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The Role of Financial Engineering Techniques in Assessing Liquidity Risks of Selected Banks Listed on the Iraq Stock Exchange

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Abstract : The aim of the research is to identify financial engineering techniques and understand their role in assessing financial risks, represented by liquidity risk, Financial engineering techniques are considered valuable tools in financial risk assessment as they help companies comprehensively understand and analyze risks and make sound financial decisions. They provide advanced mathematical tools and models that aid in accurately and efficiently analysing and estimating risks.

The research community consisted of Banks listed on the Iraq Stock Exchange, with a research sample comprising ten Bank listed on the Iraq Stock Exchange during the period from January 1, 2011, to December 31, 2023. A set of statistical programs, such as SPSS and Eviews 9 programs , was used to obtain accurate results, The study variables included the independent variable, represented by financial engineering techniques (liquidity index, credit index, operational index), and the dependent variable, represented by liquidity risk assessment, The research reached a set of conclusions, The strong negative correlation between financial engineering techniques as an independent variable and risk assessment as a dependent variable means that an increase of one unit in financial engineering techniques leads to a decrease of one unit in liquidity risk.

In light of this, the research made several recommendations, the most important being the continuous updating of information and reports published on the Iraq Stock Exchange, emphasizing the need to make them accessible to all investors.

Keywords: Financial engineering, liquidity indicators, credit indicators ،operating indicators ،liquidity risks.

INTRODUCTION: Financial engineering is a developmental process that plays a significant role in stimulating global financial markets. It contributes to the creation of new financial instruments for hedging, speculation, and investment, all of which are based on risk management. Risk management refers to the possibility of negative deviations from desired or expected outcomes. These deviations can reduce the efforts of financial institutions, especially banks, in their pursuit of survival, growth, and stability in their activities. Risks may arise as a result of changes in markets, such as fluctuations in exchange rates and interest rates, or through dealings with external parties, or even from within the institution as a result of errors or fraud, which may negatively impact the organizational and economic entity.

researchers have sought to develop methods and tools that help reduce or eliminate these risks, represented by financial engineering tools, whose importance is highlighted by the provision of innovative solutions and new financial instruments that align with economic efficiency standards. Financial engineering appears necessary in light of the major radical changes represented by the shift in the management of economic resources to a free-market economy, in addition to the interconnectedness of international financial markets resulting from the communications and information technology revolution.

Liquidity risk is one of the most significant challenges facing banks today. A lack of liquidity can lead to multiple risks, including a loss of confidence in the bank's policies. This, in turn, may prompt customers to withdraw their funds from the bank and transfer them to other banks. The concept of liquidity in a commercial bank refers to its ability to meet customer needs and provide banking services through the liquid cash balances it maintains in its fund, or by converting other assets it owns into liquid cash without incurring any losses.

Based on the above, the research is presented in three main points:

The first point represents the research methodology, while the second point covers the theoretical aspect, focusing on the study variables: financial engineering techniques on one hand, and liquidity risk on the other. The third point addresses the practical aspect through the analysis of the study data and the testing of hypotheses.

First: Research methodology

1 .Research Problem

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2. importance of research

The importance of the research stems from the significant role of financial engineering techniques in risk assessment by providing quantitative information generated by these techniques, which motivates managements to explore opportunities to achieve financial sustainability and by analysing the environmental, social, and governmental factors that affect financial markets. The importance of the research can be explained as follows:

A. a better understanding of financial risk helps companies and financial institutions make more accurate and effective decisions.

B. Financial engineering techniques enable companies to further assess, identify, and reduce potential financial risks, increasing their stability and ability to adapt to financial challenges.

C. Financial engineering techniques contribute to improving companies' financial performance by better assessing risks and selecting appropriate strategies to manage them.

3**. Research Objectives**

In light of the questions posed for the research problem, the current research aims to apply knowledge of the role of financial engineering techniques in risk assessment. Therefore, the sub-objectives required to achieve the main research objective can be identified as follows:

A .Explain the cognitive foundations of financial engineering techniques in liquidity risk assessment.

B.The research aims to develop more advanced and accurate mathematical models for Liquidity risk assessment and analyze their performance and efficiency in comparison with traditional models.

C. Determine the extent of compatibility between financial engineering techniques and liquidity risk assessment.

4**. Research hypotheses**

According to the questions presented in the research problem, the following hypotheses can be formulated:

Main hypothesis: The lack of a statistically significant effect on the possibility of financial engineering techniques in assessing the risks of the research sample Banks for the period (2011-2023).

From it, it branches into the following sub-hypotheses:

First Sub-Hypothesis:

There is no statistically significant effect of financial engineering techniques represented by liquidity indicators on liquidity risks.

Second Sub-Hypothesis:

There is no statistically significant effect of financial engineering techniques represented by credit indicators on liquidity risks.

Third Sub-Hypothesis:

There is no statistically significant effect of financial engineering techniques represented by operational indicators on liquidity risks.

5. Research community and sample

The research community represents the banking sector listed on the Iraq Stock Exchange, while the research sample amounted to Ten banks for a period of (13) years from 1/1/2011 until 12/31/2023.

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sample research the in used banks Table(1)

	Bank name	Symbol	Listing date	Capital Amount in milions dinars	Establishment date
1	Iraqi commercial bank	BCOL	2004	250.000	11/2/1992
2	Baghdad bank	BBOB	2004	250.000	28/2/1992
3	Sumer commercial bank	BSUC	2004	250.000	26/5/1992
4	Iraqi commercial bank	BNOI	2004	270.000	2/1/1995
5	Middle East bank	BIME	2004	250.000	7/7/1993
6	Iraqi investment bank	BIBI	2004	250.000	13/7/1993
7	Gulf commercial bank	BGUC	2004	250.000	13/7/1993
8	Ashur international bank	BASH	2007	250.000	25/4/2005
9	Mansour bank	BMNS	2008	250.000.	13/9/2005
10	United investment bank	BUND	2009	300.000	20/8/1994

6. **Research Variables :**

The research includes two variables:

1. Independent Variable (Financial Engineering) : Techniques represented by indicators such as liquidity indicators،credit indicators and operational indicators
2. Dependent Variable (Risk Assessment) : represented by liquidity risk

Second: The theoretical aspect

1. **Financial Engineering**

Financial Engineering Concept: Financial Engineering is an old concept, as old as financial transactions, but it has expanded and become widespread recently (Chen et al., 2022:1277) defines it as the design, development, and implementation of innovative financial instruments and mechanisms, and the formulation of creative solutions to financing problems. The concept of financial engineering and its applications has existed for a much longer period, but it was not widely used as a term. The development of the global economy in the 1960s and 1970s, and the comprehensive financial liberalization of economic transactions and prices, made financial markets and institutions surrounded by numerous financial risks, which had a widespread impact on investment returns. The financial industry was forced to develop new financing methods and strategies that could meet the needs of financial market participants while simultaneously generating cash flows. The need to develop new financing methods and strategies that could meet the needs of financial market participants while generating cash flows became apparent (Shakati 2017:4). In other words, financial engineering includes three types of activities:

1. Creating new financial instruments such as credit cards.
2. Develop new financing mechanisms to reduce operational costs for existing businesses, such as exchanges over the global network
3. Develop new financial management solutions, such as liquidity or debt management, or prepare financing formulas for specific projects that suit the project's surrounding circumstances,There are also several definitions of financial engineering, which are presented in Table (2):

Table (2) Definitions of financial engineering

ت	Source	Definition
1	**(Bin**،2006: 4)	It is the structuring of financial instruments to target investor preferences or take advantage of arbitrage opportunities.
2	(**Neftci, 2008:175)**	It is a set of activities that consist of the design, development and implementation of innovative financial tools and processes, as well as the formulation of creative solutions to financing problems..
3	(**Frank**،2009 :417)"	It is the use of financial instruments such as derivatives, futures, swaps, options and related products in order to restructure or reorganize cash flows to achieve financial goals.

According to the table, the researcher can define financial engineering as the final transformation of a financial product to either improve its returns or reduce its risks—or both—thus playing a role in changing the conditions of the financial market.

1. **The Importance Of Financial Engineering**

Financial engineering is gaining great importance, through its role in many fields, including (Alhasadı & Ilhusadı, 2018:18) and Coskun, 2013:83-84) :-

- **Risk Management :**

Risk refers to the possibility of achieving an actual return that differs from the expected return. Businesses face two main types of risks: business risks and financial risks. Business risks (operational risks) are related to the conditions of the industry to which the business belongs, such as technological level, innovation and development, and competitive conditions.

5. . **Liquidity Management:**

This is a fundamental aspect of financial engineering and refers to the ability of financial markets and companies to quickly and easily convert assets into cash without significantly impacting asset prices. This may be of greater importance to financial institutions. Liquidity is primarily based on matching the maturities of liabilities and assets to ensure that immediate funding pressures do not occur.

6. **Competition**

Various institutions are working to drive innovation to create new financial products or develop existing ones, with the aim of meeting customer needs and seizing various available investment opportunities.

B- Objectives of Financial Engineering :

Al-Qadir (2017: 12) pointed out that there are several objectives of financial engineering, as follows:

7. **Hedging**

It seeks to reduce or protect against the risks of fluctuations in the prices of raw materials, commodities, exchange rates, and securities through various financial instruments created through financial engineering. The primary goal of hedging is to manage and control risk using various methods, generally based on the diversification of financial assets.

8. **Speculation:**

Speculation is the process by which speculators trade securities to capitalize on future price expectations based on the information they have gathered and analyzed. Speculation can therefore be viewed from two different perspectives. Speculators seek to make short-term profits based on future price movements.

9. **Arbitrage:**

Arbitrage is a process that enables some investors to obtain profits that others cannot obtain due to market imbalance. The investor purchases goods at low prices in the market and then sells them in another market where these goods are at higher prices. He thus benefits from the difference between the two prices.

C.Types Of Financial Engineering:

Financial engineering encompasses a variety of tools and strategies used to analyze financial markets, manage risks, and create new financial products. Financial engineering can be classified into several main categories based on their functions and uses (Breuer & Prest, 2007:828-830), as follows:

10. **Quantitative Financial Engineering**

This involves mathematical models: Complex mathematical models are used to analyze financial markets and develop trading strategies. These models include differential calculations, statistical analysis, and probabilistic models, as well as trading algorithms. The development and implementation of automated trading strategies that rely on algorithms to identify trading opportunities and execute trades.

11. **Structured Financial Engineering**

Asset-backed securities include the creation and securitisation of securities backed by mortgages, consumer loans, and commercial debt.

12. **Advisory Financial Engineering**

This involves providing financial consulting services to companies and institutions on optimal financing strategies, capital structure, and risk management, as well as financial structuring planning related to designing optimal financial structures for companies to increase financial efficiency and achieve strategic objectives

D- Characteristics of Financial Engineering:

After defining financial engineering as the use of mathematical tools and statistical models to solve financial problems and design new financial products, or as a complex and multifaceted field that combines mathematical and technical tools to develop innovative solutions in the field of finance, it is characterised by several characteristics, including (Guo et al., 2012:209-212) and (Feng & Palomar, 2016:5-10) :-

13. **Use of advanced mathematics:**

Financial engineering relies heavily on mathematics, including quantitative analysis, statistics, calculus, and linear and nonlinear programming (Turfus, 2006:2).

14. **Financial Modeling**

Concerned with creating financial models that help estimate and evaluate the risks and returns associated with various investments and financial products.

15. **Risk Management:**

Financial engineering plays a vital role in identifying, analysing, and managing financial risks, whether related to investment, financing, or operational processes.

E: Financial engineering indicators:

- **Liquidity Index**

It is considered one of the most accurate indicators than its predecessor, which is used as a standard in indicating the ability of banks to fulfil all their obligations and carry out repayment operations for short-term obligations. In addition, increasing this percentage over the conventional percentages determined by the Central Bank (30-35%) leads to a complete decrease in the volume of liquidity risk, while at the same time it is met by a lack of compatibility between liquidity objectives and the profitability objective. This indicator is calculated through the following equation (Al-Rikabi, 2022: 24).

Cash on hand + Cash at central bank + Investments + Discounted commercial paper / Total deposits

- **Credit Index**

Analysing the bank credit index is a vital tool for assessing the financial performance and credit stability of banking institutions. This analysis aims to measure banks' ability to manage credit risk and provide loans in a balanced manner, which directly impacts their profitability and financial sustainability. The credit index is based on a set of criteria, such as the ratio of non-performing loans to total loans, the capital adequacy ratio, and the bank's credit rating**.**

Total Credit / Total Deposits.

- **Operating Index**

Analysing the operating ratio in banks is one of the primary tools for assessing the financial performance and operational efficiency of banking institutions. This analysis aims to measure the efficient use of financial and human resources within a bank by examining the relationship between operating revenues and operating expenses. Operating indicators play a pivotal role in determining a bank's ability to achieve profitability and improve the quality of financial services provided to customers.

2-Liquidity Risks Liquidity risk is considered one of the most significant challenges facing banks, and its importance has increased in recent times due to changes in economic and political conditions and their impact on financial institutions, especially during crises. Most banks face substantial challenges related to liquidity risk, which requires taking appropriate steps and measures to predict and minimise these risks.Financial institutions are fundamentally

successful in avoiding liquidity risks by adopting appropriate policies to reduce the liquidity gap, in addition to maintaining a reasonable proportion of liquid assets that enable the bank to obtain funding. Banks are exposed to liquidity risk if they make uncalculated decisions regarding withdrawals and financial obligations—either by granting financial facilities that are quickly converted into cash or by concentrating financing in a single instrument or asset class that is characterised by low liquidity, which may make it difficult to liquidate in the market. Liquidity risks increase financial risks, as a bank's ability to meet its obligations to clients depends on the availability of appropriate financial resources. Therefore, it is essential for banks to maintain a suitable proportion of liquid assets to avoid a sudden liquidity crisis or the emergence of urgent financial obligations.

The most common reason for liquidity shortages in the depositors' section is the sudden and unexpected influx of large deposit withdrawals, which forces the institution to seek funds at higher interest rates and redeposit them. (Rose & Hudgins, 2010: 183)

There are three main types of liquidity risk according to the Central Bank of Egypt (2015):

A. Funding Liquidity Risk: This occurs when a bank is unable to meet expected or unexpected cash withdrawals—whether current or future—efficiently, without affecting its daily operations or financial position.
B. Market Liquidity Risk: This arises when a bank is unable to sell one of its assets or a portion of it at the prevailing market price, due to the inability to liquidate it in the market, thus also exposing it to loss risks.
C. Margin Liquidity Risk: This results from the increased use of certain credit limits granted to counterparties or the sudden withdrawal of those limits.

3-The relationship between financial engineering techniques and liquidity risks

Financial engineering techniques are considered to be used to describe the analysis of data obtained from the stock exchange in a scientific manner. This analysis takes the form of financial mathematical models. In addition, it is the use of risk management strategies to address the form of risks faced by a company (Carmona, 2020:4)

Alhasadı & Ilhusadı (2018:18) added that it is "the design, development, and implementation of innovative tools and processes, the formulation of innovative solutions to problems in the field of finance, and the provision of creative and innovative solutions to economic and financial problems. Its role is not limited to new products only, but also extends to attempts to adapt old tools and ideas to serve the institution or company.

Liquidity risk is the risk faced by individuals, companies, or financial institutions resulting from their inability to meet their short-term financial obligations when due, or their inability to convert assets into cash quickly enough at fair market value. Simply put, liquidity risk can be understood as the inability to obtain sufficient cash to cover outstanding debts, operating expenses, or other obligations in a timely manner.(Drehmann & Nikolaou, 2013: 1024)

Third /Practical aspect

1.data description and analysis

A. Independent Variable / Financial Engineering Techniques

*** Liquidity Ratios Indicators**

The table below provides a brief description of some basic statistical indicators, as well as the normality distribution test for the liquidity ratio variable of the banks under study for the years (2011-2023):

Table (3)the statistical description and normality test of the liquidity ratio indicators variable for the sample banks under stud

Banks	Ahli Al iraqi	Iraqi comercial	Gulf comercial	Sumer comercial	United investement	Baghdad	Middle east	Mansour	Ashur iternational	Iraqi Investment
Mean	3.890	1.747	4.160	4.444	5.929	4.035	4.140	1.723	4.546	2.743
Standard Deviation	2.257	3.239	1.072	3.242	2.437	6.779	1.824	2.467	1.462	0.834
Maximum Value	8.999	3.282	6.507	8.357	16.35	7.976	9.705	3.842	9.472	7.993
Minimum deviation	1.081	0.903	1.733	2.498	0.247	0.818	1.525	0.331	0.581	1.015
Skewness	1.234	0.952	0.625	1.453	0.345	1.892	0.782	0.127	1.053	1.424
Kurtosis	0.872	-0.458	-0.923	1.208	-1.157	3.524	-0.201	-1.026	0.502	0.972

jar que-bera Test	4.952	3.454	2.182	4.734	3.941	2.452	2.057	3.122	4.872	2.642
P-Value	0.059	0.178	0.336	0.063	0.135	0.378	0.356	0.210	0.086	0.375

The table (3) show The general statistical description and the normality distribution test for the liquidity ratio indicator variable data for the banks under study indicate the following:

We observe that the skewness values are greater than the kurtosis values for the liquidity ratio indicator in most of the banks under study. This indicates that liquidity ratios have experienced sharp and sudden fluctuations during the study period, In most of the studied banks, we notice that they maintain a good level of liquidity, which means they have the flexibility to meet both long-term and short-term obligations through their liquid assets. From the standard deviation results, we notice a relative variation in liquidity ratio indicators during the study years for the banks under examination, which could be due to fluctuations in the Iraqi market, changes in the financial policies of the studied banks, or other reasons.

Regarding the normality distribution test for our data related to the liquidity ratio indicator variable, we will focus on the (Jarque-Bera) test. From the table above, we find that the Jarque-Bera test statistic values for the studied banks have a p-value greater than 0.05. This indicates the possibility of continuing to test the main research hypotheses by assuming that the liquidity ratio data follows a normal distribution for all banks in the research sample.

*** Credit Ratios Indicators**

The table below provides a brief description of some basic statistical indicators, as well as the normality distribution test for the credit ratio indicator variable for the studied banks for the years (2011-2023):

Table (4) the statistical description and normality test of the credit ratio indicators variable for the commercial banks sample under study

Banks	**Al ahli iraqi**	**Iraqi Commercial**	**Gulf Commercial**	**Sumer commercia l**	**United investment**	**dadBagh**	**Middl east e**	**Mansour**	**Ashur internationa l**	**Iraqi investment**
Mean	5.152	2.331	14.039	7.361	4.498	3.653	3.768	1.232	3.818	5.152
Standard deviation	3.936	1.878	18.961	4.012	2.089	2.301	2.544	1.267	5.026	3.954
Maximu value m	12.19 0	5.868	68.69	16.89	7.861	7.056	9.427	4.234	13.66	10.88
Minimum value	1.570	0.268	1.315	1.225	1.385	0.505	0.347	0.159	0.101	0.105
Skewnes	0.286	1.011	2.545	0.838	0.135	0.048	1.613	1.553	1.242	-0.247
Kurtosis	-1.743	-0.403	6.155	1.617	-0.719	-1.685	2.268	1.677	0.059	-1.714
test jarque-bera	2.347	3.892	3.421	3.114	3.012	1.927	2.542	1.264	1.245	2.541
value- P	0.309	0.0671	0.058	0.089	0.2222	0.384	0.543	0.472	0.342	0.543

Table (4) shows the general statistical description and the normality distribution test for the credit ratio indicator variable based on the statistical measures presented in the table above, which correspond to the data of the studied banks ,We observe that the average value of the credit ratio indicator for the years 2011-2023 for the studied banks is as follows, We notice that the skewness values are lower than the kurtosis values for the credit ratio indicator in most of the studied banks. This indicates that credit ratios do not experience sharp and sudden fluctuations during the study period. The results indicate that banks generally offer a relatively high level of credit compared to other indicators,

suggesting attempts to stimulate credit activity as part of their strategy to achieve profits and expand the customer base. However, the standard deviation values for the studied banks indicate significant fluctuation in credit ratios over the years, which may be attributed to several factors, including:

1. Variation in credit demand from year to year.
2. Changes in the credit policies of the bank.
3. Other possible factors.

Regarding the normality distribution test for our data related to the credit ratio indicator variable, we will focus on the Jarque-Bera test. From the table above, we find that the Jarque-Bera test statistic values for the studied banks have a p-value greater than 0.05. This indicates the possibility of continuing to test the main research hypotheses by assuming that the credit ratio data follows a normal distribution for all banks in the study sample.

* **Operating Indicators Variable**

The table below provides a brief description of some simple statistical indicators, as well as a normality distribution test for the operating indicator variable for the banks under study for the years (2011-2023):

Table (5) the statistical description and normality test of the operating indicators variable for the commercial banks in the study sample.

Banks	ahli Al iraqi	Iraqi commercial	Gulf commercial	Sumer commercial	United investment	Baghdad	Middle East	Mansour	Ashur international	Iraqi investment
Mean	40234	53043	17106	3925	12807	17428	110270	330075	183581	.1500
Standard deviation	728924	839488	549754	719666	421091.72	.5924	218183	26116	77048	17667
Maximum value	2,151	2,159	2,700	1,840	2,115	3,225	1,617,61	6,884	2,678	4,562
Minimum value	2,88	1,775	658,622	715,215	769,45	1,005	875,64	3,697,	115,74	769,2
Skewnes	2.126	1.081	-0.517	1.482	0.852	1.400	1.315	0.180	-1.412	0.498
Kurtosis	3.194	-0.731	0.624	0.324	-0.201	2.218	1.503	-1.598	1.350	-1.535
Test jar que-bera	1.242	2.542	0.972	1.279	2.671	3.048	2.487	1.316	2.149	1.642
value-P	0612	0.219	0761	0.246	0.137	0.094	1.428	1.567	0.342	0.219

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We observe that the average value of the operating ratio indicator for the years 2011-2023 for the studied banks is as follows, We notice that the skewness values are higher than the kurtosis values for the operating ratio indicator in most of the studied banks. This indicates that the operating ratios experience sharp and sudden fluctuations during the study period, From the results, it is evident that the banks demonstrated clear operational activity, indicating a good and noticeable level of operational performance, whether from revenues or banking operations focusing on providing

financial and credit services. However, the high standard deviation values for the studied banks indicate a very large fluctuation in operating values throughout the study years, and in some cases, the dispersion even exceeds the mean itself. This suggests that the studied bank may have gone through periods of very high operational activity in a certain year, followed by a noticeable decline or fluctuation in another year.

Regarding the normality distribution test for our data related to the operating ratio indicator variable, we focus on the Jarque-Bera test. From the table above, we find that the Jarque-Bera test statistic values for the studied banks have a p-value greater than 0.05. This indicates the possibility of continuing to test the main research hypotheses by assuming that the operating ratio data follows a normal distribution for all banks in the study sample.

B- The dependent variable is represented by financial risks (Liquidity Risk)as follows:

***liquidity risk**

The table below provides a brief description of some simple statistical indicators, as well as a normality test for the liquidity risk ratio variable for the banks under study during the years (2011-2023):

Table (6) the statistical description and the normality test of the liquidity risk ratio variable for the commercial banks in the study sample

Bank	ahli Al iraqi	Iraqi commercial	Gulf commercial	Sumer commercial	United investment	Baghada	Middle east	Mansour	Ashur international	Iraqi investment
Mean	0.630	0.4706	0.604	0.590	0.5986	0.618	0.6365	0.6244	0.5468	0.7217
Standard deviation	0.283	0.302	0.268	0.268	0.409	0.240	0.272	0.276	0.266	0.189
Maximum value	0.998	0.911	0.998	0.979	1.456	0.979	1.194	0.981	1.006	1.514
Minimum value	0.054	0.010	0.302	0.515	0.063	0.101	0.174	0.221	0.114	0.445
Skewnes	-0.682	0.142	0.5008	-0.886	0.659	-1.099	0.604	-0.351	0.564	0.231
Kurtosis	0.424	-0.984	-1.779	1.381	-0.284	1.034	0.210	-1.791	0.128	0.251
Test jar que-bera	2.546	1.794	1.834	2.953	0.937	2.167	1.628	2.945	2.526	1.346
value-P	0.243	0.438	0.429	0.237	0.617	0.376	0.569	0.379	0.269	0.222

Table (6) shows the general statistical description and the normality test for the data of the liquidity risk, Based on the statistical measures presented in the table above, which pertain to the data of the banks under study, the average liquidity risk ratio variable for the years 2011–2023 for the banks under study is as follows, We notice that the skewness values are greater than the kurtosis values for the liquidity risk ratio indicator in most of the banks under study, indicating that the liquidity risk ratios experience sharp and sudden fluctuations during the study period, The results show that the banks have moderate values, indicating that the banks under study were exposed to a moderate level of liquidity

risk in most cases, This means that the banks 'ability to cover liabilities was not critical but also not ideal. The standard deviation values of the banks indicate that there was relatively limited fluctuation in most of the studied banks, suggesting stability in the level of risks faced by the banks over the years, This stability can be attributed to

some banks maintaining a relatively cautious liquidity management policy, allowing them to withstand sharp fluctuations in this indicator.

For the normality test of our data related to the liquidity risk, we focus on the Jarque-Bera test. From the above table, we find that the Jarque-Bera test statistic for the banks under study had a p-value greater than 0.05, indicating that it is possible to proceed with testing the main hypotheses of the research by assuming that the liquidity risk ratio data follows a normal distribution for all the banks in the study sample.

3. Hypotheses Testing and Analysis (Building Mathematical and Statistical Models)

In our current study, the description of the econometric model (regression model) is as follows:

Independent Variable:

In this study, there will be one main independent variable (Financial Engineering Techniques) and three secondary independent variables: (Liquidity Index, Credit Index, and Operational Index), Based on the study variables, regression models can be constructed to represent these relationships within the current study, relying on the study hypotheses.

Dependent Variable:

In the current study, the main dependent variable will be (Risk Techniques), with three secondary dependent variables: (Liquidity Risk), which are influenced by a set of independent variables presented in the following context:

Main Hypothesis:

There is no statistically significant effect of financial engineering techniques on risk assessment in the sample banks during the period 2011–2023.

According to the econometric model, the independent variable (financial engineering techniques) affects the dependent variable (risk assessment techniques). After identifying the main components of this model, it can be

$$Yi = \beta_0 + \beta_1 Xi + Ui, \quad i = 1,2$$

mathematically formulated as follows:

Where:

Yi: Risk assessment (dependent variable)

β0: Constant term

β1: Marginal slope

Xi: Financial engineering technique (independent variable)

Ui: Random error term, which follows a normal distribution with a mean of zero and constant variance

Table (7) shows a strong negative correlation between the financial engineering techniques variable and the risk assessment variable, with a correlation coefficient (R) of -89.9%.

The same table indicates that the Adjusted R-squared value is 0.804, meaning that the independent variable explains 80.4% of the variation in the dependent variable. This implies that 19.6% of the variation is due to factors outside the scope of the study.

Furthermore, Table (7) shows a statistically significant inverse effect of the independent variable on the dependent variable, as demonstrated by the t-test, which recorded a value of -2.32211 with a p-value of 4%. This finding is further supported by the F-test, which yielded a value of 12.48148 with a p-value of 4%, These results lead to the rejection of the main hypothesis that claims no statistically significant effect of financial engineering techniques on risk assessment. Instead, we accept the alternative hypothesis, which confirms the existence of a statistically significant inverse effect — meaning that an increase of one unit in financial engineering techniques leads to a decrease of one unit in risk assessment.

The regression equation based on the estimated model can be described as:

Yi = 0.673432 - 0.483001 * Xi - 0.345124 * U(-1)

Looking at the estimated values in the equation, it is evident that the financial engineering variable (Xi) has an impact on the risk assessment variable (Yi) in both the short and long term,To test for normal distribution, the Jarque-Bera test was used. Based on Figure (1) and the previous discussion on data description and analysis, the p-value for the Jarque-Bera test was 0.422073, which is greater than 0.05. Therefore, the test and analysis are accepted under the assumption that the residuals follow a normal distribution.

Table (7): Regression coefficients of the financial engineering techniques variable on the risk assessment variable

Dependent Variable:Yi				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.673432	0.877673	0.767292	0.8434
Xi	-0.483001	0.208524	-2.32211	0.0404
R	-89.6%			
R-squared	0.873963			
Adjusted R-squared	0.803942			
F-statistic	12.48148			
Prob(F-statistic)	0.0404			

Figure (1) the residual distribution of the model illustrating the impact of financial engineering techniques on risk techniques.

First Sub-Hypothesis:

There is no statistically significant effect of the liquidity index, as a financial engineering technique, on liquidity risk in the sample banks during the period 2011–2023.

According to the econometric model, the liquidity index variable represents the independent variable that affects the liquidity risk variable. After defining the main components of this model, it can be mathematically expressed as

$$= Y1\beta_0 + \beta_1 i=1,2 \quad X1+Ui,+$$

follows:
Where:
Y_1: Liquidity risk (dependent variable)
β_0: Constant term
β1: Marginal slope
X_1: Liquidity index (independent variable)
Ui: Random error term, which follows a normal distribution with a mean of zero and constant variance
Table (8) shows a strong negative correlation between the liquidity index variable and the liquidity risk variable, with a correlation coefficient (R) of -70.3%, Moreover, Table (8) shows that the Adjusted R-squared value is 0.495, indicating that the independent variable explains 49.5% of the variation in the dependent variable. This implies that 50.5% of the variation is due to external factors not included in the study.

Furthermore, the table demonstrates a statistically significant inverse relationship between the independent variable and the dependent variable, as evidenced by the t-test result of -2.985440 with a p-value of 1%. This is further supported by the F-test result of 11.3152 with a p-value of 1%, indicating the rejection of the first sub-hypothesis that claims no statistically significant effect of the liquidity index (as a financial engineering technique) on liquidity risk in the sample banks during the period 2011–2023, and the acceptance of the alternative hypothesis that confirms such an effect.

The regression equation based on the estimated model is:
$Y_1 = -54.31595 – 0.0000102 * X_1 – 22659.11 * U(-1)$

By examining the estimated values in the equation, we observe that X_1 (liquidity index) plays a role in both the short and long term impact on Y_1 (liquidity risk), To test for normality, we rely on the Jarque-Bera test. As shown in Figure (2) and discussed in the previous section on data description and analysis, the p-value of the Jarque-Bera test is 0.687397, which is greater than 0.05. Thus, we accept the test result and confirm the assumption of the main hypothesis that the residuals are normally distributed.

Table (8): Regression coefficients of the liquidity index variable on the liquidity risk variable

Dependent Variable:Y1				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
X1	-0.0000102	3.43E-06	-2.985440	0.0124
R	-70.3%			
R-squared	0.534239			
Adjusted R-squared	0.494532			
F-statistic	11.3152	Durbin-Watson stat		1.111019
Prob(F-statistic)	0.0124			

Figure (2) the residual distribution of the model illustrating the impact of the liquidity index on liquidity ris

Second Sub-Hypothesis:

There is no statistically significant effect of the credit index, as a financial engineering technique, on liquidity risk in the sample banks during the period 2011–2023.

According to the econometric model, the credit index variable represents the independent variable that affects the

$$=Y2\beta_0+\beta_1 i=1,2\ \ X2+Ui,$$

liquidity risk variable. After identifying the main components of this model, it can be mathematically expressed as follows:
Where:
Y2: Liquidity risk (dependent variable)
β_0: Constant term
β_1: Marginal slope
X2: Credit index (independent variable)
Ui: Random error term, which follows a normal distribution with a mean equal to zero and a constant variance
To identify and test the effect of the relationship between the credit index variable (as the independent variable) and the liquidity risk (dependent variable), refer to the table below.

Table (9) shows a strong negative correlation between the credit index and liquidity risk, with a correlation coefficient (R) of -83%. Furthermore, Table (9) reports an Adjusted R-squared value of 0.69, meaning that the independent variable explains 69% of the variance in the dependent variable, while 31% is attributed to external factors not covered by the research.

The table also indicates a statistically significant inverse relationship between the independent and dependent variables, as shown by the t-test result of -4.115883 with a p-value of 0.0003. This is further supported by the F-test

result of 8.013429 with the same p-value of 0.0003, indicating the rejection of the Second sub-hypothesis that posited no statistically significant effect of the credit index (as a financial engineering technique) on liquidity risk. The alternative hypothesis, which confirms the existence of such an effect, is therefore accepted.
The regression equation of the estimated model is as follows:
Y2 = 32.12648 – 17.12881 * X2 – 0.26741 * U(-1)

From the estimated values in the equation, it is clear that X2 (credit index as a financial engineering technique) has both short-term and long-term effects on Y2 (liquidity risk as a financial risk technique), To test for the normal distribution of residuals, the Jarque-Bera test was used. As shown in Figure (3) and discussed previously in the data description and analysis section, the Jarque-Bera test result had a p-value of 0.129080, which is greater than 0.05. Thus, the null hypothesis that the residuals follow a normal distribution is accepted.

Table (9) Regression coefficients of the credit index on the liquidity risk variable

Dependent Variable: Y2				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
X2	-17.12881	4.161641	-4.115883	0.**000**3
R	-83%			
R-squared	0.7**23732**			
Adjusted R-squared	0.6**88564**			
F-statistic	8.013429	Durbin-Watson stat		2.41532
Prob(F-statistic)	0.0003			

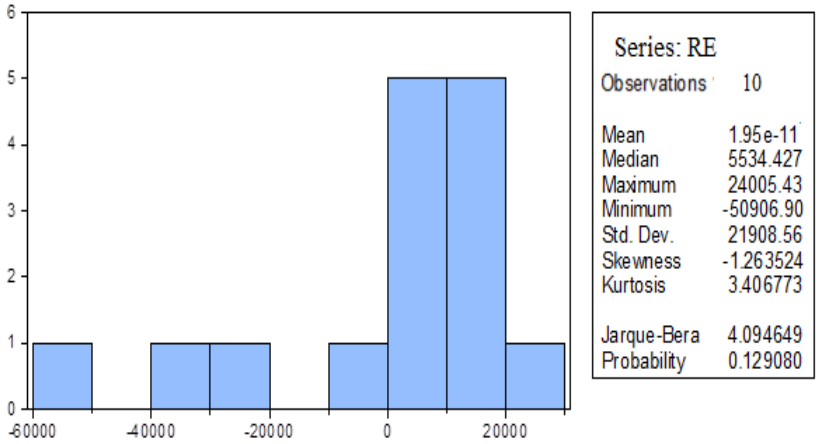

Figure (3) the residual distribution of the model illustrating the impact of the credit index on liquidity risk

Third Sub-Hypothesis:

There is no statistically significant effect of the operating index, as a financial engineering technique, on liquidity risk in the sample banks during the period 2011–2023.

According to the econometric model, the operating index represents the independent variable that affects the liquidity

$$=Y3\beta +\beta \ i=1.2 \ , X3+Ui$$

risk variable. After identifying the main components of this model, it can be mathematically formulated as follows

Where:
Y3: Liquidity risk (dependent variable)
β_0: Constant term
β1: Marginal slope
X3: Operating index (independent variable)
Ui: Random error term, which follows a normal distribution with a mean equal to zero and constant variance

To identify and test the effect of the relationship between the operating index variable (as an independent variable) and the liquidity risk (dependent variable), refer to the table below.

Table (10) shows a strong negative correlation between the operating index and liquidity risk, with a correlation coefficient (R) of -89%. Furthermore, Table (10) reports an Adjusted R-squared value of 0.79, indicating that the independent variable explains 79% of the variance in the dependent variable, while the remaining 21% is due to external factors not included in the research.

The table also shows a statistically significant inverse relationship between the independent and dependent variables, demonstrated by the t-test value of -3.593384 with a p-value of 0.0049. This result is further supported by the F-test value of 15.06531, also with a p-value of 0.0049. These findings lead to the rejection of the Third sub-hypothesis, which posited that there is no statistically significant effect of the operating index (as a financial engineering technique) on liquidity risk. The alternative hypothesis, asserting the existence of such an effect, is therefore accepted.

The regression equation of the estimated model is:

Y3 = 0.019486 – 0.000740 * X3 – 0.185936 * U(-1)

From the estimated values in the equation, it is evident that X3 (operating index as a financial engineering technique) has both short-term and long-term effects on Y3 (liquidity risk as a financial risk measure), To test the normal distribution of the residuals, the Jarque-Bera test was applied. As shown in Figure (4) and discussed earlier in the data description and analysis section, the Jarque-Bera test yielded a p-value of 0.935347, which is greater than 0.05. Therefore, the null hypothesis that the residuals follow a normal distribution is accepted.

Table (10): Regression coefficients of the operating index on the liquidity risk variable

Dependent Variable : Y3				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
X3	-0.000740	0.001247	-3.59338	0.0049
R	-89%			
R-squared	0.821233			
Adjusted R-squared	0.793321			
F-statistic	15.06531	Durbin-Watson stat		2.465424
Prob(F-statistic)	0.0049			

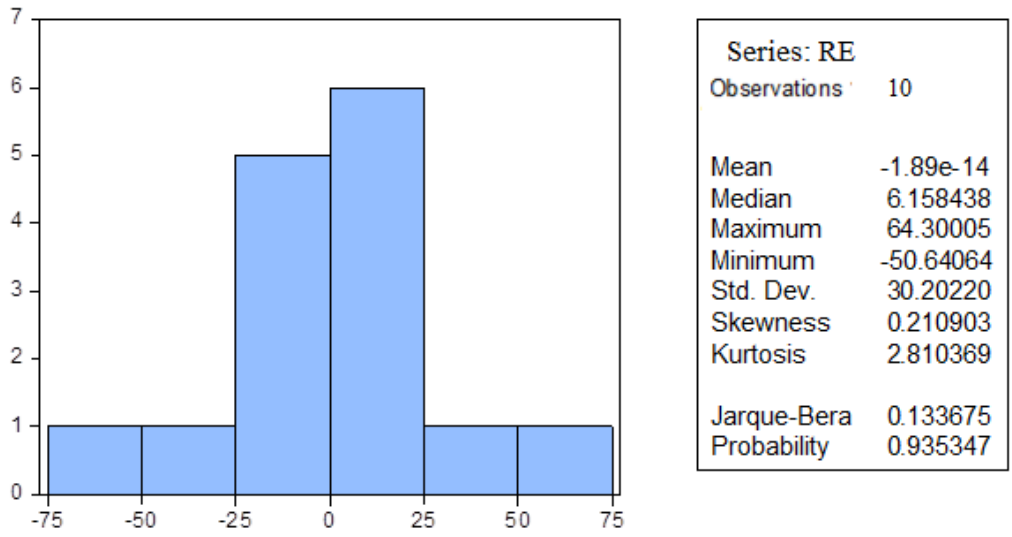

Figure (4) shows the residual distribution of the model illustrating the impact of the operational index on liquidity risk

Conclusions

1. The data distribution is normal, which confirms the validity of the statistical and financial analysis and the research hypotheses.
2. There is a strong negative correlation between financial engineering techniques as an independent variable and liquidity risk assessment as a dependent variable, meaning that an increase of one unit in financial engineering techniques leads to a decrease of one unit in liquidity risk.
3. There is a statistically significant strong negative effect of financial engineering techniques on liquidity risk assessment.
4. An increase of one unit in the technique represented by the liquidity indicator leads to a decrease of one unit in liquidity risk, as shown by the correlation between the two variables and the significant effect of the independent variable on the dependent variable.
5. An increase of one unit in the technique represented by the credit indicator leads to a decrease of one unit in liquidity risk, as shown by the correlation between the two variables and the significant effect of the independent variable on the dependent variable.
6. An increase of one unit in the technique represented by the operational indicator leads to a decrease of one unit in liquidity risk, as shown by the correlation between the two variables and the significant effect of the independent variable on the dependent variable.

Recommendations

1. The importance of continuously updating information and reports published in the Iraq Stock Exchange lies in the need to ensure they reach all investors.
2. The risk management department in the bank must strike a balance between the costs associated with managing these risks. Banks should also establish risk limits through policies, standards, and procedures that clarify responsibilities and authorities.
3. It is essential to establish rules for financial engineering and financial risk management and define their boundaries so that the bank can effectively benefit from their tools and products.
4. Increasing efforts in communication enhances customers 'and the general public's trust in the bank's services. This, in turn, provides protection against risks and contributes to the growth of the portfolio and deposit volume.
5. Delving deeper into financial engineering techniques related to risk management, integrating and developing them in line with banking activities, provides tools that help accelerate growth and prosperity, thereby enhancing global trust in them.
6. Focus on original financial products and avoid imitating traditional banking products.

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