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Asset-Liability Management (ALM) Following Liquidity Management Approach Based on Goal Programming in the Commercial Bank

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Abstract

Asset-liability management (ALM) helps managers achieve their respective objectives by surveilling and controlling the ways through which resources are obtained and allocated. Furthermore, with the help of liquidity management, which sets the required cash by banks for fulfilling costs and other needs (e.g. the cash requested by depositors), ALM controls the risk. In addition, ALM helps managers realize profitability and efficiency of the bank through the application of goal programming (GP) whereby multiple objectives are simultaneously considered when making decisions.

In the present research, upon collecting the required data and information, acquiring opinions of experts at a sample bank, and investigating balance sheet of the bank while considering respective constraints, orders of priority of objectives were determined. The results indicated consistency of some items in the balance sheet, such as cash inventory and liability to Central Bank with those set by the model. On the other hand, when it came to some other items, including receivables from the government and credited facilities to public sector, the observed growth was in line with that anticipated by the model. In the meantime, for most items of the balance sheet, including termed deposits and other deposits, investments, and joint activities, the model suggested variable yet positive growths; the growth was higher in demand deposits which are known as less expensive resources, indicating facts about Iranian banking system and Iranian economy where communities are making greater deals of effort to attract this sort of resource.

Keywords: Asset-Liability Management (ALM), Liquidity Management, Goal Programing (GP).

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Introduction

Since the dominant idea across banking industry turned from focusing on enlargement of the volume of bank balance sheets into considering rate of return on investment (ROI) and risk control, the knowledge of asset-liability management (ALM) has become a necessity for any banker (Dermin and Yousef, 2002:Prologue). ALM seeks to accomplish a set of objectives, as follows: liquidity management, interest rate and exchange rate risks management, observance of surveillance laws and regulations, improvement of the return on risk-taking, capital management, and funds transfer pricing (FTP) modeling. The very first objective of ALM is liquidity management which refers to financing business lines of the bank in case of any resource deficit, improving short-term and long-term costs, financing and ensuring security against liquidity risk (Adam, 2007:83-97).

ALM process of a bank should ensure making managerial decisions which end up creating value. Realized rate of return on bank equity or bank assets should be higher than anticipated rate of return by shareholders or shareholders' cost before value creation can be ensured (Eghtesad-e-Novin Bank, 2008:21). This constraint is, however, not observed in Iranian banking system. In fact, in the Iranian banking system, the large volume of non-current receivables, fixed assets and owned properties, as well as high interest rates can be taken as indications of inefficient ALM. Caring for proper combination of assets and liabilities in balance sheets of banks will not only continuously provide the banks with adequate levels of liquidity, but also keeps financing costs of the banks low enough to provide inexpensive resources for investors while bringing about benefits for their shareholders. As such, it is necessary to investigate the situation of ALM in Iranian banking system and its effects on profitability of banks.

The present research seeks to address the following questions: is optimal ALM in banking system capable of undertaking liquidity management while enhancing profitability at the same time? And is it feasible to find an optimal combination of assets and liabilities by which not only profitability of the bank is enhanced, but also statuary requirements set by the Central Bank and the Ministry of Economic Affairs and Finance are met? For this purpose, given the multi-objective nature of the aim followed by optimal ALM in the present research, a goal programming (GP) approach was followed. Goal programming is one of the most frequently applied techniques for ALM. Combining the sensitivity analysis with simulation tools, this technique presents a variety of optimal combinations for establishing a perspective of the best combinations of assets and liabilities, thereby outperforming similar techniques (Kosmidou and Zopounidis, 2004). The goal programming is a multi-criteria decision-making model in the scope of linear algebra. Taking into consideration multiple objectives at the same time, this model is adjusted based on minimization of the deviation from the objectives. The main advantage of the goal programming is that it accounts for the limitations and the goals along with the decision variables and eliminates, or at least attenuates the contribution of poor human reasoning into the planning and decision-making processes.

ALM unit originates from the history of insurance and banking industry. The financial crises in the 1980s and 1990s proved the importance of risk management in the process of decision-making by managers of financial institutions. During this period, executive directors of banks established and promoted risk management units. Following with this trend, ALM teams were developed with particular strategies, organization, and information systems (Adam, 2007:13-15).

ALM can be defined based on the objective it follows. On this basis, ALM seeks to harmonize financial decisions of a financial institution in such a way that structure of assets and liabilities of the institutions establishes an optimal level of risk and return within the framework of precautionary rules set forth by legislator (William *et al.*, 2015:4). According to another definition, ALM refers to the process of planning, organizing, and controlling the volumes of assets and liabilities, due dates, rates, and their return for minimizing the associated risk with interest rate while maintaining profitability at an acceptable level (Moni, 2003:295). Implementation of an internal FTP system constitutes the basis of ALM. Implementation of such system allows one to turn ALM into an independent profit center, which can trade resources among different branches of bank or take open or closed positions in capital market to not only cover liquidity gaps and interest rate, but also make some profit (Adam, 2007:61-82). In general, considering the ALM objectives and definitions, the followings can be pointed out as the main components of ALM: interest rate risk management, liquidity management, exchange rate risk management, FTP, and capital management and allocation.

In order for the components of ALM to be implemented properly, some conditions should be met previously. In the following, these conditions are described as necessary dimensions for ALM.

One of the infrastructural dimensions required for ALM in a financial institution is represented by structure and organization of the institution. In organizational structure of banks, ALM is often incorporated into risk management unit, treasury unit, or in some cases, budgeting unit. In early 1990s, ALM teams were used to be administered under financial or risk management units where statuary reports for regulatory authorities were prepared and hence information systems of the bank were managed. Nowadays, ALM units are principally independent from financial and risk management units in banks (Adam, 2007:83-97). Asset-liability committee (ALCO) serves as the beating heart of ALM organization. In large banks, ALCO may have a few sub-committees including main ALCO and secondary ALCOs, such as ALCO for business units and local ALCOs. Typically, ALCO is membered by the bank's CEO (or his/her representative), ALM unit manager, treasury unit manager, financial deputy, managers of the main business groups (corporate banking, commercial banking, etc.), and risk unit manager (Moorad, 2011:167-219; Adam, 2007:83-98). In one of the fundamental early definitions of the objectives of ALCO, James Bekker referred to the followings as objectives of ALCO: reviewing current and future statuses of national and international economies, predicting the volume of deposits and facilities and the extent to which predicted plans were achieved, reviewing rates and due dates of assets and liabilities, reviewing daily balance, investigating non-current receivable reserves, investigating the states of interest-based revenues and expenses, etc. (Bekker, 1978). In another definition, ALCO is responsible for managing investment, loans, and other assets and liabilities in such a way to achieve positive profit margin between interest-related costs and revenues. It is a supreme committee who makes decisions in the scope of balance sheet management while surveilling capital allocation process (Charlotte, 2009). Figure 1 depicts general structure of a typical ALM unit (Adam, 2007:83-97).

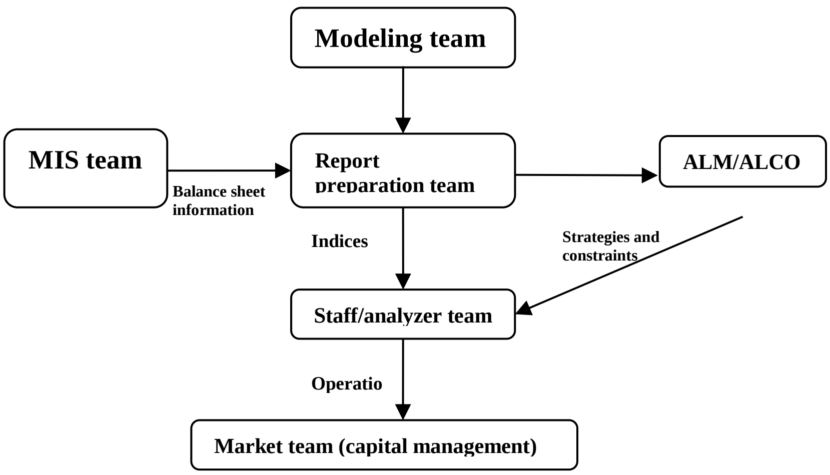

Figure1. Structure of an ALM unit (*Source: Adam, 2007:83-90*)

As a sub-unit of ALM, information systems represent another structural component of ALM and ensure joint function of other sub-units to end up with an integrated ALM. Indeed, this sub-unit runs a set of sub-systems, including the systems for registering and storing historical information, financial and analytic data, reports, modeling results, and simulation systems. Core components of an information system for ALM include data bank, analysis tools and reporting facilities. Figure 2 shows how these components are connected to one another (Xenius and Ziemba, 2006:18).

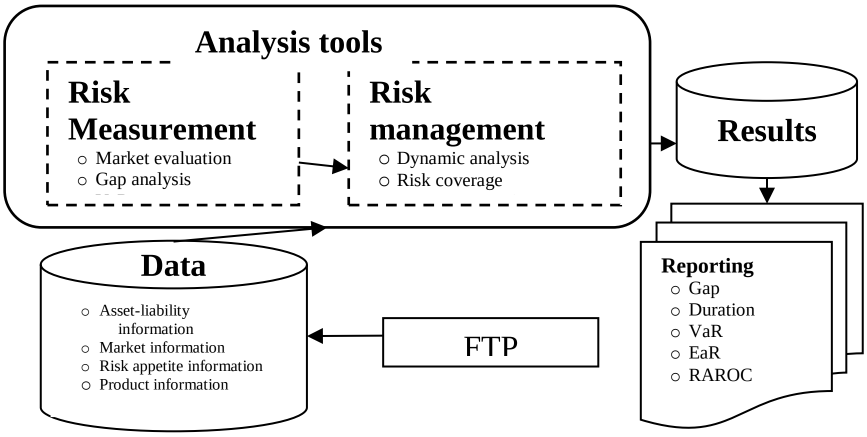

Figure2. Core components of an information system for ALM (*Source: Xenius and Ziemba, 2006:18*)

The Objective of an information system of ALM is to simulate items of balance sheet and flows of revenue, undertake sensitivity analysis, evaluate assets, dynamically model the balance sheet to prepare reports for decision-making by management, and cover risk (Xenius and Ziemba, 2006:18).

Another infrastructural dimension required for ALM is risk measurement methods and the way information are analyzed through such methods. Various categorizations have been presented in this respect. For most part, these categorizations cover generally the same methods, but categorized differently. The most common classification of the methods used for risk measurement in ALM is based on their approach to risk management considering time of incidence and associated uncertainties, as depicted in Figure 3 (Xenius and Ziemba, 2006:20).

In single-period static models used for financial decision-making, the time is considered as a single period from present to an infinite time. This approach is time-invariant, thereby assuming no change following the present and prior to the end of the period. As a matter of fact, static models do not include changes in upcoming periods. Dynamic models, however, assume portfolio optimization in the form of a multi-period process over time, and hence make decisions for multiple future periods, namely $t = 0, 1, \ldots, T$, before updating the model periodically. In terms of risk, considering Figure 3, risk factors can be considered either statically or dynamically. Upon considering the factors statically, the risk factors (interest rate, etc.) are assumed to be almost fixed over time, i.e. experiencing hardly negligible changes. Given the diverse changes in market forces in practice, the above-mentioned situation is not realistic; this has been addressed by stochastic models. In general, thanks to their realistic and reliable approach to analysis of the environment and effects of changes in market forces, multi-period stochastic models are preferred over other models.

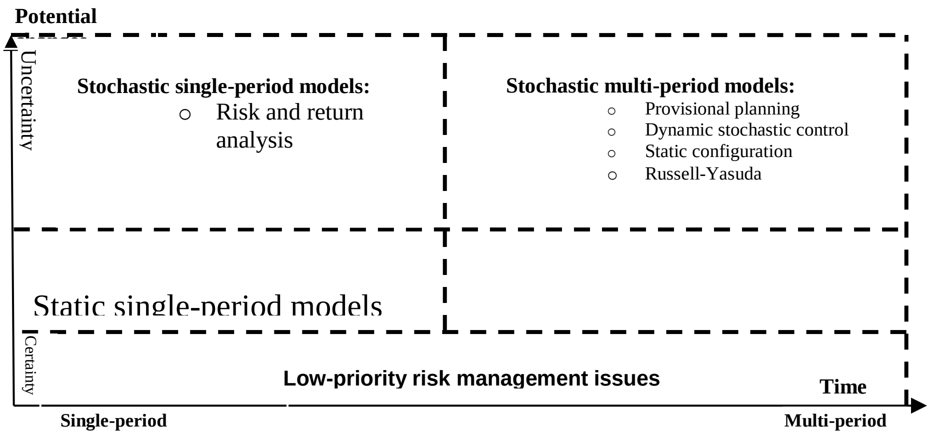

Figure3. Classification of ALM models based on time and associated uncertainties (Source: Xenius and Ziemba, 2006:20)

Of course, there are other classifications of ALM methods; as an example, ALM methods can be classified into deterministic and stochastic techniques (Kairaki and Constantine, 2004:44-103).

Another significant structural dimension of ALM is the observance of regulations and guidelines. Regulations set and interventions taken by governments and Central Banks are different in different states. Some countries have set forth limitations for entering different industries, based on which financial institutions shall obtain a permission from the respective Central Bank before those can raise deposit funds, and also shall retain their capital amount above a certain threshold (i.e. capital adequacy). In addition, in most countries, Central Banks communicate to banks sets of guidelines regarding establishment of new branches, lending and depositing interest rates, investment ratios, liquidity control, capital adequacy, and limits of participation in non-banking activities. Furthermore, the central banks apply controls regarding banks' exposure to the exchange rate and interest rate variations. In many countries, Central Banks put some pressure onto banks to establish ALCO to surveil profitability of the banks, control balance sheet risks, and check for observance of related rules and regulations by the banks. Moreover, governmental pressures on boards of banks for assigning individuals to surveil risk management processes are another measure taken toward the same purpose. However, with the regulations proven to be ineffective in most cases, banking industry in many countries has taken steps toward so-called deregulation, and Central Banks are now keeping focused on only five key controls over banks: rules regulating entry into the industry (permissions for various business activities), risk assessment-based capital regulations (Basel regulations), liquidity-related regulations, regulations on interest rate and exchange rate-related risks, and public disclosure of financial information (Ziemba, 2007:16).

In general, the dimensions described above constitute the foundation of ALM around the world, and evaluation of the quality of implementation of different components of ALM in banks shall be practiced by taking these dimensions into account. These dimensions and their quality in banks can contribute into performance of ALM components in the banks.

In a bank, asset management cannot be isolated from liability management. Simultaneous management of assets and liabilities to maximize profit while minimizing the risk requires the analysis of a set of information, as follows:

1. Existence of strategic goals and development objectives which are different in nature and include measurement of overall amount of deposits the bank is willing to attract and total number of loans the bank is willing to lend.
2. Determination of "the best temporary structure" of ALM for maximizing profit while ensuring robustness of banks. Not all capitals can be liquefied via the same way. In terms of assets, loans are different from issuance of large number of termed securities comprising capital liabilities of the bank. Arrangement of temporary structures of ALM is of paramount importance, as it prevents problems associated with reduced liquidity which result in a large deal of damage.
3. Asset risk management where the main focus is on assets. In this respect, quality assessment of loan shares, credit risk, and shares on securities are further measurable.
4. Establishment of a comprehensive factor representing the entire range of banking operations. This is mainly related to

determination of interest rate for all loans and deposits. In this way, for the numerous liabilities demanded by a bank for particular set of mediatory operations, it is evident that pricing is not a concern in bank market where banks work in a competitive space. This subject-matter is not raised even when all sorts of interest rate and liabilities are applied through financial power. In fact, as a basic characteristic, bank markets are dominated by mono-polar competition. Therefore, the subject-matters of decision-making and an independent pricing system, as well as product diversity are of significant importance. As far as assets are concerned, independent pricing is related to risk management. This is a common fact for all banks that lending interest rate are set in such a way to enhance the risk the banks assess in any case. Product diversity policy includes all sorts of products, including loan and capital products based on a comprehensive search ensuring the best possible recognition of market conditions.

Literature Review

In paper entitled as "*A nonlinear goal programming model for efficient asset-liability management of property-liability insurers*", Dash and Kajiji (2005) used a branch of goal programming (GP) to solve equations related to assets and liabilities. In this research, a linear programming model was pointed out where mathematical techniques are used to determine optimal combination of banks and financial and credit institutions. Furthermore, results of the research indicated that the model can determine the best combination of assets and liabilities for ALM in financial institutions.

Taktas *et al.* (2005) published a paper titled as "*Asset and liability management in financial crisis*", where they suggested that efficient ALM requires maximization of profit while controlling different risks. The proposed multi-objective decision-making model sought such objectives as maximization of liquidity, revenue, capital adequacy, and market share within the framework's general policies of the institutions, as well as regulatory and financial requirements. In their modeling, they showed that how different management strategies affect financial health of banks during crises.

In the paper entitled as "*A nonlinear goal programming model for efficient asset-liability management of property-liability insurers*", Dash and Kajiji (2005) used a branch of GP to solve equations related to assets and liabilities. In this model, cash liquidity management was also estimated. Furthermore, using a simulation technique, optimal values of decision variables (i.e. significant liquidity ratios and balance sheet items) were extracted, the extracted values from the two methods were compared to actual data and results were presented.

In order to strengthen and improve the cash management in the Islamic banking considering the depositors' characteristics and investment behaviors and expectations, Ismal (2010) presented an integrated and comprehensive model for analysis, evaluation, and planning for liquidity risk management (LRM) in the Indonesian banking system. Considering every dimension of the liquidity risk, this model provided a better approach to the LRM based on the principles of Sharia.

According to Umarani and Jayanthi (2015), ALM is a dynamic process for planning, organizing, coordinating, and controlling the assets and liabilities in terms of their volumes, due periods, efficiency, and associated costs, so as to achieve net interest revenue. In all transactions, banks are known to focus on raising and depositing the funds. In a similar way, the ALM has considered a larger weight for risk management at Indian banks. The liquidity risk measurement and management represent an important dimension of the ALM. Mismatch between the maturities of the assets and liabilities puts the bank balance sheet at the risk of liquidity. In order to assess the liquidity risk in the SBI Bank and affiliated banks in the India during 2011-2012, they used gap analysis method. Their findings indicate that the banks were at the liquidity risk.

Mohammadi and Sherafati (2015) works on the optimization of LRM at Parsian Bank using goal programming (GP) and Fuzzy Analytic Hierarchy Process (FAHP). This optimal liquidity management model accounted for capital adequacy, liquidity risk, external claims, investment portfolio, total expenditure-to-resource ratio, total asset growth, fixed assets, and other assets. Subsequently, the objective and structural constraints of the variables were investigated. Finally, an optimal liquidity management model was estimated. In the next step, the input (liabilities on the balance sheet and associated sub-items) and output (assets on the balance sheet and associated sub-items) variables were set to calculate optimal levels of liquidity ratios and other parameters on the balance sheet during 2011-2012 using the LINGO Software. Based on a survey performed among top financial managers at banking institutes, 8 objectives were designed for preparing the optimal liquidity management model using the FAHP technique. Findings of this research showed a significant increase in the efficiency of the estimated model, as compared to the actual efficiency of the bank. In addition, the estimated model could reduce the liquidity risk while boosting total asset growth at Parsian Bank. This could further add to the validity and applicability of the liquidity estimation management model for the banking system.

Halim *et al.* (2015) studied the six objectives set at a top Malaysian bank, including compilation of assets, reduction of liabilities, strengthening the stock worth, profitability, and optimal management, based on financial statements of the bank. The required data was collected from the annual reports of the bank during 2010-2014. The goal of GP was to find optimal solutions for the six objectives using the LINGO Software. All of the six objectives were examined based on the findings of this model. The results indicated good financial performance of the top Malaysian banks. However, there were opportunities to improve four of the mentioned objectives, namely stock worth, revenue, profitability, and item ratios on the financial statements, so as to improve the overall financial performance of the bank. The proposed model can serve as a guide for the banks in decision-making and strategy-setting toward encountering various economic scenarios.

In a research on the effective methods for liquidity management at banks, Bakhtiyari (2006) pointed out the required principles for implementing the liquidity management at banks followed by a discussion on the characteristics of chastity assets and liabilities at the banks. Next, introducing a number of fund raising instruments at banks, he investigated the liquidity management.

Persuading optimal ALM at banks, Eslami Bigdeli *et al.* (2011) used FAHP and GP to apply quantitative techniques for asset management at banks and optimal allocation of available resources to the expenditures.

Purzandi *et al.* (2012) began with determining the variables affecting the liquidity risk and the objectives and structural and goal-related constraints of the model, and then proceeded to utilize the GP as a multi-objective model for measuring the liquidity risk.

Aiming at determining the optimal level of liquidity and the liquidity risk, Omrani and Azimi (2016) defined a number of objectives and used them as a basis for optimal ALM at Mellat Bank. With its multiple objectives and considering the existing constraints across the banking system while taking advantage of the previous experiences, this research proposed a fuzzy goal programming model with fuzzy constraints. In order to achieve the final solution, a total of 9 goals together with more than 30 fuzzy constraints were considered in the model. The goals presented in this work included profit maximization, observing the loan-to-deposit ratio limit, improving the bank’s share of total deposits across the banking system, leveraging the items on the balance sheet, enhancing the share of particular assets with reference to the total assets, satisfying the capital adequacy requirements, lowering the level of investment on fixed tangible assets, keeping the amount of receivables from the Central Bank of Iran above the bank’s total liabilities, and keeping the bank’s receivables from other banks and financial institutions above the bank’s liabilities toward them. The importance level of each goal was evaluated using AHP. Ultimately, the results of deterministic and fuzzy calculations were compared, indicating the better results of the fuzzy analysis.

Research methodology and conceptual model

Goal programming (GP)

Goal programming was first introduced by Charnes and Cooper in the 1960s and later on developed by Igniso and Lee. Being the first technique with multiple objective functions, it was widely accepted for industrial and servicing applications. GP problems can be formulated through linear, nonlinear, and integer approaches; in any case, such a problem seeks to achieve more than one objective. In GP, an attempt is made to consider the mathematical rationale defining an optimal model along with the decision-maker's tendency toward particular objectives.

Due to the presence of more than one objective, managers try to achieve a simply satisfying solution rather than the actual one in many cases. Structure of linear programming is developed around a single objective and tries to optimize it with no chance of escaping any constraint. In practice, however, even in cases where we are dealing with one objective only, there are problems where the observance of each and any stringent constraint turns the approach into an unreasonable one which ends up with no solution. GP is an approach by which one can dominate over single-objectivity and stringent constraints. Another significant advantage of GP over linear programming is its flexibility (Momeni, 2006:98).

General form of a GP model is as follows:

$$\text{Min } Z = \sum_{k=1}^{q}\sum_{i=1}^{m} P\text{k}\,(\text{di-} + \text{di} +)$$
$$\text{St: } \sum_{j=1}^{n} \text{Cij Xj} + \text{di-} - \text{di} + = \text{bi} \quad (i=1,2,\ldots,m) \qquad (1)$$
$$\sum_{j=1}^{n} \text{arj Xj} \le \text{br}' \quad (r=0,1,\ldots,s)$$
$$\text{Xj}, \text{di-}, \text{di} + \ge 0 \quad (i=1,2,\ldots,m),(j=1,2,\ldots,n)$$

Where:
Xj: denotes decision variables of the model and can be any non-negative real number.
di + , di-: indicate positive and negative diversions from the i^{th} goal, respectively.
Pk: determines the k^{th} priority (k = 1, 2, …, n) of goal.
arj: presents technical coefficients of the model.
Cij: indicates coefficients of the j^{th} decision variable for the i^{th} goal.
br': numbers on the right refer to functional constraints.

This model has n decision variables, m goals, k priorities, and s functional constraints. Mathematical relationships in this model are linear and first-order.

Revised simplex method is the method of choice for solving GP models (Taylor, 2004:254). Similar to linear programing model, assumptions on which GP is based include summability, divisibility, proportionality, and determination. In a GP model, however, a set of prioritized objectives are used to construct the desired goal. To solve such a model, one may begin with minimizing the diversion from goal for the objective with highest priority and then proceed to lower priorities.

The rationale behind solving a GP model is to achieve goals of the objective function in the order of their priorities. Once a particular goal was achieved, the next goal with the highest priority among the remaining goals is considered. As long as a higher priority goal is not achieved, goals of lower priority will not be taken into consideration (Taylor, 2004:261). In the present research, weighting factor and priorities of objectives are calculated using analytic hierarchy process (AHP).

Analytic hierarchy process (AHP)

Analytic hierarchy process (AHP) was proposed by Thomas Saaty, an originally Iraqi researcher. The technique analyzes problems following an approach similar to that followed by human brain to enable decision-makers determine mutual and simultaneous effects in many complex and stochastic situations and arrange priorities based on their objectives, knowledge and experience (Momeni, 2006:40). AHP is a method for converting subjective assessments of relative priorities to a set of weighting factors. This technique is one of the most comprehensive systems already designed for multi-objective decision-making as it provides a basis for formulating the problem through a hierarchical process while taking into account various qualitative and quantitative criteria. This process includes different attributes into decision-making and makes it possible to run sensitivity analysis on criteria and sub-criteria. In addition, AHP is based on pair-wise comparisons which facilitate judgment and calculations. The technique further shows consistency and inconsistency of decision, which defines a unique feature of this technique in multi-attribute decision-making. Furthermore, AHP has a strong theoretical foundation constituted by the following axioms (Ghodsipoor, 2005:6):

Widespread application of AHP is because of, among others, its relative simplicity, ease of understanding, and reasonability, so that its process can be easily explained for others. A secondary advantage of this method is its application in group decision-makings.

AHP-GP hybrid model

Goal programming is a structured approach for determining and evaluating solutions based on assigned priorities or weights, so as to rank the goals. GP has no systematic approach for determining priorities or relative significance (i.e. ranking) of goals, while AHP enjoys such capability, so that its application along with GP can address the weaknesses of GP. Figure 4 demonstrates a decision-making process based on an integrated system composed of the two mathematical programming models.

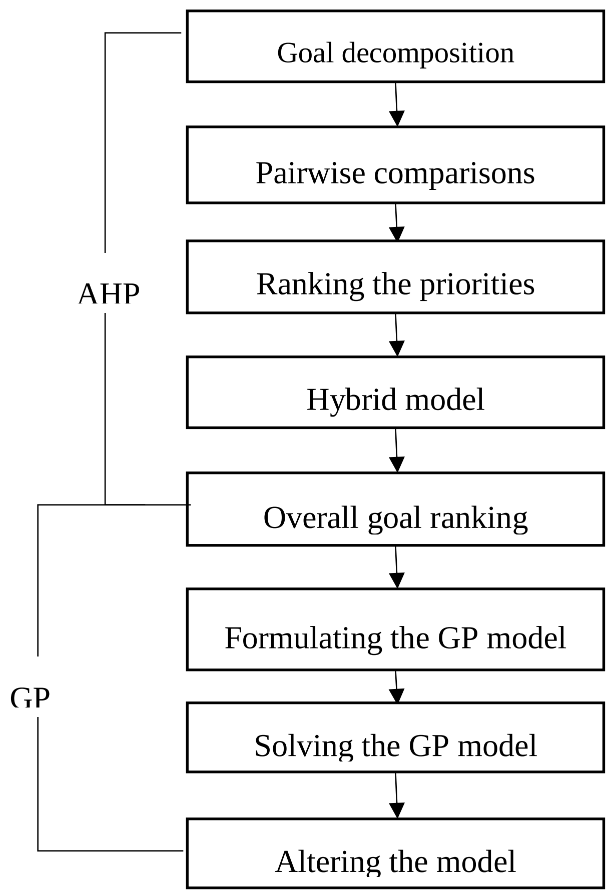

Figure 4. Integrated decision-making process (*Source: Mehregan, 2007: 290*)

The research model

Given that the principle objective of ALM is to undertake liquidity management, firstly, all input and output variables to and from liquidity management were recognized. Financial statements (i.e. balance sheet, income statement, and cash flow statement) were then investigated. Subsequently, financial ratios affecting assets and liabilities were identified using existing literature, as well as experts' opinions.

In the next stage, goal- and system-related constraints of the model were defined. The most important goal-related constraint of the model was that, sum of inputs (resources) plus cash inventory in the first period plus provisory reserves, less sum of outputs (expenditures) from cash flow system shall be within a desired level. For the purpose of this research, the desired level was set at zero. Other goal-related constraints included observance of the ratios affecting liquidity, including quick ratio, liquidity ratio, capital adequacy ratio, liquidity factor (ratio of liquid assets to total resources), ratio of the balance of bank's account at other banks to cash, ratio of non-demand deposits to demand deposits, ratio of total expenditures to total resources, ratio of cash and pseudo-cash at bank's cash to balance of demand deposits, ratio of unstable deposits to current facilities, and coefficient of receivables (total receivables to total payables ratio).

Systematic constraints based on requirements of the Central Bank of Iran were further added to the model. In the next step, a questionnaire was designed to investigate priorities of the ratios affecting ALM, whereby the ratios were scored based on judgments by experienced experts and managers of Iranian banking system. The data obtained from the questionnaire were analyzed using AHP, as implemented in Expert Choice Software, so as to calculate weights of different ratios in the objective function. Other systematic constraints were added to the model considering the requirements set by the Central Bank of Iran and financial statements of the studied bank. Finally, the prepared GP model could be solved using Lingo Software.

Weights of the ratios affecting the liquidity in the objective function

Upon analyzing the questionnaires using AHP, it was found that, out of the 70 questionnaires distributed, 36 questionnaires were returned, of which only 34 ones were acceptable for the analysis. Significance (weight) of each of the ratios affecting liquidity was obtained in Expert Choice Software by adopting an inconsistency rate of 0.02, as follows:

Table 1. Weights of the ratios affecting ALM.

No.	Ratios affecting ALM	Weight of the ratio in objective function
1	Quick ratio	0.152
2	Liquidity ratio	0.186
3	Capital adequacy ratio	0.238
4	Non-demand-to-demand deposit ratio	0.134
5	Total expenditures to total resources ratio	0.133
6	Ratio of cash and pseudo cash to balance of demand deposits	0.050
7	Coefficient of receivables (ratio of net total receivables to net expenditures)	0.107

In AHP-based questionnaires, reliability and validity of the results are calculated using consistency rate test. In case the rate exceeds 0.1, reliability and validity are questioned. The obtained rate of 0.02 in this research indicated validity and accuracy of the designed questionnaire.

Model variables

The model has a total of 51 variables of which 14 variables represent diversion from goal and 37 variables are decision variables, as follows:

Table 2. Decision variables of the model.

	Assets		Liabilities
X14	Cash inventory	X1	Liabilities to Central Bank
X15	Receivables from Central Bank (statuary deposit)	X2	Liabilities to other banks and credit institutions
X16	Receivables from other banks and financial institutions	X3	Facilities received from other banks
X17	Current accounts at banks, our accounts	X4	Demand deposits (current accounts)
X18		X5	Deposits at current accounts
X19	Credited facilities		
X20	Facilities credited to and receivables from public sector	X7	Saving deposits and similar accounts
X21	Receivables for credited facilities/governmental guarantees, etc.	X8	Termed investment deposits
X22	Facilities credited to and receivables from public sector	X9	Other sorts of deposit
X23	Due, deferred, and suspended receivables from public sector	X10	Proposed dividends
X24	Receivables from private sector	X11	Base capital
X25	Housing facilities	X12	Retained earnings
X26	Other receivable accounts	X13	Sum of equities
X27	Letters of credit and termed bills	X37	Other liabilities
X28	Investments and joint activities		
X29	Tangible fixed assets		
X30	Intangible fixed assets		
X31	Other assets		
X32	Bonds		
X33	Owned collaterals (for more than 2 years)		
X34	Flout of funds		
X35	Liabilities for letters of credit		
X36	Liabilities for guarantees		

Model constraints

The developed model had a total of 11 constraints, of which 7 constraints were goal-related and the remaining 4 constraints were systematic ones, as follows:

Goal-related constraints

1. Quick ratio: refers to the ratio of liquid assets to current liabilities, with its standard value be1ing 1.

$$X14 + X15 + X17 - (X1 + X2 - X3 + 25\% X5 + 10\% X8 + 50\% X3) + N1 - P1 = 0$$

2. Liquidity ratio: globally desired value of this ratio is 1.3%; but in Iran, values between 3% and 5% are acceptable.

X14 + X15 + X16 – X19 + 50% X32 + 50% X19 – 4% (X1 + X2 – X3 + 25% X5 + 10% X8 + 50% X3) + N2 – P2 = 0

3. Capital adequacy ratio

According to the requirements set by the Central Bank of Iran, Article 3 of the Capital Adequacy Regulations, approved by the Monetary and Credit Council on 25/11/2008, this ratio shall be at least 8%.

X11 – 8% (20% X34 + 20% X16 + 50% X25 + X23 + X22 + X28 + X29 + X31 + 20% X35 + 50 X36) + N3 – P3 = 0

4. Non-demand to demand deposit ratio

Standard value of this ratio under inflationary conditions is any value above 1.

X7 + X8 + X9 – X4 + N4 – P4 = 0

5. Expenditures-to-resources ratio

According to Basel Committee on Banking Supervision (BCBS) – Basel III, standard value of this ratio ranges between 70% and 80%.

X14 + X15 + X16 + X20 + X22 + X27 + X28 + X29 + X30 + X31 + X34 + X35 + X36 – 75% (X1 + X2 + X4 + X7 + X8 + X9) + N5 – P5 = 0

6. Ratio of cash and pseudo cash to balance of demand deposits

Standard value of this ratio ranges between 7% and 10%.

X14 – 8.5% X4 + N6 – P6 = 0

7. Coefficient of receivables (ratio of net receivables to net expenditures)

Given that standard value of this ratio at international level is about 3%, we applied the same threshold for the studied bank.

X21 + X23 – 3% (X20 + X22 + X27) + N7 – P7 = 0

Systematic constraints

1. According to the directive No. 89/257248 adopted by Money and Credit Council on February 10th, 2011 and based on the Production Barriers Inhibition Act of 2014, ratio of net value of fixed assets (non-revenue generating) and collaterals to equities may not exceed 70%.

$X29 + X30 + X33 \leq 70\% (X13 – X12)$

2. Statuary deposit: According to monetary, credit, and surveillance policies set forth by Iranian banking system in 2016, the statuary deposit for various types of deposit ranges from 10 to 13%. However, since the prepared model cannot differentiate between long-term deposits based on their term (in years), statuary deposit ratio for all types of deposit at the studied bank was considered as 12%.

$X15 = 12\% (X4 + X7 + X8 + X9)$

3. Investments and joint activities: According to the Production Barriers Inhibition Act of 2014 and executive policies of the act, banks are required to use less than 40% of their base capital for investment and joint activity purposes.

$X28 \leq 40\% (X11)$

4. Sum of assets shall be equal to sum of liabilities:

$X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + X9 + X10 + X13 + X37=X14 + X15 + X16 + X17 + X18 + X19 + X20 + X21 + X22 + X23 + X24 + X26 + X27 + X28 + X29 + X30 + X31 + X32 + X33 + X34$

Objective function of the model

Objective function of a GP model is defined as minimization of adverse diversions from the goals:

$Min = W1 (N1 + P1) + W2 (N2 + P2) + W3 (N3 + P3) + W4 (N4 + P4) + W5 (N5 + P5) + W6 (N6 + P6) + W7 (N7 + P7)$

Based on requirements set by the Central Bank of Iran and financial statements of the studied bank, goal-related constraints, other systematic constraints, and objective function of the model are as follows:

1. $X14 + X15 + X17 – (X1 + X2 – X3 + 25\% X5 + 10\% X8 + 50\% X3) + N1 – P1 = 0$
2. $X14 + X15 + X16 – X19 + 50\% X32 + 50\% X19 – 4\% (X1 + X2 – X3 + 25\% X5 + 10\% X8 + 50\% X3) + N2 – P2 =0$
3. $X11 – 8\% (20\% X34 + 20\% X16 + 50\% X24 + X25 + X23 + X28 + X29 + X31 + 20\% X35 + 50 X36) + N3 – P3 = 0$
4. $X7 + X8+ X9 – X4 + N6 – P6 = 0$
5. $X14+ X15 + X16 + X20 + X22 + X27 + X28 + X29 + X30 + X31+ X34 + X35 + X36 – 75\% (X1+ X2 + X4 + X7 + X8 + X9) + N9 – P9 = 0$
6. $X14 – 7\% X4 + N101 – P101 = 0$, $X14 – 10\% X4 + N102 – P102 = 0$

7. 20% (X4 + X7 + X8 + X9) – 30% (X20 – X21 + X22 – X23 + X27) + N111 – P111 = 0.20 (X4 + X7 + X8 + X9) – 0.33 (X20 – X21 + X22 – X23 + X27) + N112 – P112 = 0
8. X21 + X23 – 7% (X20 + X22 + X27 + X28) + N12 – P12 = 0

Systematic constraints

9. X29 + X30 + X33 ≤ 70% (X13 – X12)
10. X15 = 12.5% (X4 + X7 + X8 + X9)
11. X28 ≤ 40% (X11)
12. X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + X9 + X10 + X13 + X37=X14 + X15 + X16 + X17 + X18 + X19 + X20 + X21 + X22 + X23 + X24 + X26 + X27 + X28 + X29 + X30 + X31 + X32 + X33 + X34

Table 3. Modeling results.

Variable	Title	Value in 2015 balance sheet	Value in optimal model
X1	Liabilities to Central Bank (received deposit)	22,622	25,000
X2	Liabilities to other banks and credit institutions	5,953	5,953
X3	Facilities received from other banks	-	-
X4	Demand deposits	10,293	30,000
X5	Deposits at current accounts	-	-
X6	Sold cheques	-	-
X7	Saving deposits and similar accounts	3,438	3,438
X8	Termed investment deposits	403,124	520,000
X9	Other sorts of deposit	6,192	6,192
X10	Proposed dividends	157	157
X11	Base capital	72,294	72,294
X12	Retained earnings	9,541	9,541
X13	Sum of equities	75,421	75,421
X14	Cash inventory	61,357	61,357
X15	Receivables from Central Bank (statuary deposit)	7,303	9,000
X16	Receivables from other banks and financial institutions	9,105	9,105
X17	Current accounts at banks, our accounts	-	-
X18	Termed deposits at domestic banks	-	-
X19	Facilities credited to other banks	-	-
X20	Facilities credited to and receivables from public sector	-	-
X21	Receivables for credited facilities/governmental guarantees, etc.	-	-
X22	Facilities credited to and receivables from public sector	335,420	500,000

X23	Due, deferred, and suspended receivables from public sector	7,788	17,598
X24	Receivables from private sector	-	-
X25	Housing facilities	29,916	33,000
X26	Receivable interest (facilities)	23,199	34,119
X27	Letters of credit and termed bills	-	-
X28	Investments and joint activities	17,604	17,604
X29	Tangible fixed assets	9,210	9,210
X30	Intangible fixed assets	5,186	5,186
X31	Other assets	9,261	10,500
X32	Bonds	-	-
X33	Owned collaterals (for more than 2 years)	-	-
X34	Flout of funds	-	-
X35	Liabilities for letters of credit	90,068	105,000
X36	Liabilities for guarantees	39,496	45,000
X37	Other liabilities	7,519	7,519

Conclusion

An important task in every bank is to undertake assets and liability management (ALM) to improve the efficiency while minimizing the risk. This highlights the need to reconsider special internal and external regulations. Liquidity risk represents a challenge faced by banks when attempting to deploy the ALM. Accordingly, the present research investigates optimal ALM in a sample bank using goal programming and analytic hierarchy process considering actual levels of deposits and equities.

According to the table detailing the developed model’s output, allocation of resources by the model was somewhat different from actual balance sheet. The model attempts not to exceed a certain limit when it comes to the observance of requirements while fulfilling all objectives considering the constraints and requirements (it is worth noting that, for all of the model variables, minimum values were set according to the bank's balance sheet for 2015, while maximum values were set considering differences in growth capacity of the bank).

The following items of assets and liabilities were different between the optimal model and 2015 balance sheet:

- Regarding liabilities to Central Bank, the optimal model considered a growth rate of about 10% in its value in comparison with the value in 2015.
- Of the most important results extracted from the optimal model was 200% growth in demand deposits. Indeed, maximum

allowable growth in demand deposits was 200%, and the model opted 200% as optimal growth in the demand deposits.

- As far as termed deposits were concerned, the optimal model proposed a growth of about 25% in the values in comparison with the value in 2015.
- According to the optimal model, amount of receivables from the Central Bank grew by about 300% in the value compared to the value in 2015.
- Based on the optimal model, facilities credited to private sector should be increased by about 50%. In fact, this indicates that, based on the capital adequacy ratio of the studied bank, the bank enjoys large capacities for enhancing the level of credited facilities in an attempt to improve its profitability.
- According to the optimized model, non-current receivables should be grown by about 150%, indicating that the bank has implemented an excellent accreditation process.
- According to the optimized model, housing facilities should be grown by 10%.
- Receivable interests exhibited a growth of about 50%.
- Other assets grew by about 10%.

Other items of assets and liabilities in the optimized model exhibited no significant difference to the values in 2015 balance sheet of the bank.

Results of the model indicate that the optimal allocation of available resources will increase the revenues while reducing the risk at the studied bank. Moreover, the results obtained upon solving the model, comparing its outputs to respective real values, and evaluating the deviation from the goals versus actual values of the considered variables indicated enhanced efficiency of the model in optimal allocation of the resources. In addition, determining the required cash for the bank to supply its expenditures along with the depositors' demand for cash, the liquidity management controls the risk. After all, the use of goal programming, where decision-making can be done by considering multiple attributes simultaneously, helps manages realize enhanced profitability and efficiency of the bank.

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