

A Multi Objective Optimization Approach for Resources Procurement of Bank

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Abstract

Calculating total cost of bank resources procurement methods which include current -free loan deposit, saving interest-free loan deposit, regular and net short-term investment deposit, long-term investment deposit and surety bond cash deposit and presenting their optimal integration require precise scientific studies. Hence, this study is an attempt to know which methods are the best optimal integration banking resources. Linear and ideal planning techniques are used to find an optimal solution according to existing mathematical models. We use three algorithms to construct mathematical models. In the suggested mathematical models, linear planning has 6 variables and 2 constraints in getting no information algorithm and 6 variables and 7 constraints in getting information algorithm and the problem is solved by WINQSB software. But, 6 variables and 8 constraints are solved by LINGO8 software. The results of the study show that presenting an optimal integration of resources procurement methods by using mathematical models is possible and is applicable with regard to determining rational and suitable constraints and ideals for all resource procurement methods. In addition, with regard to the calculation and investigation of procurement cost in financial procurement methods, it is found out that total cost (i.e. real operational cost plus nonoperational cost) is the basis of judgment for studying resource procurement cost. Further, as with the total cost of resource procurement methods, current interest-free loan deposit and long-term investment deposit are the most expensive methods while surety bond cash deposit is the cheapest resource procurement method and other methods fall in between.

Key words: goal programming; comprehensive criterion technique; lexicography banking deposits (sight, unsight and other deposits); banking resource procurement cost; banking resource optimal integration

1. Introduction

Bank system of each country is like a heart that does two important functions of receiving food and distributing it to all parts of body by veins. In other words, it does resources equipping (deposit collecting) and resources allocation (granting facilities) (Jamshidi [5]). Therefore, it is considered the main basis of economy and its optimal activities cause development of economic activities and in turn economic growth, and its crisis leads to economical crisis. Although both functions of banking system (i.e. resources equipping and allocating) are important, resources equipping takes priority over resources allocation as rate of resources allocation depends on absorbed resources. Capital and savings are a small fraction of resources in banking system and main resources equipping is made by banking deposits (people Deposits) including sight deposits (current), unsight deposits (saving and payable at maturity) and other kinds of deposits (Jamshidi [5]). These deposits have different costs, and all financial institutes such as banks look for absorbing cheap resources to increase profitability and

survival. Costs of banking resources equipping include operational costs (e.g. deposit profit ratio, interest-free-loan rewards) and nonoperational or public costs (e.g. personnel, official, disputable receipt, and amortization). This study aims to study resource procurement costs of the Commercial Bank of Zanjan in different ways (sight and unsight deposits). Several mathematical models are used to find optimal resources procurement integration to simultaneously minimize and maximize cost of resources procurement and rate of resources, respectively.

2. Statement of the Research Problem

The main objective of banks and profit making organizations is to make profits and increase them to guarantee their survival. As an important part of economy, banking system can develop and improve economic activities and in turn economy by absorbing capitals and public deposits and then proper planning for making use of collected capitals. If banking system

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doesn't operate well and is not in harmony with economic programs of country, it hinders development in different geographical parts of country. Therefore, due to the significance effect of banking system on economy, focusing on its main functions (resources equipping and allocating) is necessary. In resource equipping, selecting resources integration in a way to simultaneously absorb maximum resources and have the minimum cost for bank is especially important. Increasing bank profits is possible through rise in income and reduction in costs. Bank costs include financial procurement costs. Resources procurement methods cost differently, so attention to resources procurement methods and their costs is one of the important strategies for the survival of financial and monetary institutes. Banks have to make a lot of effort to decrease the costs and increase the bank profitability for financial procurement through getting cheap financial resources. But to what extent can banks use cheap resources that may cause decrease in resources? Or what is the optimal point for procuring resources in different ways? To answer these questions, we should be aware that banks are financial institutions which have limitations in using resources procurement methods and do not have much power to select whatever they want since customers decide about the kind of deposits. Banks can use frameworks for absorbing resources in different ways by calculating costs of different resources procurement methods (sight deposits, unsight deposits and other deposits) and for reaching an optimal integration of them which is the main issue of resources absorption. In this regard, a question arises as to whether there is any comprehensive model for optimal integrations of banking resources procurement methods or not. In order to address the above-mentioned questions about resources procurement, the following research questions are put:

- 1- How much is the cost of resources procurement and what is the rate of absorbed resources in sight deposit (current account)?
- 2-How much is the cost of resources procurement and what is the rate of absorbed resources in unsight deposit (payable at maturity)?
- 2-1- how much is the cost of resources procurement and what is the rate of absorbed resources in interest-free loan deposit?
- 2-2- how much is the cost of resources procurement and what is the rate of absorbed resources in regular short-term deposit?
- 2-3- how much is the cost of resources procurement and what is the rate of absorbed resources in net short-term deposit?
- 2-4- how much is the cost of resources procurement and what is the rate of absorbed resources in long-term deposit?
- 3- How much is the cost of resources procurement and what is the rate of absorbed resources in private surety bond cash deposit?

3. Review of the Literature

3.1. Capital structure

Capital structure is the integration of debts and shareholders' rights. Capital structures are formed by different resources of financial procurement, so they in turn affect capital cost and financial risk of profit making organizations. There are different theories in relation to the effects of capital structure on capital cost and value of profit making organization that include net income theory, net operational income theory, traditional theory and Moding Liani and Miller theory (Ahmad- Zade et al. [1]). According to net income theory, economic agency can decrease its capital cost using debt, and optimal capital structure is gained when capital cost is kept to a minimum. Net operational income theory states that because of shareholders' sensitiveness toward increase of debt rate in capital structure, profit making unit using financial basis cannot impact total capital cost. According to traditional theory, capital cost can be decreased with suitable integration of debt and capital; therefore there is an optimal capital structure for each economical agency (Davis & Sihler [4]). However, Moding Liani and Miller state two theories with regard to some assumptions such as lack of tax. In the first theory, drawing on lack of tax assumption (not for firm and person), Moding Liani and Miller show that increase in shareholders' profit caused by loan application will be nullified by risk increase, so using financial basis is not appropriate and does not affect capital and value cost of firm. But, in the second theory, they balance lack of firm tax to some extent; since profit cost is not liable to taxation and tax is subtracted from draftee's income, using financial basis brings about profits for firm (Beri Gam Ohgin et al. [3]).

3.2. Capital cost

Capital cost is a profit ratio which is expected from proposal long-term investments and this ratio is the minimum expected value. Capital cost has two elements of shareholders' rights cost and debt cost with the former including riskless profit ratio plus risk. One formula for calculating shareholders' rights cost is as follows:

$$(\text{Shareholders' rights cost}) = R_f + b(k_m - R_f)$$

In which:

R_f = riskless profit ratio

b = risk index of determined stock (beta coefficient)

k_m = profit ratio on whole (market) or determined numbers of active firms

$(k_m - R_f)$ = risk on average stock i.e. amount of risk must be incurred for increasing profit from riskless profit value.

Debt cost is debt profit ratio (KD) with each constant profit which is paid to lender multiplied by $(1-t)$ that t is firm tax ratio and

$$\text{Debt cost} = KD (1-t)$$

3.3. Bank financial resources

Banks financial resources are:

1- Shareholders' rights that include accumulated profits of capital.

2- debts that include deposits (current , saving and long-term investment deposit), loan from central bank , loaning from banking system , controlled funds, payable bill of exchange , receivables and accepted bill of exchange (Ahmad- Zade et al. [1]).

3.4. Costs of bank financial resources procurement

Main financial resources procurement costs of banks are:

1- Operational costs: according to article note (3) of usury less banking system act, banks relation with long- and short-term investment depositors is like the relation of attorney and client, that is, banks as depositors' attorney, invest their cession deposits in cases mentioned in the aforementioned note, and then subtracting the cost of honorarium, pay gained profit to depositors. Therefore, according to law, payable profit to depositors is not considered among bank costs. However, since payable profits must be reflected in cost calculation of money collection, they are considered as operational costs. Reward ratio of saving interest-free loan deposit is a part of operational costs.

2- Official-organizational costs: like other official institutes, banks have official – organizational costs which must be considered in cost calculation of absorbed resources. They are called personnel costs and official costs which have titles. Because official-organizational costs comprise a high proportion of banks total cost, their inclusion in financial resources procurement is very important (Norusi Nav [10]).

3.5. Cost calculation of banking resources

As mentioned in the previous section, cost of each resource procurement method includes both operational cost and nonoperational cost:

Total cost of each resource procurement method = operational cost + nonoperational cost

This formula is presented for calculating the elements of resource procurement cost and this is applicable to all resource procurement methods. In the present paper, real operational costs are used to study resource procurement costs as follows.

3.6. Calculation of real operational costs

Operational cost is an on account profit which is paid to several groups of depositors and its ratio is determined by central bank annually. In this respect, current interest-free

loan and surety bond cash deposits have no cost while saving interest-free loan, regular and net short-term investment and long-term deposits have cost. But, real operational cost is the operational cost ratio which is calculated for net balance of deposits. Deposits without operational cost make a rise in bank profits with real operational cost calculation, and real cost ratio of deposits have higher operational costs than the ratio determined by central bank.

The following formula is used to calculate real operational cost ratio for all resources procurement methods (Norusi Nav [10]):

$$\frac{(AD * DR) - [(LR * RR) + (GB * GR)]}{AD - (LR + GB + K)} = \text{real operational cost ratio}$$

ratio

Where:

AD = average of deposits and resources

DR = equipping ratio of deposits and resources

LR = legal deposit rate in each type of deposit

RR = legal deposit profit rate in each type of deposit

GB = purchased bonds rate from each deposit place

GR = purchased bonds profits

K = cash on hand (liquidity), precaution rate

3.7. Calculation of nonoperational costs

For nonoperational cost (personnel and official), different deposits have different costs related to received services from shareholders of these deposits, and ratio of this cost is calculated for all methods. The following formula is used for this end:

Nonoperational cost ratio=

$$\frac{\text{Cost allocation rate} \times (\text{amortization cost} + \text{official cost} + \text{personnel cost})}{AD - (LR + GB + K)}$$

Nonoperational cost of each procurement resources method = Cost allocation rate × (amortization cost + official cost+ personnel cost

Net average balance of each deposit =

$$AD - (LR + GB + K)$$

Where:

AD = average of deposits and resources

LR = legal deposit rate in deposits

GB = purchased bonds rate from each deposit place

K = cash on hand (liquidity), precaution rate

3.8. Optimal capital structure

It is the integration of debt and shareholders' rights which maximizes market value of profit making unit (Rostami Anvari [11]). The criteria used for studying banks optimal capital structure are as follows:

1- Capital adequacy ratio: capital is a tool that guarantees bank against credit risk. This issue became official after the financial crisis in the south-eastern of Asia when Baal Committee approved a minimum value (as the capital adequacy ratio) for banking in the international banks to avoid such events in the future. This amount is 8 percent risk assets.

2- Proportion of deposits to debts: as diversifying assets integration is important for confronting with investors' commercial risk, diversifying financial procurement resources are necessary for decreasing the risk of entire evacuation of bank resources and for increasing certainty toward relative stability of either type or number of resources. Hence, attention to bank deposits which are obtained from a number of depositors is necessary.

3- Proportion of long-term deposits to total deposits: the significance of long-term deposits is due to their unsight nature for banks. These deposits are the most stable resources, so using them to procure necessary financial resources for long-term facilities can be beneficial.

4 – Capital cost: capital cost is one of the most important criteria for evaluating optimality of structure. Thus, optimal capital structure seems to be the integration of a financial resource which has the minimum average well-balanced capital cost. Obtaining cheapest resources to increase bank profitability is vitally important among senior management. Regarding the issues of capital structure and scales of optimal capital structure particularly capital cost scale, we can conclude that having an optimal integration of resources procurement methods is essential to firms and financial institutes and leads to increase in value and decrease in cost. In this article, mathematical models are used to reach an optimal integration of resources procurement methods.

3.9. Related empirical studies

Several studies have been done about financial procurement and capital structure in the foreign countries. Modigliani and Miller are pioneers in devising a theory about capital structure which states financial structure and capital model have no roles in determining firm value. However, later, they added that taxation savings due to debts interest increase firm value, and firms use their maximum possible debt in financial resources integration. Scot and Martin [13] in a survey about the US capital structure found that industry type is a major determinant of the financial structure of firms. Conducting a survey about a railway firm, Warner (1977) concluded that the current value of debts bankruptcy in the firm was insignificant in comparison with the increase in value due to debts. Myres [9] formulated a hierarchical financial procurement methods hypothesis based on his investigations. This hypothesis can be summarized in the following cases:

1. Firms prefer internal financial resources procurement.
2. If firms need external (foreign) financial resources

procurement, they initially issue the most secure valuable papers, that is, they use debt and if possible colored valuable papers like changeable bonds, and as last they use shares as financial procurement. Anderson (1990) investigated interrelation of financial structure and its technology and concluded that in comparison with work firms, absorbing investment firms brings about a higher proportion of debts (Sami'Heibat [12]). Doing a survey about bank capital structure, Rabin Cohen (2006) investigated optimal capital structure of depository institutes (banks). He found out that banks capital structure is very dependent upon profitability and risk management. Further, there are a lot of differences between functions and type of stock and depository companies which complicate the determination of bank capital structure. The differences named as factors are as follows: 1- Limited provisions for capital 2- interrelation of deposits and loans 3- changing attitudes in capital efficiency when deposits and loans risks are calculated. Cohen suggested that there is a kind of dependency between loans and deposits which can create an optimal capital structure in institutes. To attain this optimal capital structure, he supposed that the aim of institutes is to create positive profits for shareholders and this goal is achievable only when differences between loan rate and deposit are positive. This issue must be considered in relation to capital adequacy proportion (Sami'Heibat [12])

In Iran, some attempts also have been made to study financial procurement and capital structure in some banks. Studying money gathering in the Commercial Bank of Iran, Norusi Nav [10] concluded that for determining the rate of bank facilities, there was no attention to the cost of cash collecting. In a survey about resources equipping and allocation in the National Bank of Iran for a period of eight years, Shakeri [14] concluded that because of resources allocation, resources absorbing cost is more than productivity and the National Bank has no profitability in financial intermediary. Conducting a research with the aim of evaluating the capital structure and financial resources in the Agricultural Bank of Iran and suggesting a suitable strategy to optimize them, Ahmad- Zade et al. [1] tested two hypotheses: the first hypothesis stated that there is no relation between capital structure and capital cost. This hypothesis was confirmed at the end; the second hypothesis which concerned lack of optimality in the capital structure of the Agricultural Bank in 2001 was investigated and confirmed through a four-stage framework. The steps of the framework were proportion of capital to risky assets, proportion of deposits to debts, proportion of long-term deposits to total deposits and capital cost. Finally, in another study by Asgari Aluj [2], resources absorbing cost in the Commercial Bank of Ardabil was calculated and contrasted with cash cost in the economic market. The results showed that there was a meaningful difference between the total cost of resources of the banking system

and the cash cost in economy.

4. Methodology

The present deceptive-functional investigation was carried out in 31 branches of the Commercial Bank of Zanjan, Iran for a three-year period from 2006 to 2009. The data were gathered using filed and library methods. Then, resources procurement cost calculation was done by using the related formula and EXCEL Software. The Mathematical models used after the total cost calculation of all banking resource procurement methods are as follows:

4.1. Linear planning model

This model is one of the efficient models for real issues and different fields such as rare resources allocation like raw materials, human force, and machineries and broadly for elements mixing, timing, human forces planning and especially economical planning which is applied in this survey (Mehregan [8]). Because the model of this survey includes several objective functions, the mathematical models are used with several objective functions:

$$\begin{aligned}
 &Max \quad (Min) \\
 &Z_1 = Z_1(x_j) \\
 &Z_2 = Z_2(x_j) \\
 &\vdots \\
 &Z_p = Z_p(x_j) \\
 &St : \\
 &g_i(x_j) \leq b_i, \quad i = 1, 2, \dots, m \\
 &x_j \geq 0, \quad j = 1, 2, \dots, n
 \end{aligned} \tag{1}$$

This model has p objective functions, n decision variables and m limitations.

4.2. Linear ideal planning model

This model is the first objective function technique which is applied broadly in different decision making fields in industry and services. Linear ideal planning issues are those which involve more than one objective (Mehregan [7]):

$$\begin{aligned}
 &min Z = \sum_{i=1}^m d_i^- + d_i^+ \\
 &St : \\
 &\sum_{j=1}^n C_{ij} X_j + d_i^- - d_i^+ = b_i \quad (i = 1, 2, \dots, m) \\
 &\sum_{j=1}^n C_{rj} X_j \leq b_r \quad (r = 1, \dots, s) \\
 &X_j, d_i^+, d_i^- \geq 0 \quad (i = 1, 2, \dots, m), (j = 1, 2, \dots, n)
 \end{aligned} \tag{2}$$

Where:

X_j : Denotes decision variable which can select each non negative natural number

d_i^+, d_i^- : Show deviations of variables from i positive negative ideal

b_i : Presents right hand number or i ideal orientation level

a_{rj} : Presents model technical coefficients

C_{ij} : Shows j variable coefficient in i ideal

This model has n variables, m ideals and s functional limitations and all of its mathematical relations are first rate.

4.3. Comprehensive scale method

As one of the several problem solving methods which do not get information from decision maker, this method solves problems so that difference between each objective function and optimal value will become minimal. A problem with P linear objective functions which all of its constraints are first rate is explained as follows (Mehregan [8]):

$$\begin{aligned}
 &Max Z = [Z_1, Z_2, \dots, Z_p] \\
 &St : \\
 &g_i(x_j) \begin{cases} \leq \\ \geq \\ = \end{cases} b_i, \quad i = 1, 2, \dots, m \\
 &x_j \geq 0, \quad j = 1, 2, \dots, n
 \end{aligned} \tag{3}$$

Problem solving through the comprehensive scale method necessitates three steps:

First step: solving P linear planning problems which each one having a different objective function from a problem with P objective functions.

Second step: creating a table of optimal answers from step 1. If there was an ideal answer among the obtained answers, that would be the final answer.

Third step: obtaining the preferred answer. The final answer is obtained as the result of solving the following model:

4.4. Presidency optimization method (lexicography)

This method is one of the solving problem methods with several objective functions in getting information mood. At first, all considered objectives are ranked according to their importance by decision maker. Then, problems with the most important objective are optimized, and with retaining the optimal value for the most important objective, the second objective is optimized too, and this cycle goes on (Mehregan [7]).

The solution of a problem with several objectives with the lexicography method is as follows:

If among **P** objectives, the most importance one is shown with Z_1 and the next most important objective with Z_2 , the first problem that must be solved is:

$$\begin{aligned} & \text{Max } z_1 = z_1(x_j) \\ & \text{St:} \\ & g_i(x_j) \leq b_i, \quad i=1,2,\dots,m \\ & x_j \geq 0, \quad j=1,2,\dots,n \end{aligned} \quad (5)$$

If optimal answer to the above problem was unique with Z_1^* value, the approach would end and optimal answer would be obtained. Otherwise, the second mode which must be solved with adding the endeavor that guarantees lack of change in the first objective is as follows:

$$\begin{aligned} & \text{Max } z_1 = z_1(x_j) \\ & \text{St:} \\ & g_i(x_j) \leq b_i, \quad i=1,2,\dots,m \\ & z_1(x_j) = z_1^*, \quad j=1,2,\dots,n \\ & x_j \geq 0 \end{aligned} \quad (6)$$

This trend continues in this way for all objectives. To decrease optimal sensitivity value of objective function in proportion to lack of change in other optimal values, it'd better optimize second objective function provided that first objective optimization decreases by the point which its value is determined with decision maker and tolerance. Thus, a K stage problem is as follows:

$$\begin{aligned} & \text{Max } z_k = z_k(x_j) \\ & \text{St:} \\ & g_i(x_j) \leq b_i, \quad i=1,2,\dots,m \\ & z_l(x_j) = z_l^* - \delta_l^*, \quad l=1,2,\dots,(k-1) \\ & x_j \geq 0, \quad j=1,2,\dots,n \end{aligned} \quad (7)$$

4.5. Specific vector method

The following steps must be considered in specific vector method to calculate weights for determining objective priorities (Mehregan [7]):

Step1: form a pair comparison matrix. Matrix $[A-\lambda I]$

Step2: determine Value λ determinant and set it as zero and calculate $[A-\lambda I]$

Step3: calculate Relation, use the aforementioned $[A-\lambda_{\max} I] \times W = 0$ and put it in λ_{\max} name λ

Step 4: greatest Relation to calculate weight values. Is an scalar which W is the specific vector and λ in the above relations W is the weight vector and is specific value for A matrix. λ

5. Problem description and model construction

Modeling requires three following processes of introducing decision variables, determining decision variables coefficients and objective functions, and determining constraints. Presenting average rails of financial (x_j) in ($j=1,2,3,\dots,6$), decision variables are shown with procurement in **i** methods. Six fold methods are: current interest-free loan deposits, saving interest-free loan deposits, regular short-term investment deposit, net short-term investment deposit, long-term investment deposit and private surety bond cash deposit, respectively.

$$C_j = C'_j \cdot x_j + C''_j \cdot x_j \quad (8)$$

Decision variables coefficients are defined as following:

C'_j : total cost of financial procurement in **i** methods

C''_j : Coefficient of nonoperational cost of financial procurement in **i** methods

Non operational coefficient cost of financial procurement in **i** method. C'_j --

5.1. Objectives of the model

Three objective functions are considered to meet the objective of the survey that is optimal integration of resources procurement:

1-The minimum total cost of financial procurement in each method of financial procurement is determined through:

$$\text{Min} Z_1 = \sum_{j=1}^6 (c'_j + c''_j)(x_j) = \sum c_j \cdot x_j \quad (9)$$

2- The maximum average sum of resources in each year is calculated through:

$$\text{Max} Z_2 = \sum_{j=1}^6 x_j \quad (10)$$

3- The proportion of total growth of n years resources to n-1 years is obtained through:

$$\text{Max} Z_3 = \sum_{j=1}^6 x_j + K \quad (11)$$

Where K is difference rates of total resources in n years proportional to n-1 years.

In this study, the specific vector method and pair comparisons are used to determine objective priority and the following weights are obtained:

$$W_1 = 0.5936, W_2 = 0.2503 \text{ and } W_3 = 0.1561$$

So, Z_1 is in first priority, Z_2 is in second priority and Z_3 is in third priority. Since the third objective is achieved as the result of obtaining the second objective and the third objective is the next priority after the second objective, the third objective is excluded and the problem will be solved with first and second objectives.

5.2. Constraints of the model

The constraints of the model are defined as follows:

1- The model necessitates an average growth of total resources in each year (i.e. reaching a real average value of total resources absorbed in different ways):

n: real average of total absorbed deposits in each year

$$\sum_j x_j \geq n, (j=1,2,3,\dots,6) \quad (12)$$

2- It requires achieving a determined objective for each year according to bank policies

m: average of determined rial objectives in each year

One of the constraints will be ineffective in solving the problem due to covering two above constraints.

$$\sum_j x_j \geq m, (j=1,2,3,\dots,6) \quad (13)$$

3- Bounded constraints in getting information mood will be added to the model as follows:

$$u \leq x_j \leq L, (j=1,2,3,\dots,6) \quad (14)$$

U: Real average of rial price for xj methods in i years

L: Real average of rial price for xj methods in i+1 years

Considering the objectives and constraints of the model, the final models are as follows:

5.3. First mood model (without getting information)

$$MinZ_1 = \sum_j C_j \cdot x_j$$

$$MinZ_2 = \sum_j x_j$$

st:

$$\sum_j x_j \geq n \quad (15)$$

$$\sum_j x_j \geq m$$

$$x_j \geq 0, (j=1,2,3,\dots,6)$$

5.4. Second mood model (with getting information)

$$MinZ_1 = \sum_j C_j \cdot x_j$$

$$MinZ_2 = \sum_j x_j$$

st:

$$\sum_j x_j \geq n$$

$$L \leq x_j \leq u, (j=1,2,3,\dots,6)$$

(16)

Now, the ideal planning model is presented in the second step of modeling:

-The decision variables of the model are the same as the previous variables which are defined as 8 ideals (d_i^-, d_i^+). Variables deviations from the ideal are as follows:

$d_1^-(A_1)$ a= negative deviation of total cost in financial procurement from ideal value.

$d_1^+(B_1)$ = positive deviation of total cost in financial procurement from ideal value.

$d_2^-(A_2)$ B= negative deviation of total deposits from determined ideal.

$d_i^+(B_i)$ = positive deviation of total deposits from determined ideal.

$d_i^-(A_i)$ = negative deviation of xj resource value from determined ideal.

$$(j=1,2,3,\dots,6) \quad (i=3,4,5,\dots,8)$$

5.4.1. Constraints

Ideal (1): management should consider that total cost of financial procurement methods in each year is not more than n:

$$\sum_j C_j \cdot x_j + d_1^- - d_1^+ = n, (j:1,2,\dots,6) \quad (16)$$

Ideal (2): average of total deposits should not be more or less than k:

$$\sum_j x_j + d_2^- - d_2^+ = k \quad (17)$$

Ideal (3): average rial price of financial procurement in x1 method(s) is not more or less than F:

$$x_1 + d_3^- - d_3^+ = F \quad (18)$$

Ideal (4): average rial price of financial procurement in x2 method(s) is not more or less than H:

$$x_2 + d_4^- - d_4^+ = H \quad (19)$$

Ideal (5): average rial price of financial procurement in x3 method(s) is not more or less than S:

$$x_3 + d_5^- - d_5^+ = S \quad (20)$$

Ideal (6): average rial price of financial procurement in x4 method(s) is not more or less than L:

$$x_4 + d_6^- - d_6^+ = L \quad (21)$$

Ideal (7): average rial price of financial procurement in x5 method(s) is not more or less than R:

$$x_5 + d_7^- - d_7^+ = R \quad (22)$$

Ideal (8): average rial price of financial procurement in x6 method(s) is not more or less than T:

$$x_6 + d_8^- - d_8^+ = T \quad (23)$$

5.4.2. Objective functions

In objective functions of the ideal planning model, undesirable deviations of variables from the ideals should be minimized. The first ideal of this survey is related to bank resources procurement cost in which the positive deviation of (d_1^+) from the ideal (cost increase) is undesirable and should be minimized.

In order to reach the determined ideals, both positive and negative deviations of variables (d_1^-, d_2^+) need to be minimized. Therefore, the ideal function of the model in this survey is as follows:

$$Min = (d_1^+, d_i^-, d_i^+)$$

St:

$$\sum_j C_j \cdot x_j + d_1^- - d_1^+ = n$$

$$\sum_j x_j + d_2^- - d_2^+ = k$$

$$x_1 + d_3^- - d_3^+ = F \quad (24)$$

$$x_2 + d_4^- - d_4^+ = H$$

$$x_3 + d_5^- - d_5^+ = S$$

$$x_4 + d_6^- - d_6^+ = L$$

$$x_5 + d_7^- - d_7^+ = R$$

$$x_6 + d_8^- - d_8^+ = T$$

$$(i = 2, 3, 4, \dots, 8)$$

$$(j : 1, 2, \dots, 6)$$

$$x_j, d_i^+, d_i^- \geq 0$$

6. Results

The findings of this study include two main parts which provide answers to the secondary and main questions respectively: resources procurement cost calculation in different ways and modeling and model solving.

6.1. Results of the calculation of resources procurement cost

In this section, real operational ratios of resources procurement methods, nonoperational ratios of resource procurement methods and total cost of resources procurement in all methods are presented.

6-1-1. Real operational cost ratio

Considering the determined operational ratio by the central bank, and the results of studies about the factors needed in formula number 1, real operational cost ratio has been calculated. The calculated ratios of 5 deposit groups (one, two, three, four, and five years deposits) are used to obtain long-term real operational cost ratio with regard to average of these resources in balance average area, and the results are presented in Table 1.

6-1-2. Nonoperational cost ratio

This ratio has been calculated with the second formula and its calculations including average of resources procurement methods and some other factors. It has been calculated for each method in 31 statistical society branches for 4 years. Then, for all branches, balance average ratios have been used to calculate nonoperational cost ratio in Zanjan. Resources average has been obtained in two ways: at first we use monthly average (12 months) for current and saving interest-free loan deposits and surety bond cash deposit, and then we calculate resources average with regard to payable operational cost for profitable deposits. The results are displayed in Table 2.

Table 1
 Real operational ratios of different resources from 1384(2006) to 1387(2009)

Real operational profit ratio	1387 (2009)	1386 (2008)	1385 (2007)	1384 (2006)
current interest-free loan deposit	-0.26	-0.2	-0.2	-0.2
saving interest-free loan deposit	2.18	2.28	2.28	2.28
regular short-term investment deposit	8.5	8.5	8.5	8.5
net short-term investment deposit	19.8	19.2	14	11
One year long -term investment deposit	19.2	19.3	18	16

Two years long-term investment deposit	19.1	19.4	18.7	19.5
Three years long-term investment deposit	19.7	19.5	19.2	20.4
Four years long-term investment deposit	21.8	19.7	19.5	20.8
Five years long-term investment deposit	22	19.8	19.8	21
Long-term investment deposit	20.7	19.4	19.1	19.1
Private surety bond cash deposit	-0.26	-0.2	-0.2	-0.2

Table 2

Nonoperational cost ratio of the deposits of the Commercial Bank of Zanzan from 1384(2006) to 1387(2009)

Private surety bond cash deposit	Long-term investment deposit	net short-term investment deposit	regular short-term investment deposit	saving interest-free loan deposit	current interest-free loan deposit	year
1.81	1	1.92	4.93	8.62	15.55	1384
0.5	0.8	1.73	4.4	9.3	10.16	1385
0.2	0.6	0.7	3.22	6.47	8.33	1386
0.2	0.7	0.5	3.84	7.05	10	1387

6.1.3. Total cost of resources procurement in different methods

Total cost ratios of resources procurement methods are the sum of real operational cost ratio and nonoperational cost ratio (i.e. the results of Tables 1 and 2) which are

presented in Table 3. The rial costs of resources procurement methods are calculated via multiplying total cost ratio of each method by the resource rate (Table 3 × Table 4) and then the average of area resources and resources procurement cost (rial price) are presented in Tables 4 and 5, respectively.

Table 3

Total cost ratio of the deposits of the Commercial Bank of Zanzan from 1384(2006) to 1387(2009) (values are in percent)

Private surety bond cash deposit	Long-term investment deposit	net short-term investment deposit	regular short-term investment deposit	saving interest-free loan deposit	current interest-free loan deposit	year
1.61	20.1	12.92	13.43	10.9	15.35	1384
0.3	19.9	15.73	12.9	11.58	9.96	1385
0	20	19.9	11.72	8.75	8.13	1386
-0.06	21.4	20.3	12.34	9.23	9.74	1387

Table 4

Average of resources of Zanzan Commercial Bank in different methods from 1384 to 1387(2006-2009) (values are in million rials)

Average of	Private surety	Long-term	net short-term	regular short-	saving	current	year
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	total area resources	bond cash deposit	investment deposit	investment deposit	term investment deposit	interest-free loan deposit	interest-free loan deposit	
average of total	667009	Private 12231	Long 221992	net short 972	regular 186918	saving 96367	current 197167	year 1384
	1076933	93724	252346	6157	186918	114394	423394	1385
	1741312	170589	656841	63398	257443	153706	439335	1386
	2023425	291455	513781	250054	289214	177972	500949	1387

Table 5
 Total cost of resources procurement of Zanjan Commercial Bank in different methods from 1384 to 1387(2006-2009) (values are in million rials)

Variables	Based answer $\min z_1$	Answers of the model by second objective function ($\max Z_2$)				
		$z_1^* = 0.02\delta$	$z_1^* = 0.04\delta$	$z_1^* = 0.06\delta$	$z_1^* = 0.4919\delta$	$z_1^* > 0.4919\delta$
Z_1^*	104283	106369	108454	110540	155589	
Z_2^*	667009	755599	773385	788915	1076933	
X_1^*	197367	197367	197367	197367	197367	
X_2^*	69367	103646	114394	114394	114394	
X_3^*	138280	138280	139951	155481	186918	Lack of rational answer
X_4^*	972	972	6157	6157	6157	
X_5^*	221992	221992	221992	221992	252346	
X_6^*	12231	93724	93724	93724	93724	

6.2. Results of modeling and model solving

In this section, the solutions of the constructed models are presented and compared using the calculations in the previous section and the introduced models in different methods. It should be noted that only the results of calculations for one year (i.e. 84(2006)) are presented due to the identical results for all four years.

6.2.1. First kind of linear planning (without getting information) for the year 1384 (2006)

At first, the constructed model should be solved with each objective function based on the comprehensive scale method. The results for the first objective function minimum Z_1 are as follows and there is no rational answer for the second objective function maximum Z_2 .

$$x_1^* = 0, x_2^* = 0, z_1^* = 10 \text{ billion rials}, x_3^* = 0$$

$$x_6^* = 667 \text{ billion rials}, x_4^* = 0, x_5^* = 0$$

In results of the model, the resources procurement cost value is 104 billion rials and the real value decreases up to 10 billion rials. But the bank does not want to reach

this optimal answer because there is no possible way to absorb optimal value for surety bond cash deposit (x_6^*).

6.2.2. Second kind of linear planning (with getting information) for the year 1384(2006)

As Table 6 indicates, some analyses are presented for the solving results of the model by the preceding optimization method:

- 1- Optimal values of the solving model for the first objective function are identical to the real values and their lower limitation.
- 2- Financial procurement methods integrations change in relation to tolerance changes δ and increasing Z_1^* value in the solution of the model for the second objective function. Z_2^* value increases and accessible resources of Z_1^* changes are different with regard to price as cheap resources in their first priorities have the most changes. Solving the model for the second objective function, decision maker can attribute different values to tolerance. In this survey, several numbers have been considered to study Z_1^* effects on Z_2^* value.

Table 6
 Results of the model for the first and second objective functions (values are in million)

area resources	deposit	deposit	deposit	deposit	loan deposit	loan deposit	
104283	197	44620	126	7693968	25422	30265	1384
130996	281	50217	969	24112	13247	42170	1385
223323	16573387	131368	12616	30172	13449	35718	1386
261443	55811212	109949	50761	35689	16427	51397	1387

3-The percentage of Z_1^* changes is obtained which the rates of resources procurement methods increase in relation to it and the problem has no rational answer with respect to its higher percentage of changes.

6.2.3. Objective programming for the year 1384 (2006)

The optimal answer after solving the model is as follows:
 $x_1^* = 197167, x_3^* = 1380280, x_5^* = 22922, d_1^* = 0.35$
 $x_2^* = 96367, x_4^* = 972, x_6^* = 12231$

For other variables which have zero value:
 1-we cannot reach the first ideal. Their variation is so low and their value is 0.35 million rials. Thus, based on $d_1^+ = 0.35$, we confront increase in cost.

2-we can reach the remaining ideals (2 to 8) and as the deviation of variables from ideals is zero, we have $(d_i, d_i^+, (i=2,3,4,...,8))$.

6.2.4. Comparison of the results of applied models

For the sake of comparison, the results of applied solving models (i.e. LP and GP models) are presented in Table 7 for the year 1384(2006). With regard to the optimal answers, the LP primary values are more optimal than others but they are not achievable. The LP secondary optimal answers (getting information) are identical to the optimal answers of GP model probably because of equality of the constraints values of LP model to the ideals of GP model. The results of comparison of optimal values for the years 1385 and 1386 (2007-2008) are identical to the results for the year 1384(2006).

1. With focus on the cost calculation of different resources procurement methods, we can conclude that attention must be paid to the total cost of each resources procurement method that is the sum of operational and nonoperational cost calculations. It is necessary to consider real operational cost against operational one (on account profit ratio) which is determined by central bank annually.

2. Current interest-free loan among nonoperational costs and long-term investment deposit among real operational costs are the most expensive resources in Zanjan whereas surety bond cash deposit is the cheapest resources and current interest-free loan deposit and regular short-term investment deposit fall in between.

3. Regarding the range of changes in operational cost, nonoperational cost and the average of absorbed resources in net short-term investment deposit, we suggest that because of the relative stability of nonoperational cost and entity of this method, sensitivity of the method toward operational cost changes is too high.

4. As with the presented models and their solutions, it is possible to introduce a mathematical method for finding an optimal integration of resources procurement methods, that is, a synchronized optimization of opposed objectives (cost decrease and resource increase). But considering the results of the model in the first mood (without getting information), we obtain an inaccessible optimal point. The results of the model in the second

Table 7
 Optimal answers of GP and LP models in 1384(2006) (values are in million rials)

Optimal answer	LP models		GP model
	Without getting information $0 \leq x_j$	In getting information mood $u \leq x_j \leq L$	
Z_1^*	10000	104283	104283
Z_2^*	667009	667009	667009
x_1^*	0	19167	19167
x_2^*	0	96367	96367
x_3^*	0	138280	138280
x_4^*	0	972	972
x_5^*	0	221992	221992
x_6^*	667009	12231	12231

7. Conclusions

Several conclusions can be drawn from the results of this study:

mood with ideal planning and limitation or rational (suitable) ideals must be determined in the modeling and resources procurement methods, respectively.

The findings of the study promise several implications. Having obtained an optimal integration of resource procurement methods, we suggest that separate annual objectives should be determined for each resource absorption method instead of general annual objectives for resource absorption. Besides, cost of annual resource procurement can be estimated; at first for resources in total and then for each method separately. In addition, mathematical planning may be used to determine objectives with regard to resources and cost. After determining optimal integration of resources procurement based on mathematical models, accessible and rational objectives can be identified based on calculated optimal integration. Last but not least, about the total cost of resources procurement methods calculated in this paper, we suggest that the percentage of costly methods (current interest-free loan deposit and long-term investment deposit) may be subtracted by region resources integration and its cost may be added to cheap resources (surety bond cash deposit).

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