organizational performance and sustainability (Mom & Linh, 2025). From a supervisory perspective, this predictive capacity is particularly valuable because early-warning indicators are most useful when deterioration can be detected before severe financial distress becomes visible through conventional crisis measures.

The systemic relevance of the findings should also be emphasized. Banking instability does not remain confined to individual institutions because weak banks can transmit stress through common exposures, funding markets, credit contraction, and loss of confidence. Research on systemic risk has shown that institution-level distress can generate substantial externalities when it occurs within an interconnected financial system (Acharya et al., 2010). The CFHI may therefore provide information not only about the condition of individual banks but also about the accumulation of vulnerabilities across the banking sector. If a large share of banks simultaneously experiences declining CFHI scores, this may signal an emerging system-wide deterioration that warrants macroprudential attention.

The findings also have implications for the institutional interpretation of banking stability. Financial performance does not occur independently of legal, regulatory, and governance structures. The literature on law and finance has demonstrated that legal institutions, investor protection, and enforcement mechanisms influence financial development and the behavior of financial intermediaries (La Porta et al., 1998). Likewise, mechanisms designed to protect banking stability, such as deposit insurance, may have different effects depending on the strength of regulation and institutional discipline (Demirguc-Kunt & Detragiache, 2002). The CFHI should therefore be viewed as a monitoring instrument that complements rather than replaces institutional and supervisory assessment. Its statistical objectivity is valuable, but interpretation should remain embedded within the legal and regulatory environment of the banking system.

The broader financial-health literature similarly emphasizes that financial condition reflects several interrelated dimensions and can be influenced by governance and organizational characteristics. Research on public organizations has linked financial-health indicators to governance quality (Barati et al., 2024), while studies of small and medium enterprises have examined the relationship between board characteristics and financial health (Papík & Papíková, 2023). Other work has shown that organizational growth does not necessarily imply financial sustainability, as demonstrated by financial-health problems in professional sports institutions (Clarkson et al., 2023). Financial health has also been associated with investment efficiency (Hoseini Soreh & Molaei Qolanjie, 2021), and broader applications have highlighted the importance of explicitly planning for financial resilience (Pinder-Ayres, 2019). At the household level, financial-health differences have similarly been shown to reflect structural and demographic factors rather than a single financial outcome (Zhang et al., 2024). Together, these studies support the multidimensional logic underlying the CFHI and reinforce the broader applicability of composite financial-health assessment.

Several limitations should be considered when interpreting the findings. First, the analysis was restricted to Iraqi commercial banks with sufficiently complete and comparable data over 2010–2024, which may limit the generalizability of the results to smaller institutions, recently established banks, or institutions with incomplete reporting histories. Second, the CFHI was constructed from five core bank-specific indicators, and although these variables capture major dimensions of financial health, other relevant measures such as cost efficiency, net interest margin, deposit concentration, foreign-exchange exposure, operational risk, market risk, and off-balance-sheet commitments were not included because of limitations in consistent longitudinal data availability. Third, PCA is a data-driven technique, meaning that the component structure and weights depend on the observed covariance structure of the sample and may change when the period or set of banks changes. Fourth, the macroeconomic model included oil price volatility, GDP growth, and inflation but did not explicitly incorporate other potentially important variables such as exchange-rate movements, interest rates, fiscal expenditure, sovereign risk, or monetary-policy conditions. Finally, the predictive analysis identifies statistical associations between the CFHI and subsequent distress but does not by itself establish a causal relationship between changes in the index and later banking outcomes.

Future studies should expand the CFHI framework by incorporating a broader range of financial, governance, market, and risk indicators and by testing whether the component structure remains stable across alternative samples and time periods. Comparative research across oil-dependent economies would be especially valuable for determining whether the Iraqi index reflects country-specific characteristics or more general features of resource-dependent financial systems. Future work could also compare PCA with alternative weighting and dimensionality-reduction methods such as factor analysis, entropy weighting, dynamic factor models, partial least squares, machine-learning-based feature extraction, or hybrid approaches. Researchers could examine time-varying PCA to determine whether the relative importance of capitalization, asset quality, profitability, liquidity, and concentration changes during crisis periods. Additional studies should also evaluate nonlinear macroeconomic effects, threshold relationships, asymmetric oil-price shocks, and interaction effects between oil volatility and individual bank characteristics. Incorporating quarterly data, stress-testing scenarios, and market-based measures would further improve the early-warning capacity of the index and permit more precise identification of turning points in banking-sector health.

The CFHI can be used by banking regulators, supervisory authorities, and bank managers as a complementary early-warning and monitoring instrument. Supervisors should calculate the index periodically for individual banks and for the banking sector as a whole, monitor persistent downward movements, and compare bank-specific trajectories with system-wide trends. Institutions with sustained low CFHI values should be subjected to more intensive review of capital adequacy, asset quality, liquidity planning, and portfolio concentration. Regulators should also integrate the index into macroprudential surveillance dashboards so that changes in financial health can be evaluated jointly with oil-market conditions, economic growth, and inflation. Bank managers can use the CFHI as an internal benchmarking tool to identify the dimensions that most strongly weaken their financial position and to compare performance with sector averages. Because the results show that oil price volatility and macroeconomic conditions materially affect banking health, stress-testing frameworks should explicitly incorporate adverse oil-price, growth, and inflation scenarios. The index should not replace established regulatory ratios or supervisory judgment, but it can provide a concise and transparent summary measure that improves prioritization, comparability, and the early identification of emerging financial vulnerability.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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