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Optimization of Bank Liquidity Management using Goal Programming and Fuzzy AHP

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Abstract

In this research, Goal Programming (GP) and Fuzzy Analytic Hierarchy Process (FAHP) were integrated. The financial objectives of Parsian Bank (a leading private bank in Iran) were identified and prioritized. An optimal liquidity management model incorporating the following objectives was devised; capital sufficiency, liquidity risk, liquidity ratio, claims from other banks, investments portfolio, total consumption to total resources ratio, growth of total assets, fixed assets and other assets. Afterwards, the goal and structural limitations of variables were taken consideration and finally, the optimal liquidity management model was estimated. Then, by using the input variables (the liabilities side in the balance sheet and the related subsets) and the outputs (the assets side in the balance sheet and their subsets) in the period of 2011-2012, the optimal values for liquidity ratios and other items in the balance sheet were calculated using Lingo software. They were then compared with real values in the balance sheet accordingly. Next, the solutions and suggestions were offered for optimizing liquidity management in the bank. The eight objectives used for the preparation of optimal liquidity model were prioritized using the viewpoints of senior financial directors of the bank with the emphasis on a questionnaire, which was designed based on the FAHP method. Furthermore, in order to test the estimated model and assess its efficacy, the total return of the bank (R) was calculated once using the real items in the balance sheet, and another time using the values obtained from the model as well as the return formula (both for the period of 2011-2012). The results demonstrateda noticeable increase in the return of the estimated model in comparison with the real return of the bank. In addition, it should be stated that the estimated model can diminish the liquidity risk and increase the growth of the total assets of Parsian Bank, which evidently presents the reliability, validity, and application of the estimated liquidity management model for the banking system.

Keywords: Optimization, liquidity management, ratios, fuzzy AHP, goal programming.

Introduction

Liquidity risk is the risk due to lack of sufficient liquidity to cover short-term obligations and unexpected outflow of funds .This risk Includes both asset liquidity and funding liquidity risk[1]. “Liquidity Management” is the ability of forecasting of bank’s liquidity in different time periods and financing these needs by minimizing the costs. Similar to other fields of management, liquidity management is based on the comparison between risk and productivity[2].

Depositing more liquidity may result in decreasing the risk in the banks. However, the banks may lose the chance of investment and ended up to deduction of the productivity of resources. In addition, it is worthwhile to mention that smart liquidity management can help banks to reach the liquidity safe harbor and enable them to satisfy the liquidity needs of their depositor clients or the clients receiving facilities timely and with no error[3].

Credit institutions usually convert their short-term liquid liabilities to long-term non-liquid assets. Although this conversion enables banks to protect their customers against liquidity problems, it also exposes the banks to liquidity risks. This unfavorable situation highlights the importance of liquidity management[4]. In other words, liquidity management means to assure that the bank is capable of fulfilling its contractual obligations. In fact, liquidity management presents the bank’s ability to optimally manage the decreases in deposits and other debts, while managing the growth of loans portfolio, other assets, and other items out of the balance sheet. Consequently, the bank can compensate the deficiencies in its liquidity at an acceptable expense in the quickest possible time[5].

This paper is an attempt to propose a model for optimizing liquidity management with GP perspective and integrating GP with FAHP. A variety of efforts have been undertaken to employ this model to estimate the optimal values of important liquidity ratios, the balance sheet items, and different items in financial statements of the bank.

Review of Literature: Liquidity Optimization Models: In an optimization problem, we assume that all the parameters associated with the decision variables in the objective function or in constraint set are known and we need to find an optimal solution to it[6]. An overview of the most important liquidity optimization and measurement models in financial systems especially banks have been provided in the following:

Baumol Maturity Model: Baumol used the economic order quantity in certain conditions. In uncertain situations where cash payment is high, this model may not be used and other models should be employed instead[7].

Miller and Orr Model: This model controls the limits. To explain more, when the cash reaches its high limit, cash will be converted to negotiable instruments. On the other side, when the cash reaches the low limit, the conversion of negotiable instruments into cash will be set off. Therefore, when the cash level is positioned between the two limits, no transfer will be made[8].

Stone Model: This model considers the present cash position as well as the cash position in the coming days[9].

Demand for Bank Money: This model presupposes that the cash (central bank instruments) and bank money (bank deposits) cannot be substituted. Thus, two demand functions (one for cash and one for bank money) should be defined[10].

Bank Profit Maximization with Reserve Maintenance Presupposition: This model presupposes that the bank is not involved in any optimization challenge other than the profit modeling. According to this model, the bank can eliminate uncertainties and provide certain conditions[10].

Profit Maximization for Definite Capital Values: The aim of this model is to maximize profit with regard to the available capital along with the constraints imposed by policymakers[10].

Money Management Model: This is a framework for asset allocation. The goal function of this model is a geometric mean of holding period returns.

Goal Programming in Capital Budgeting: This model is designed to determine and satisfy the goals of a firm in selecting capital projects. However, considering the special type of the model, a method for determination of liquidity from the inventory perspective has been proposed[11].

Related Research: In some studies, GP has been used alongside simulation analysis. In some other, Fuzzy GP has been utilized [12]. In several studies, non-linier GP has been applied for managing assets and liabilities[13]. In some others, a combination of GP and AHP has been employed[14].

Table-1
Several previous related researches

Authors and Year	Subject	Results
Pokutta Schmaltz[15] 2010	Managing liquidity: Optimal degree of centralization	They show that volatility is the key driver behind (de-) centralization and provide an analytical solution for the 2-branch model and show that liquidity center can be interpreted as an option of immediate liquidity. Finally, they show that the n-branch model for real-world banking groups can be solved with high granularity within less than 30 seconds.
Rochet Villeneuve[16] 2011	Liquidity management and corporate demand for hedging and insurance	They find that the patterns of insurance and hedging decisions are pole apart: cash-poor firms should hedge but not insure, whilst the opposite is true for cash rich firms. They also find non-monotonic effects of profitability. This may explain the mixed detections of empirical studies on corporate demand for hedging and insurance.
Sawada[17] 2010	Liquidity risk and bank portfolio management in a financial system without deposit insurance: Empirical evidence from Prewar Japan	They found that banks reacted to the liquidity shock sensitively through an increase in their cash holdings not by liquidating bank loans but by selling securities in the financial market. Therewith, banks subjected to local financial contagion adjusted the liquidity of their portfolio mainly by actively selling and buying their securities in the financial market. Finally, there is no evidence to conclude that the existence of the lender of last resort mitigated the liquidity constraints in bank portfolio adjustments.
Merrouche Schanz[18] 2010	Banks' intraday liquidity management during operational outages: Theory and evidence from the UK payment system	Using a non-parametric method, we find that this prediction is supported by data, implying that banks effectively contain the disruption caused by the operational outage: payment flows between healthy banks remain unaffected.
Cornett McNutt Strahan Tehranian[19] 2011	Liquidity risk management and credit supply in the financial crisis	They conclude that efforts to manage the liquidity crisis by banks led to a decline in credit supply.

Authors and Year	**Subject**	**Results**
Demiroglu James[20] 2011	The use of bank lines of credit in corporate liquidity management: A review of empirical evidence	This Recent empirical research offered that access to lines of credit is contingent on the credit quality of the borrower as well as the financial condition of the lender. These findings suggest that lines of credit are an imperfect substitute for cash as a source of corporate liquidity.
Bech Garrarr[21] 2002	The intraday liquidity management game	They use a game theoretical framework to analyze the intraday behavior of banks with respect to settlement of interbank claims in a real-time gross settlement setting. Banks are risk neutral, but they show that most of the results are unaffected by risk aversion.

Overall, no study based on a combination of AHP and GP was found in the literature.

Review of Fuzzy Numbers and Fuzzy AHP: Fuzzy numbers: Fuzzy numbers are in fact natural generalizations of ordinary numbers. An ordinary number like $\ddot{a}$ can be shown with the following membership function:

$$\mu_{\ddot{a}}(x) = \begin{cases} 1 & ; if x = a \\ 0 & ; if x \neq a \end{cases}$$

Therefore, any real number can be stated as a fuzzy number. The simplest fuzzy numbers are triangular fuzzy numbers [22].

We define a fuzzy number M on R to be a triangular fuzzy number, if its membership function $\mu_{\ddot{a}}(x): R \to [0\,,1]$ is equal to:

$$\mu_{\ddot{a}}(x) = \begin{cases} \frac{x}{m-l} - \frac{l}{m-l}, & x \in [l, m] \\ \frac{x}{m-u} - \frac{u}{m-u}, & x \in [m, u] \\ 0 & otherwise \end{cases},$$

The triangular fuzzy numbers can be expressed by (l, m, u). The parameters l, m, and u respectively indicate the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event.

There are various operations on triangular fuzzy numbers. But here, the two important operations used in this study are illustrated. If we define, two positive triangular fuzzy numbers (l_1, m_1, u_1) and (l_2, m_2, u_2), then:

$$(l_1, m_1, u_1) \cdot (l_2, m_2, u_2) = (l_1.l_2, m_1.m_2, u_1.u_2)$$
$$(l_1, m_1, u_1)^{-1} \approx \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right)$$

Fuzzy AHP: AHP is one of the well-known multivariate decision making methods invented by Saaty in 1970s. Indices may be qualitative or quantitative. AHP is based on pair wise comparisons in which decision-maker forms a hierarchical decision tree and defines its indicators and choices. Then, she makes some pair wise comparisons and determines the weight of each factor in comparison with rival ones[23].

The traditional AHP method is problematic because it uses the exact value to express the decision maker's opinion in a comparison of alternatives[24]. AHP method is often criticized due to the application of unbalanced scale of judgments and its inability to appropriately handle the inherent uncertainty and imprecision in the pairwise comparison process[25]. To overcome all these shortcomings, FAHP was developed for solving the hierarchical problems. Decision-makers usually find it more confident to give interval judgments rather than fixed value judgments[26].

In this study, the extent FAHP is utilized which was originally introduced by Chang. Let X = {x1,x2,x3, ... , xn} an object set, and G={g1 , g2 , g3 , ... , gn} be a goal set. According to the procedure of Chang's extent analysis, each object is taken and extent analysis for each objective is performed respectively. Thus, extent analysis values for each object can be obtained, with the following signs:

$$M_{gi}^{i}, M_{gi}^{2}, M_{gi}^{3}, \ldots, M_{gi}^{m} \quad , \quad i = 1,2,3, \ldots, n$$

Where $M_{gi}^{j}(j = 1,2, \ldots, m)$ all are Triangular fuzzy numbers. The steps of Chang's extent analysis[27] (can be given as follows: Step 1. With respect to the its object, the value of fuzzy synthetic extent is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \cdot [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}]^{-1}$$

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$, the fuzzy addition operation of m extent analysis values for a particular matrix is performed as follows:

$$\sum_{j=1}^{m} M_{gi}^{j} = (\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j)$$

And to obtain $[\sum_{j=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}]^{-1}$, the fuzzy addition operation of $M_{gi}^{j}(j = 1,2,3, \ldots, m)$ values is performed such as

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} \mathrm{m_i}, \sum_{i=1}^{n} \mathrm{u_i}\right)$$

Step 2. As $\mathrm{M_1 = (l_1, m_1, u_1)}$ and $\mathrm{M_2 = (l_2, m_2, u_2)}$are two triangular fuzzy numbers, the degree of possibility of $\mathrm{M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)}$ is defined as

$$V(M_2 \geq M_1) = \begin{cases} 1 & if m_2 \geq m_1 \\ 0 & if l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_1) - (m_2 - l_1)} otherwise & \end{cases}$$

Figure-1 illustrates equation-10 where d is the ordinate of the highest intersection point D between µMl and µM1. To compare M1 and M2, we need both the values of V(M1 ≥ M2) and V(M2 ≥ M1)[26].

Step-3. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy Mi (i = 1,2, ..., k) numbers can be defined by:

V(M ≥ M1, M2, …, MK)=V[(M ≥ M1) and (M ≥ M2) and (M ≥ MK)]= Min V(M ≥ Mi) , i= 1,2,3,…, k Assume that d(Ai) = min V(Si ≥ Sk) for k =1, 2, ... ,n; k ≠ i. Then the weight vector is given by $W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T$

where A i (i =1, 2, ... , n) are n elements.

Step 4. Via normalization, the normalized weight vectors are:
$W = (d(A_1), d(A_2), \ldots, d(A_n))^T$
where W is a non-fuzzy number.

Research Methodology

In this research, GP is integrated with multi-criteria fuzzy decision-making methods in order to optimize liquidity management. First, all the inputs and outputs of the cash management system were identified and determined. Then, the bank's resources, consumption plans, and financial statements (including the balance sheet, profit and loss account, and cash flow statements) were reviewed. Moreover, important financial ratios affecting liquidity system were identified with regard to the experiences of other banks and the opinions obtained from bank financial experts. Subsequently, they were prioritized based on their importance using FAHP.

All the liquidity system inputs and outputs were identified using the bank's resources and consumption tables. Then, the goal and systemic limitations of the model were defined.

Interviews with senior financial managers of banks showed 7 overall objectives for optimization of liquidity management. These objectives were presented to financial managers of Parsian Bank. Risk manager, financial manager, and their subordinates were interviewed and 8 specific objectives were extracted for Parsian Bank. Major objectives of Parsian Bank for liquidity management optimization included: capital sufficiency, liquidity risk, liquidity ratio, claims from other banks, investments portfolio, consumptions to resources ratio, total assets growth, fixed assets and other assets.

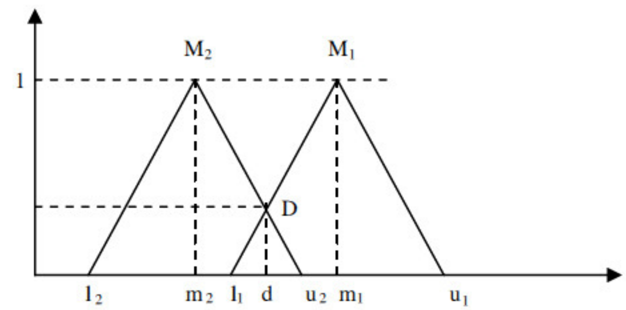

Figure-1
The intersection between two triangular fuzzy numbers (M_1 and M_2)

The above 8 objectives are not of equal importance for the bank. Therefore, by using AHP, the objectives are given coefficients. The outputs are determined in proportion with the importance of objectives. Suppose that the goal function of the GP for liquidity management is:

$$\min z = \sum_{r=1}^{m}\sum_{k=1}^{n} a_r (w_{kr} d^{+}, w_{kr} d^{-})$$

W_i is the weight of objective and di is the positive or negative deviation from the objective.

Therefore, a questionnaire was designed using AHP method and the weights of the 8 objectives were estimated.

As mentioned above, all the objectives are not equally important for the bank and some of the objectives surpass the others in importance for the bank. Thus, all the objectives cannot have coefficient 1 and AHP method should be employed in order to optimally prioritize the 8 objectives.

GP function calculates the outputs and optimal values for the balance sheet. Therefore, the most important objectives of the bank were estimated as the objectives of the bank can be different or even contradictory. Therefore, the two contrary objectives may not be met. Thus, for calculating the outputs, it should be recognized that which of the two contrary objectives will be estimated and this is possible through giving the weights to the objectives.

Research Model: GP models consists of three parts. Decision variables (model inputs and outputs), objectives, and limitations. In this section, decision variables, objectives, and limitations of GP model of liquidity management in Parsian Bank are studied.

Identification of Objectives: In linear programming and GP models, the objective(s) of the decision-maker in terms of optimization are to be identified from the decision-makers point of view. Afterwards, the importance coefficient of each objective should be determined as GP estimates the objectives in sequence proportion with their importance. In other words, GP optimizes decision variables and model outputs, and hence, the most important objectives can be estimated in the first place. Sometimes some of the objectives may be contradictory and the model may fail in estimating them simultaneously. Thus, the most important ones were recognized. In this research, the objectives of the bank's management for liquidity optimization were determined through several interviews. As already disclosed, the objectives include capital sufficiency, liquidity risk, liquidity ratio, claims from other banks, investments portfolio, total consumption to total resources ratio, growth of total assets, fixed assets and other assets.

Model Decision Variables: Having devised the model's objective function, decision variables and the model's limitations should be determined. With regard to the balance sheet structure, the following definitions were declared for decision variables (the model's input and output variables).

Deviation from goal (d_i): Di in a GP model shows the limit in achieving goals. Since the principal goal of the GP model is to minimize the deviation, when the deviation is minimized, the goal achievement can be maximized accordingly.

Thus, deviations are determined based on the limits with respect to the objective function. In this model, both positive and negative deviations are considered within the limits of the model, for any allocation of sums to any of the items. Therefore, it should be expressed that in the objective function, either the positive or the negative deviation or even both can be taken into account as the desirable goal.

Using deviations in the objective function is dependent on the desires and interests of the designer or users of the model. If someone wants to reach a certain level of the goal (not less nor more), then one should take both positive and negative deviations. Thus, the second group of decision variables includes positive and negative deviations.

Limitations: The required limitations for determination of the composition of the balance sheet items are presented in two groups: obligatory limitations (structural or systemic) and goal limitations. Obligatory limitations are stated in the form of limitations with higher and lower limits. Goal limitations are expressed with positive or negative deviations from the goal. The main objective function exhibits the deviation from the objectives and is dependent on the type of the objective, which defines the decrease in positive, negative, or both deviations.

The model has 29 limitations, 21 of which are structural (related to the structure of the balance sheet) and 8 are goal limitations (related to the selected goals).

Table-2
The first group of the model's input, output, and decision variables

Assets	**Xi**	**Liabilities and Equities**	**Yi**
Cash	X_1	Debts to Central Bank	Y_1
Securities	X_2	Debts to other banks and credit institutions	Y_2
Legal Reserve with Central Bank Ratio	X_3	Demand deposits	Y_3
Deposits with other banks	X_4	Investment deposits	Y_4
Short-term investments	X_5	Other deposits	Y_5
Credits granted and claims	X_6	Dividends	Y_6
Claims and down payments	X_7	Other payable accounts	Y_7
Long-term investments	X_8	Tax reserve and severance compensation	Y_8
Tangible fixed assets	X_9	Total equities	Y_9
Intangible assets and other assets	X_{10}	-	-
Below-the-line items	X_{11}	-	-
Obligations for guarantees	X_{12}	-	-

Source: The balance sheet and financial statements of Parsian Bank

Table-3
The second group of model decision variables

Determined goals	**Di^+**	**di^-**
Capital sufficiency	d_1^+	d_1^-
Liquidity risk	d_2^+	d_2^-
Liquidity ratio	d_3^+	d_3^-
Claims from other banks and credit institutions	d_4^+	d_4^-
Investments portfolio	d_5^+	d_5^-
Total consumption to total resources ratio	d_6^+	d_6^-
Total growth of assets	d_7^+	d_7^-
Fixed assets and other assets	d_8^+	d_8^-

In addition, the model has 37 decision variables, including 21 principal variables (related to balance sheet items) and 16 deviation variables (8 positive deviations and 8 negative deviations). The limitations of the model were uncovered by using the interviews with senior bank managers added to the obligations prescribed by the central bank, and the relationships between the balance sheet and financial statements items with those of previous years. They are pointed numerically in the model presentation section.

The model's structural (systemic) limitations: The structural limitations are related to the ratios of the balance sheet items, financial ratios, and liquidity that play significant roles in model estimation. These limitations were extracted from the obligations prescribed by the Central Bank, the structure of Parsian Bank, and the results obtained from the questionnaire and interviews. It is worthwhile to mention that the model has 22 structural limitations.

In fact, the model's target has been to obtain the optimal values for the assets-side variables (cash, short-term and long-term investments, securities, credits grant, etc.) with regard to the real values of the liabilities-side variables (such as the types of deposit). The values obtained from the model and software determine whether the credits that were granted lately, or the case that was maintained by the bank, or the amount of claims and down payments, or the amount of short-term and long-term investments, or the amount of fixed assets and other assets, in the balance sheet are optimal or not; and if not, how far they are away from the optimal values.

Overall, the final return of the bank is calculated in two forms. The real values of the balance sheet and the optimal values extracted from the model will be calculated and compared accordingly. The final return will be a helpful benchmark to evaluate the efficacy of the model.

Results and Discussion

Model Estimation and Results: Results of FAHP: Based on the FAHP algorithm and with the aid of Excel software, the available options were prioritized as follow:

First priority	Liquidity risk with a coefficient of 0.288
Second priority	Capital sufficiency with a coefficient of 0.243
Third priority	Liquidity ratio with a coefficient of 0.190
Fourth priority	Total consumptions to total resources ratio with a coefficient of 0.104
Fifth priority	Total growth of assets with a coefficient of 0.062
Sixth priority	Investments portfolio with a coefficient of 0.049
Seventh priority	Claims from other banks with a coefficient of 0.040
Eighth priority	Fixed assets and other assets with a coefficient of 0.025

In this section, the overall GP model for achieving the research objectives is formed. First, the model's limitations including the goal and structural limitations are presented in parametric and numerical forms. Then, the model's objective function will be presented using the coefficients of ratios and objectives, which were identified to optimize liquidity management in parametric and numerical forms. At last, when the model is absolutely devised, the model components will be entered in Lingo software and the optimized ratios and outputs will be achieved.

GP Model Estimation: The final model is as shown here: $Min z = 0.228d_2^- + 0.243d_1^- + 0.190d_3^+ + 0.104d_6^- + 0.062d_7^- + 0.049d_5^- + 0.040d_4^+ + 0.025d_8^-$

S.T: $x_1 \geq 0.007(y_3 + y_4 + y_5)$ Limitation of the bank's cash reserve

$x_2 \geq 0.003(y_3 + y_4 + y_5)$ Limitation of securities

$x_2 \leq 0.01(y_3 + y_4 + y_5)$

$x_3 = 0.17(y_1 + y_2 + y_3 + y_4 + y_5 + y_6 + y_7 + y_8 + y_9)$ Limitation of the statutory reserve ratio

$x_4 \geq 0.03(y_3 + y_4 + y_5)$ Limitation of the investments or claims from other banks

$x_5 = 0.02(y_3 + y_4 + y_5)$ Limitation of short-term investments

$x_6 \leq 0.8(y_3 + y_4 + y_5)$ Limitation of the credits granted and claims

$x_6 \geq 0.7(y_3 + y_4 + y_5)$

$x_7 \geq 0.12x_6$ Limitation of claims and down payments

$x_8 = 0.08(y_3 + y_4 + y_5)$ Limitation of long-term investments

$x_9 \geq 0.01(y_3 + y_4 + y_5))$Limitation of tangible fixed assets and intangible assets

$x_{10} \geq 0.06(y_3 + y_4 + y_5)$ Limitation of other assets

$x_{11} \leq 0.3(y_3 + y_4 + y_5) + y_{10} + 0.1x_1$Limitation of below-the-line items of the balance sheet

$0.16x_2 + 0.25x_5 + 0.2x_6 + 0.2x_8 + 0.02x_{12} - 0.17y_4 - 0.015(x_6 - 98456043) - 0.01(y_3 + y_4 + y_5) = R$ Limitation of total return

$y_1 = 4321283$ Limitation of debt to the Central Bank

$y_2 = 4706522$ Limitation of debt to banks and other credit institutions

$y_3 = 7231139$ Limitation of demand deposits

$y_4 = 151677644$ Limitation of investment deposits

$y_5 = 3100670$ Limitation of other deposits

$y_6 = 0.8R$ Limitation of dividends

$y_7 = 7061700$ Limitation of other accounts payable

$y_8 = 612431$ Limitation of tax reserve

$y_9 = 52941$ Limitation of staff severance compensation

$y_{10} = 12897052$ Limitation of equities

$$\sum_{i=1}^{5} x_i - 0.37\sum_{j=3}^{5} y_j + d_1^- + d_1^+ = 0$$
$$y_{10} - 0.08(x_2 + 0.2x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + 0.2x_{11}) + d_2^- + d_2^+ = 0$$
$$\sum_{i=1}^{5} x_i + x_7 + x_8 - 0.05\sum_{j=1}^{5} y_j + d_3^- + d_3^+ = 0$$
$$\sum_{i=1}^{11} x_i - 0.7\sum_{j=1}^{10} y_j + d_4^- + d_4^+ = 0$$
$$\sum_{i=1}^{10} x_i - d_5^- + d_5^+ = 192233878$$
$$x_5 + x_8 - 0.3y_{10} + d_6^- - d_6^+ = 0$$
$$x_4 - 0.08(y_3 + y_4 + y_5) + d_7^- - d_7^+ = 0$$
$$x_9 + x_{10} - 0.3y_{10} + d_8^- - d_8^+ = 0$$

The values of variables obtained from the model are mentioned in the table-4 (retrieved form Lingo software):

Table-4
Values of the variables obtained from the model and those entered in the balance sheet in 2011 (values of in million Rials)

Variable	Title	Balance Sheet 2011	Model Results	Different between the Model Values and Balance Sheet Values
X1	Cash	4,065,625	3,209,661	-855,964
X2	Securities	55,000	103,878	+48,878
X3	Statutory reserve	24,487,164	28,321,098	+3,833,934
X4	Deposits with other banks	2,614,810	2,106,552	-508,258
X5	Short-term investments	162,454	229,668	+67,214
X6	Facilities granted	117,785,833	155,099,041	+37,313,208
X7	Claims and down payments	29,429,439	32,544,817	+3,115,378
X8	Long-term investments	2,307,459	2,665,913	+358,454
X9	Tangible fixed assets	3,024,267	2,870,437	-153,830
X10	Intangible assets and other assets	8,301,827	8,761,891	+460,064
Total assets		192,233,878	235,912,956	+43,679,078
X12	Securities	15,009,450	23,046,772	+8,037,322
Y1	Debt to the Central Bank	4,321,283	4,321,283	0
Y2	Debt to banks and institutions	4,706,522	4,706,522	0
Y3	Assets deposits	7,231,139	7,231,139	0
Y4	Investment deposits	151,677,644	151,677,644	0
Y5	Other deposits	3,100,670	3,100,670	0
Y6	Dividends	32,496	41,095	+8,599
Y7	Other accounts payable	7,601,700	7,601,700	0
Y8	Benefits reserve	612,431	612,431	0
Y9	Severance compensation reserve	52,941	52,941	0
Y10	Equities	12,897,052	12,897,052	0
Total of debts and rights		192,233,878	192,242,477	+8,599

Discussion: In liquidity management, the fluid or cashable assets are more likely to be converted to cash promptly. These assets are the banks' reserves to tackle any predictable and unpredictable economic fluctuation in balance sheet items. For example, when the financial markets are undeveloped and the claims can only be cashed on their maturity dates and there is no possibility for purchasing or selling them, it is suggested that the bank (especially in the bank under study) saves high amounts of cash in order to avoid paying the interest rates or prevent being paid less. In such conditions, the cashable assets can be approximately 10% (20% in critical situation) of the total assets of a bank.

Expansion of markets throughout the world and diversity of financial tools have offered a financial flexibility in liquidity management for short-term plans, which in turn have decreased the need to maintain high amounts of cashable assets. In the developed financial markets, banks only keep 5% of their total assets as cashable assets. Thus, studying the markets before any kind of transaction is a must, because in some periods some assets seem to be cashable but it may be hard in practice to cash them at other times. The main objective of keeping cashable assets is to ensure that the predicted financial flows can meet the demands appropriately at the planned time. This obligatory investment can decrease the financial flexibility and increase the expense of granted credits for economic sectors. As credit expense increases, the bank's financial risk level will increase consequently. In many countries, the growth of financial markets and the increase in investment portfolio generally reflex the growth of banks' tendency towards innovative operations. In such situations investment portfolio includes different securities tools. This orientation in risk management means to benefit from the replacement of credit risk in the market prices fluctuations.

As for the deposits, it can be said that deposits usually form a large portion of the bank's liabilities. Customers' deposits show the sums received from the public including savings, demand deposits, fixed deposits, deposits with former notification, and the deposits in foreign currencies. The structure and stability of deposits are the most important factors, which require serious considerations. The density, maturity, stability, and currency are the issues to be taken care of at the times it is needed to use these resources. The competition for equipping these resources is a normal issue in banks and most of the depositors including families and companies try to maximize the return of their sums. Thus, it is highly suggested that Parsian Bank deploys a viable strategy to absorb and maintain the deposits and adopt analytical procedures to study the orderliness, stability, and structure of deposits in order to use them in case it is needed to withdraw the resources.

Another suggestion can be the provision of resources through inter-bank loans. When the bank finds it difficult to meet the demands for immediate cash from the depositors and supply financial resources, it may take an inter-bank loan. However, these resources are usually short-term and are used only in financial crises. Using such resources is a critical alarm and can decrease the validity of the bank. The expenses and amounts of inter-bank loans are strongly dependent on the validity of the bank. Moreover, frequent utilization of such resources can harm the reputation of the bank. The higher the reputation of the bank is, the lower will be the expense to use these resources and the higher can be the amounts of loans. Using such sources usually decreases the relative stability of plans. Therefore, it is suggested that the bank should be cautious when using this tool.

The other suggestion is borrowing from the central bank. Borrowing from the central bank can be amongst the bank's liabilities. The most important reason for borrowing from the central bank is to increase the volume of cash reserves as a result ofthe fluctuations in deposits. This change may occur when banks fail to predict their daily reserve status correctly and in order to fill the gap, they are forced to borrow. In such cases, the banks are helped in provisional resources supply conditions. Getting long-term credit from the central bank shows the abnormal situation of the bank; thus, borrowing from the central bank should be completely planned in order to evade the significant negative consequences.

Conclusion

Several important notes have been spotted in the above table (including the real values and the values obtained based on the bank's objectives for liquidity management optimization), which can be summarized as follow:

Firstly, the real values of the balance sheet for liabilities and assets are formed based on the natural trend and tangible and experiential obligations. In contrast, the values allocated by the model are based on the major objectives of the bank, the importance coefficients, and prioritization of objectives according to the legal and structural obligations in addition to the model limitations. Thus, it can be summed up that they obtained values are more scientific and by taking them into consideration, the bank's managers can acquire useful insights to manage their liquidity efficiently. Moreover, in the estimated model, the majority of the liabilities side items in the balance sheet and those variables which values are out of the bank's control (such as types of investments and equities) are estimated as input variables of the model. On the other side, based on the values for a specific year, the objectives, obligations, goal and structural limitations, and the optimal values for the assets side items, which are mostly under the bank's control (such as cash, credits, claims from Central Bank and other banks, investments, fixed assets and other assets) are estimated as output variables.

Secondly, the total assets in the estimated model displays 18% growth in comparison with the real values in the balance sheet. The main reason for this difference and the difference in resource allocation is that the model primarily tries not to exceed the determined limits in supply necessities and meet all the objectives considering limitations and obligations.

Thirdly, less sums are allocated to such assets that have low returns but are obligatory, compared with the real values. These items include cash, claims from other banks, fixed assets, other assets, etc.

Furthermore, the items and assets with higher returns such as securities, credits, and investments are given more value than the real values.

Another important note that can be expressed as a merit of the estimated model is that the bank's model in the estimated form is higher than the real return of the bank and this can be definitely an asset for the bank to have.

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