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OPTIMAL ALLOCATION OF BANK CREDIT AMONG AGRICULTURAL SUBSECTORS UNDER UNCERTAINTY CONDITION

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Abstract

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One of the institutions that play an important role in financing the agricultural sector is Agricultural Bank. Since there is still no specific model for optimal allocation of Agricultural Bank credits in Iran, this research seeks to provide an optimal model for allocation of credits using multi-criteria linear programming based on Analytic Hierarchy Process (AHP) and fuzzy logic, considering the risk and uncertainty conditions. The study period is related to the data of Agricultural Bank between 2011 and 2015. Using Cochran's Formula, the sample size has been calculated 39 people out of the statistical population including all bank experts in Mazandaran province. Results show that the current model of credit allocation in Agricultural Bank is not optimal so that the first prioritization of credit allocation should belong to agricultural industries and agricultural services followed by farming, livestock, non-agricultural sector, horticulture, poultry, fishery, natural resources and machinery respectively.

Key words: optimal allocation; agricultural bank credits; multi-criteria linear programming; analytic hierarchy process; risk and uncertainty

Introduction

Achieving development and improving the quality of life are the ideals that have occupied the human mind. Development will be realized when an optimal use is made of all of the production factors, facilities and resources of the country (Ghadermarzi, 2015). Economic growth is considered an important goal of any economy which cannot be achieved without capital, which in turn arises from savings, and managing this flow is thus of particular importance. With that in mind, managing the savings and using them in productive investments are among the main tasks of the banking system. Since the past decades, the manufacturing sector has been facing the lack of liquidity, while the economy has been facing the increased liquidity and inflation. Non-optimal allocation of credits for the financing of the production projects and the diversion of the resources towards unproductive and transaction sectors during the recent decades and particularly in recent years have not only made the national production encounter a severe crisis, but also brought about a sharp increase in the amount of the bank arrears and created serious doubt in the effectiveness and legitimacy of the banking system (Bagheri Pormehr & Taheri, 2014). As one of the most important economic pillars of any society, banks have the task of collecting short-term and medium-term savings of the community and allocating them as optimally as possible. If the economic system of a society is likened to the human body, the banking system may be likened to the circulatory system. This system collects the required funds and redistributes them using the signs that it receives from different sectors of the economy. These signs in a society's economic organization include each sector's obtaining profits and efficiency while complying with other legal rules and regulations in the society (Naghshineh et al., 2013).

Agriculture is of great importance as one of the major production activities in most countries, especially in devel-

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oping countries (Mir Ahmadi and Torkamani, 2010). The agricultural sector is of great importance in Iran's economy for such reasons as supplying the community's food, income generation, production of the raw materials needed for other sectors, facilitating widespread employment, creating balance in the labor and capital markets, the existence of the natural and comparative advantages of the country in the production of certain agricultural products, the lack of need for highly complex technology and specialties, little need for foreign investment and the short time of investment return on investment (Akbari and Sharif, 2006). Agricultural development has different components, each of which has particular importance. One of these components is the return on investment in this sector (Taghiloo and Abdollahi, 2013). Considering the importance of the agricultural sector and the attempts made by the authorities to mechanize and improve the efficiency and productivity of this sector on the one hand, and considering the fact that most of the people working in this area have low-level income on the other hand, it is particularly important to allocate bank credits to this sector optimally so as to support the people working in this area since the total credits granted to the applicants in this sector are considerably limited despite the large number of applicants and sub-sectors that apply for these credits. Since currently there is no specific model for the optimal allocation of credits in Agriculture Bank of Mazandaran Province, the present research seeks to provide a model for the optimal allocation and distribution of credits among different agricultural sectors, so that the credit distribution system of this bank may be optimized by considering the limitations faced by the bank and the conditions of uncertainty, and by using multi-criteria linear programming based on Analytic Hierarchy Process (AHP) and fuzzy logic.

Literature and background research

Several studies have been conducted in recent years on the topic of allocation of bank credits using ranking methods including AHP, Fuzzy AHP, TOPSIS, Numerical Taxonomy, etc. Here we review the results of some studies closer to the methodology used in our research.

Mohammadnejad et al. (2015) conducted a study to analyze the relationship between bank credits and economic growth and to account for the most appropriate model of economic growth for Iran. The results of the estimation using the selected models revealed that the granted credits of production have the greatest effect on the non-oil sector and that the agricultural sector is of high significance in the non-oil sector. That's why it is suggested that the planning system in the banking and macro levels should be modified in such a way that the flow of credits can be directed towards the non-oil sector (and particularly to the agricultural sector). Their results confirmed the Hasanov & Huseynov's findings in Azerbaijan (2013) which showed that bank credits have a positive impact on non-oil tradable sectors output both in the long- and short-run.

Makian et al. (2010) carried out a study in which they investigated the optimality of the granted bank credits by Tehran Agriculture Bank based on risk and fuzzy logic in Iran.

Mandic et al. (2014) ranked Serbian banks in terms of indexes such as stock, resources, current assets, cash, net interest income etc. and finally concluded that Banca Intesa had the highest score and the best ranking among the banks of this country using fuzzy AHP and TOPSIS methods.

Che et al. (2010) studied financial enterprises in Taiwan to choose the important index in loaning evaluation using Fuzzy Analytic Hierarchy Process (FAHP) and to establish one complete and efficient loaning decision-making module with its weights and Data Envelopment Analysis (DEA). A large number of firms were simultaneously evaluated based on multiple criteria and a decision for granting loans was made in the evaluation process. In addition, a practical study demonstrated the effectiveness of the solution proposed by their methodology.

Regarding the direct relationship between bank credits and economic growth, we can also mention some studies particularly those conducted recently by Caporale and Helmi (2016), Kork Maz (2015) and Olowofeso et al. (in Nigeria) (2015).

Research Method

Research method and modeling

The current study aims identifying the optimal model of allocation of Agricultural Bank credits to applicants in various economic sub-sectors of the agricultural sector in Mazandaran Province. For this purpose, the most important and influential indexes in the optimal and influential distribution of bank credits (some of which are qualitative and some are quantitative) are first determined with the help of a questionnaire and via interviews with the experts of the credit sector of Agricultural Bank of Mazandaran Province, and the weights and the degree of priority of each one of the alternatives (applicants of the credits in the sub-sectors of agriculture) were determined at the next stage using Expert Choice Software and with the help of the Analytic Hierarchy Process (AHP), which is one of the best and most accurate multi-criteria decision-making methods (Ghodsipour, 2005). These weights actually represent the coefficients of objective function in the mathematical programming model of this research. After the weights

and the degree of priority of each one of the sub-sectors are determined, the monetary and foreign exchange credits of the bank to each one of the various sub-sectors of agriculture should be optimally allocated. Like any other enterprise, the banking system also encounters many limitations during this process. These limitations are indeed the limitations of the mathematical programming model of this research (financial constraints, managerial constraints, legal constraints, etc.). The effects of the fluctuations and uncertainty conditions on the decisions made by the bank managers and economic experts are very important in real-world situations, especially in the financial and banking affairs and activities. Therefore, we can apply fuzzy logic in the right-hand parameters of the mathematical programming model, and thus involve the range of fluctuations and changes made in the total inventory of each limitation in the model results (Callahan, 2003). For this purpose, we can calculate the amounts of these fluctuations and enter them in the linear programming model of this research by help of fuzzy logic by referring to the statistical data of the previous financial period (2011-2015) collected by the Iranian Center for Statistics and Information of Agriculture Bank. The decision variables of the model used in this research, which are indeed the unknown parameters, represent the credits that should be paid to each one of the various agricultural sub-sectors by the bank, so that the bank gains the greatest utility despite the limitations ahead. The amounts of credits granted to each of the sectors are displayed with the variables X_1 to X_{10} respectively as can be seen in Table 1.

Finally, we can determine the optimal amount of credits assigned to each sector using WinQsb Software. The fuzzy linear programming model of the present research is shown in Equation (1), where w_j represents the degree of priority of the j-th sub-sector of the credits and is determined using AHP method. X_j represents the amount of the credit that should be allocated by the bank to the j-th sub-sector, $\tilde{b}_i$ represents the total floating inventory of the i-th source which is available to the bank and also is a fuzzy number and represents the amount needed from the i-th source for credit allocation to the j-th sub-sector.

$$\begin{aligned} &Max\ z = \textstyle\sum_{j=1}^{n} w_j x_j \\ &s.t: \\ &\textstyle\sum_{j=1}^{n} a_{ij} x_j (\leq = \geq) b_i,\ \forall i\ .\ 1 \leq i \leq m \quad \tilde{b}_i = [b_i,\ b_i + p_i] \\ &x_j \geq 0,\ \forall j\ .\ 1 \leq j \leq n \end{aligned} \tag{1}$$

The membership function of the fuzzy number $\tilde{b}_i$ has been given in Equation (2):

$$\mu\tilde{b}_i = \begin{cases} 1 & t < b_i \\ \dfrac{b_i + p_i - t}{p_i} & b_i < t < b_i + p_i \\ 0 & t > b_i + p_i \end{cases} \tag{2}$$

As the right – hand values of the programming model (1) are fuzzy, the answer to that question is also variable, which leads to fuzziness of the objective function. This is done by calculating z^u (z for the upper limit of the range of parameters) and z^i (z for the lower limit of the range of parameters) and Equation (1) is changed into the solvable Equation (3) using the rules of fuzzy logic, in which λ represents the risk and uncertainty parameter and is determined by solving the model.

$$\begin{aligned} &Max\left(Min\left[\mu\tilde{b}_1\left(\sum_{j=1}^{n} a_{1j}x_j\right),\ \mu\tilde{b}_2\left(\sum_{j=1}^{n} a_{2j}x_j\right),\ ...,\right.\right. \\ &\left.\left.\mu\tilde{b}_m\left(\sum_{j=1}^{n} a_{mj}x_j\right),\ \mu_{\tilde{z}}\left(\sum_{j=1}^{n} c_j x_j\right)\right]\right) \\ &\lambda = Min\left[\mu\tilde{b}_1\left(\sum_{j=1}^{n} a_{1j}x_j\right),\ \mu\tilde{b}_2\left(\sum_{j=1}^{n} a_{2j}x_j\right),\ ...,\right. \\ &\left.\mu\tilde{b}_m\left(\sum_{j=1}^{n} a_{mj}x_j\right),\ \mu_{\tilde{z}}\left(\sum_{j=1}^{n} c_j x_j\right)\right] \\ &\lambda(z^u - z^l) - \left(\sum_{j=1}^{n} c_j x_j\right) \leq -z^l \\ &\lambda\, p_i + \left(\sum_{j=1}^{n} a_{ij}x_j\right) \leq b_i + p_i,\ \forall i\ .\ 1 \leq i \leq m \\ &x_j,\ \lambda \geq 0,\ \forall j\ .\ 1 \leq j \leq n \end{aligned} \tag{3}$$

Study population and sample size

The study population includes all experts and managers working in the credit-allocation sector of Agriculture Bank

Table 1
The decision variables

Unit	Credits paid for Sector	Variable	Unit	Credits paid for Sector	Variable
Billion Rials[1]	Horticulture	X_2	Billion Rials	Farming	X_1
Billion Rials	Poultry	X_4	Billion Rials	Livestock	X_3
Billion Rials	Natural Resources	X_6	Billion Rials	Fisheries	X_5
Billion Rials	Agricultural Services	X_8	Billion Rials	Agricultural Machinery	X_7
Billion Rials	Non-Agricultural	X_{10}	Billion Rials	Agricultural Industries	X_9

[1]1$≈ 39500 Rials (Jan 2017)

in Mazandaran Province. A cluster and simple random sampling method has been used in this study. The sample size was determined as 43 experts using Cochran's Formula.

$$n = \frac{N \times z^2_{a/2} \times P \times (P-1)}{\varepsilon^2 \times (N-1) + z^2_{a/2} \times P \times (P-1)} = \frac{43 \times (1.96 \times 1.96) \times 0.5 \times 0.5}{(0.05 \times 00.05) \times (43-1) + (1.96 \times 1.96) \times 0.5 \times 0.5} = 38.7 \approx 39 \quad (4)$$

Specification of the model

The following points need to be considered for the mathematical programming modeling:

Understanding the purpose of the problem

The aim of this research is to develop the best model for optimal distribution of the credits of Agriculture Bank among different subsectors of agriculture, taking into account the constraints facing the managers and financial planners of the bank in order to achieve the highest level of utility for the bank using fuzzy linear programming multi-criteria technique:

$$Max\ z = \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_4 + \alpha_5 x_5 + \alpha_6 x_6 + \alpha_7 x_7 + \alpha_8 x_8 + \alpha_9 x_9 + \alpha_{10} x_{10} \quad (5)$$

In this equation, x_is represent the decision variables from Table 1 and α_is represent the objective function coefficients obtained by determining the priority of the decision variables from the results of the questionnaire.

Identifying the Decision Indexes of the problem

The investigations as well as the consultations with the experienced managers and experts of Agriculture Bank showed that the most important decision indexes that should be considered by this bank for allocation of credits to the sub-sectors of the agricultural sector are determined as follow:

1. The customers' degree of validity and return of debts (guaranteeing the return of the sum of principal and interest by the applicant.),
2. Duration of the return of principal and interest,
3. The Bankers' degree of expertise in providing different types of credits to each sub- sector of agriculture,
4. The credits' profitability degree for the bank in each one of the agricultural sub-sectors,
5. The number of applicants, or simply, the customers' desire or tendency to take credits in each one of the agricultural sub-sectors,
6. Imposing legal restrictions on banks by the Central Bank,
7. The risk level of granting credits to each agricultural sub-sector,
8. The need for foreign exchange credits,
9. The approach and policies adopted by the bank managers regarding credit allocation.

These indicators are displayed arbitrarily from T_1 to T_9.

Understanding the alternatives of the problem

The decision alternatives in this study represent each one of the agricultural sub-sectors applying for credits from Agriculture Bank. The careful analysis and consultations with experts of Agriculture Bank showed that the majority of customers and applicants of credits from this bank belong to the economic sub-sectors of the agricultural sector, including: 1. Farming, 2. Livestock, 3. Poultry, 4. Natural Resources (exploitation of forests and rangelands), 5. Horticulture, 6. Fisheries and Aquaculture (breeding fish and hunting shrimp), 7. Agricultural Services (channeling and mechanized irrigation, etc.), 8. Machinery and agricultural implements, 9. Industries dependent on the agricultural sector (handicrafts and carpet weaving industry, food industries, processing industries etc.) and 10. Activities not related to the agricultural sector.

These sectors which are in fact the decision-making alternatives are displayed arbitrarily from C_1 to C_{10} respectively.

Recognizing the limits of the problem, formulating and determining their technical coefficients

– Limitation in the total credits (Rial and Dollar) that can be granted by the bank

The interviews conducted with the Bank experts and a review of the data and statistics of the bank during the previous fiscal years (2011-2015) revealed that one of the major constraints faced by the bank is the limitation of the total credits including the monetary (Rial) and the foreign exchange (Dollar) credits that can be granted by the bank to each one of the applicants in various sub-sectors of agriculture.

In order to include these limitations in solving the decision-making problem, we can observe the algebraic form of these limitations for the monetary (Rial) and foreign exchange (Dollar) credits in Equations (6) and (7) respectively.

$$\sum_{j=1}^{10} x_j \le (\widetilde{RC}) \quad (6)$$

$$\sum_{j=1}^{10} a_{fxcj} x_j \le (\widetilde{FXC}) \quad (7)$$

Equation (6) shows that the total monetary credits in the agricultural sub-sectors can at most be $\widetilde{RC}$ billion Rials. In this equation, $\widetilde{RC}$ represents the total monetary (Rial) and foreign exchange (Dollar) credits transferable by Agriculture Bank, the value of which is shown in the equation in the fuzzy and volatile form in order to show the influence of the risk conditions.

On the other hand, Equation (7) shows the sum of foreign exchange credits that can be transferred by the bank to the applicants in the economic sub-sectors, where a_{fxcj} repsresents the technical coefficient of the equation and the average foreign exchange credits (in billion dollars) per each one billion Rials of the monetary credits received by the credit applicants in the $j^{\text{-th}}$ economic sub-sector, and its value is calculated by dividing the average foreign exchange credits granted to each one of the sub-sectors by the average monetary credits granted to that sub-sector between 2011 and 2015. Also in Equation (7), ($\widetilde{FXC}$) represents the total number of foreign currency credits that can be transferred to the credit applicants in the fuzzy form. A review of the statistics and data of Agriculture Bank in Mazandaran Province during the research period showed that unfortunately this bank has had no specific activity in foreign exchange credit payment. That's why Equation (7) is not included in the model and is considered zero.

– The legal constraints imposed by the Board of Directors of Agriculture Bank

Agriculture Bank considers the total credits granted to the farming, horticulture and agricultural machinery sectors equal to the sum of the credits granted to the livestock, poultry and fisheries sectors. It also considers the total credits granted to the farming, horticulture, livestock, poultry, fisheries and natural resources sectors at most equal to the total amount of credits granted to the agricultural machinery, agricultural services and agricultural industries sectors. Furthermore, it also assumes that the total credits transferred to the livestock sector should at least be equal to the total credits granted to poultry and fisheries sectors, and that the total credits granted to agricultural industries should at least be equal to the total credits granted to the agricultural machinery and agricultural services sectors (Makian et al., 2010).

$$\begin{aligned} &x_1 + x_2 + x_7 - x_3 - x_4 - x_5 = 0 \\ &x_1 + x_2 + x_3 + x_4 + x_5 + x_6 - x_7 - x_8 - x_9 \le 0 \\ &x_3 - x_4 - x_5 \ge 0 \\ &x_7 + x_8 - x_9 \le 0 \end{aligned} \tag{8}$$

– The legal restrictions imposed by the Central Bank

Specialized banks can allocate up to 10 percent of their total credits to the sectors out of their specialties.

$$x_{10} \le 0.1\widetilde{RC} \tag{9}$$

– The market and customer restrictions

A review of the statistics and data of the total amount of credits transferred to each sector during the research period indicated that the minimum amount of credits transferred to each sector has not been less than 2% of the total credits that can be transferred per year. A look at the performance of Agriculture Bank during the past years shows that this bank should be open to various credit customers due to the existing conditions of the credit market and the diversity of customers applying for loans for various agricultural subsectors. A simple mathematical calculation shows that the minimum transferred credits arising from the market and a customer restriction on each sector is 2%.

$$x_i \ge 0.02\widetilde{RC},\ \forall i,\ 1 \le i \le 10 \tag{10}$$

– The credits' non-negativity constraint

Since the amount of credits transferred to each sector is at least zero, the decision variables cannot take negative values.

$$x_i \ge 0,\ \forall i,\ 1 \le i \le 10 \tag{11}$$

Modeling the problem

Considering the importance of the agriculture sector in Iran's economy and the need to grant credits and financial assistance to the producers in this sector, the present research seeks to determine the optimal allocation of bank credits to each of sub-sectors of agriculture. Therefore, it is necessary and inevitable to consider the combined effect of several indicators in the decision-making process, the constraints ahead of the bank in credit allocation, the uncertainty issue and the existing volatility in the volume of the granted credits. This is why we have used fuzzy multi-criteria linear programming technique in this research in order to include all these parameters and to adopt an optimal and sound decision.

Investigations on the figures and data about the amounts of credits paid by Agriculture Bank during the research period showed that the least amount of granted credits was 8872.205 billion Rials in 2011, whereas the largest amount was 15 070.931 billion Rials in 2015. These figures will later be used as the pessimistic and optimistic values in fuzzy linear programming multi-criteria model to obtain the optimal levels of granted credits to each subsector under uncertainty condition. The objective function to maximize the utility of the bank in credit allocation has been defined considering the problem restrictions in Equation (12).

$$\begin{aligned} &Max\ z = \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_4 + \alpha_5 x_5 + \\ &\qquad + \alpha_6 x_6 + \alpha_7 x_7 + \alpha_8 x_8 + \alpha_9 x_9 + \alpha_{10} x_{10} \\ &s.t: \\ &\widetilde{RC} = [8872.205,\ 15070.931] \\ &x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} \le \widetilde{RC} \\ &x_{10} \le 0.1\widetilde{RC} \\ &x_i \ge 0.02\widetilde{RC},\ \forall i,\ 1 \le i \le 10 \\ &x_1 + x_2 + x_7 - x_3 - x_4 - x_5 = 0 \\ &x_1 + x_2 + x_3 + x_4 + x_5 + x_6 - x_7 - x_8 - x_9 \le 0 \end{aligned} \tag{12}$$

$$x_3 - x_4 - x_5 \geq 0$$
$$x_7 + x_8 - x_9 \leq 0$$
$$x_i \geq 0,\ \forall i,\ 1 \leq i \leq 10$$

Data and Empirical Results

Prioritization of the indexes of credit allocation to the sub-sectors of agriculture

In order to determine the priority of credit allocation among different agricultural sub-sectors, we have used a group AHP method in which the priority of the indexes over one another and the priority of alternatives over indexes are calculated from the geometric mean of the experts' viewpoints. The degree of importance and the priority of the indexes considered by experts of Agriculture Bank are as follow:

As shown in Table 2, "the customers' degree of validity and return of debts" and "the need for foreign exchange credits" are the most and least important indexes respectively from experts' viewpoints.

Prioritization of the alternatives for credit allocation among sub-sectors of agriculture

According to the experts' viewpoints and also the summarized effects and results of the 9 above-mentioned indexes, as shown in Figure 1, the first alternative, i.e. farming sector receives the highest score whereas the tenth one, i.e. the non-agricultural sector, has the lowest priority in credit allocation of Agriculture Bank. Horticulture, livestock, poultry, fisheries, natural resources, agricultural machinery, agricultural services and agricultural industries sectors are ranked from second to ninth respectively in the priority of credit allocation of this bank.

By weighting the decision variables in diagram (1) and extracting the required information, the final form of Equation (12) will be as follows:

$$Max\ z = 0.3108x_1 + 0.2032x_2 + 0.1663x_3 + 0.1x_4 + 0.0782x_5 + 0.0497x_6 + 0.0370x_7 + 0.0238x_8 + 0.0172x_9 + 0.0138x_{10}$$

s.t:

$$\widetilde{RC} = [8872.205,\ 15070.931]$$
$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 - x_7 + x_8 + x_9 + x_{10} \leq \widetilde{RC}$$

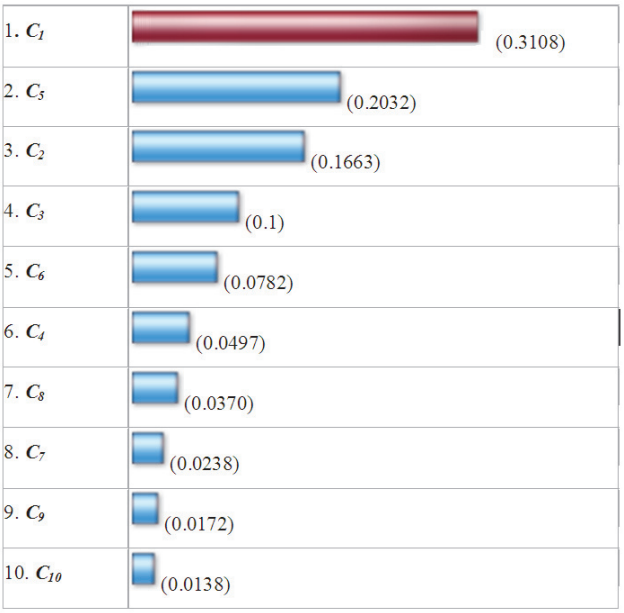

Fig. 1. The priority of credit allocation among different agricultural subsectors

$C_1 > C_5 > C_2 > C_3 > C_6 > C_4 > C_8 > C_7 > C_9 > C_{10}$

$$x_{10} \leq 0.1\widetilde{RC} \quad (13)$$
$$x_i \geq 0.02\widetilde{RC},\ \forall i,\ 1 \leq i \leq 10$$
$$x_1 + x_2 + x_7 - x_3 - x_4 - x_5 = 0$$
$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 - x_7 - x_8 - x_9 \leq 0$$
$$x_3 - x_4 - x_5 \geq 0$$
$$x_7 + x_8 - x_9 \leq 0$$
$$x_i \geq 0,\ \forall i,\ 1 \leq i \leq 10$$

Solving above multi-criteria programming model in WinQsb software under two scenarios (pessimistic; the least amount of granted credit & optimistic; the largest amount of granted credit), optimal levels of credit allocation under pessimistic and optimistic circumstances (z^l & z^u) are determined. Then, z^l & z^u are placed in equation 3 in order to reach optimal level of credit allocation among different subsectors of agriculture under uncertainty condition. The results under three scenarios are shown in Table 3. The opportunity cost

Table 2
The degree of the priority of the indexes considered by experts of Agricultural Bank

T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
0.4223	0.2074	0.1141	0.0925	0.0632	0.0365	0.0245	0.0155	0.0203

$T_1 > T_2 > T_3 > T_4 > T_5 > T_6 > T_7 > T_9 > T_8$

Table 3
The current and optimal pattern of bank credit allocation based on the minimum, maximum and uncertainty conditions in the volume of credit (Billion Rials)

Decision variables	Current pattern	Optimal pattern			
		Minimum (pessimistic condition)	Maximum (optimistic condition)	Uncertainty condition	Opportunity cost
X_1	3315.60482	1818.8020	3089.5410	3189.7210	0
X_2	2109.93034	177.4441	301.4186	202.7663	0
X_3	2260.63965	1818.8020	3089.5410	3189.7210	0
X_4	2411.34869	177.4441	301.4186	202.7663	0
X_5	452.12793	177.4441	301.4186	202.7663	0
X_6	301.41862	177.4441	301.4186	202.7663	0
X_7	753.54655	177.4441	301.4186	202.7663	0
X_8	1205.7448	1996.2460	3390.9600	3392.4870	0
X_9	904.25586	2173.6900	3692.3780	3595.2530	0
X_{10}	1356.38379	177.4441	301.4186	788.5685	0
The optimal value of	–	1038.1590	1763.4870	= 0.9841λ	–

of all activities is zero. To compare current and optimal patterns, the current level of credit allocation is also presented.

A Comparison between current and optimal model of credit allocation of Agriculture Bank among different agricultural subsectors in Mazandaran Province shows that the current model is by no means optimal and needs to be modified (Figure 2).

As shown in Table 3 and Figure 2, agricultural industries, agricultural services, farming and livestock sectors have attained the first to fourth ranks in receiving bank credits followed by non-agricultural activities, horticulture, poultry, fisheries, natural resources and machinery sectors respectively. These results seem more realistic due to the effects of the limitations and considering the risk and uncertainty condition. In addition, except for farming sector which receives almost optimal credit level, the current allocation of resources to other sectors is far from their optimal level so that horticulture, poultry and agricultural machinary sectors receive more credit than their optimal levels while agricultural industries and services receive less credit than what optimal model suggests considering uncertainty condition.

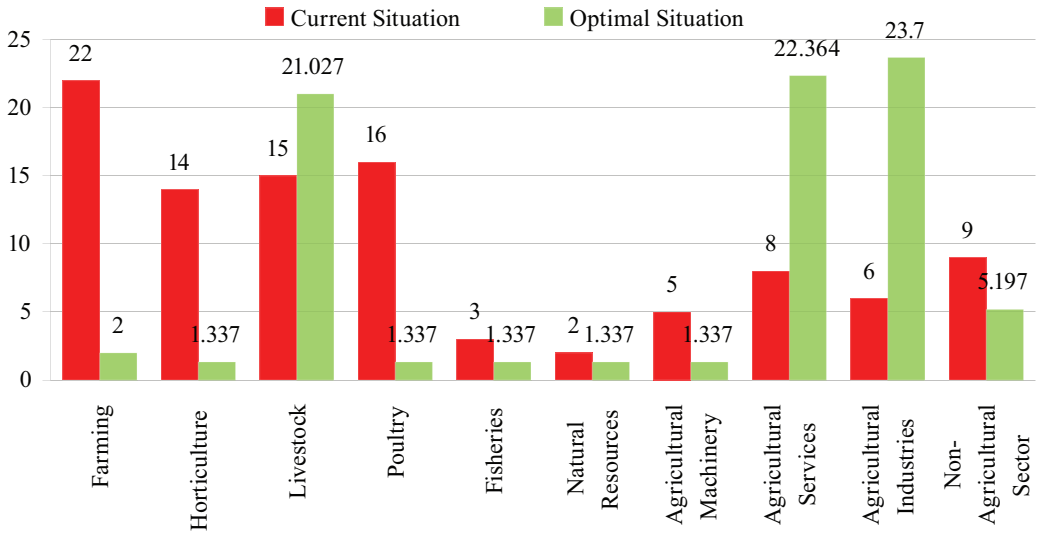

Fig. 2. Comparison between current and optimal model of credit allocation among different agricultural subsectors (in percent)

Conclusion and Suggestions

The results of this research indicate that the credit sector of Agriculture Bank in Mazandaran Province has paid little attention to the agricultural industries and services in this province. The reason for this may lie in the general fact in developing countries that governments neglect agricultural processing industries and in the absence of capital such sectors can't progress due to lack of technology. That is why their agricultural economy mainly relies on the export of unprocessed crops rather than processed foods. It is thus recommended that these sectors receive further attention in order to reach higher utility.

The wasting of credit resources in horticulture and poultry sectors is evident according to Figure 2 and this requires more attention from Agriculture Bank to prevent such diversions.

Based on the results of this research, the experts of the credit sector of Agriculture Bank are recommended to optimally allocate 21.027 percent to farming, 1.337 percent to horticulture, 21.027 percent to livestock, 1.337 percent to poultry, 1.337 percent to fisheries, 1.337 percent to machinery, 22.364 percent to agricultural services, 23.7 percent to agricultural industries and 5.197 percent to the non-agricultural sector, in which the opportunity cost of the bank could be zero in all activities. So, for example, the bank should decrease 14.67% and 12.67% of credits granted to the poultry and horticulture subsectors respectively and also increase 17.7% and 14.36 % of credits to the agricultural industries and services respectively so that it can move towards the optimal model.

The researchers are recommended to perform a similar study at the national or regional level in the country. Moreover, optimization of the model of credit allocation to each one of the agricultural subsectors can also be investigated separately. This study can be generalized to other economic sectors such as housing and industry and so on.

References

Akbari, N. and M.Sharif, 2006. Agricultural Economics, *Tehran, Allameh Tabatabai University Press* (Persian).

Bagheri Pormehr, S and J. Taherpour, 2014. Pathology of Granting Bank Credits and its Consequences, *Research Institute of Tadbir-e Eqtesad*, pp. 1-2. (Persian).

Callahan, J.C., 2003. An introduction to financial planning through Fuzzy linear programming. *Cost and Management*, **47** (1): 7-12.

Caporale, G.M. and M.H. Helmi, 2016. Islamic banking credit and economic growth: Some empirical evidence. *CESIFO Working Paper No. 5716 Category 7: Monetary Policy and International Finance.*

Che, Z.H., H.S. Wang and C. Chih-Ling, 2010. A fuzzy AHP and DEA Approach for Making Bank Loan Decisions for Small and medium Enterprises in Taiwan. *Elsevier, Expert Systems with Applications,* 37, pp. 7189-7199.

Ghadermarzi, H., 2015. Strategic planning of employment development in rural areas of Javanroud Township. *Quarterly Journal of Space Economics and Rural Development*, **11:** 109-130 (Persian).

Ghodsipour, H., 2005. Analytical Hierarchy Process (AHP), *Amirkabir Industrial University Press* (Persian).

Hasanov, F. and F. Huseynov, 2013. Bank credits and non-oil economic growth: Evidence from Azerbaijan. *International Review of Economics & Finance*, *Elsevier,* 27 (June): 597-610.

Kork Maz, S., 2015. Impact of bank credits on economic growth and inflation. *Journal of Applied Finance & Banking*, **5**(1): 57-69.

Makian, S.N., A.R. Nasser Sadrabadi and A. Sarlak, 2010. Determining the Optimal Model of Bank Credit Allocation Using Fuzzy Logic and Considering the Conditions of Risk (Case Study: credits granted by Tehran Agriculture Bank). *Journal of Economic Policy*, 4 (Autumn and Winter): 57-79 (Persian).

Mandic, K., B. Delibasic, S. Knezevic and S. Benkovic, 2014. Analysis of the financial parameters of Serbian banks through the application of the Fuzzy AHP and TOPSIS methods. *Elsevier, Science Direct, Economic Modelling,* pp. 30-37.

Mir Ahmadi, M. and J. Torkamani, 2010. The effect of credits on the macro variables of the agricultural sector in Iran. *Journal of Agricultural Economics Research*, **2:** 1-16 (Persian).

Mohammadnejad, N., M.H. Fatros, M.R. Ma'soumi, 2015. Analysis of the relationship between bank credits and economic growth. *Bi-quarterly Journal of Monetary-Financial Economics, (Former Knowledge and Development),* **22** (10): 1-21 (Persian).

Naghshineh, N., F. Hanifi, H.R. Kordlouei, 2013. Management of assets and bank debts by help of linear multi-objective programming with the econometric simulation, case study: X Bank. *Journal of Financial Engineering and Management of Securities,* **20:** 95-117 (Persian).

Olowofeso, E.O., A.O. Adeleke and A.O. Udoji, 2015. Impact of private sector credit on economic growth in Nigeria. *CBN Journal of Applied Statistics*, **6** (2): 81-101.

Taghiloo, A.A. and A. Abdollahi, 2013. Development of agriculture with an emphasis on the relationship between cities and villages, The case study of West Azarbaijan. *Quarterly Journal of Space Economics and Rural Development*, **2:** 29-50.

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