Plant Archives Volume 21, No 1, 2021 pp. 500-507 *e-ISSN:2581-6063 (online), ISSN:0972-5210*

Plant Archives

Journal home page: www.plantarchives.org

DOI Url: https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no1.070

OPTIMAL ALLOCATION OF BANK CREDITS TO APPLICANTS IN AGRICULTURAL SECTORS

Abouzar Nahvi, Mohammad Ghorbani*, Mahmoud Sabouhi, and Arash Dourandish

Department of Agricultural Economics, Ferdowsi University of Mashhad, 9177948974, Mashhad, Iran

Email: ghorbani@um.ac.ir

(Date of Receiving-09-11-2020; Date of Acceptance-30-01-2021)

ABSTRACT

Credit portfolio management is one of the fundamental aspects of banking that can lead to the loss of bank revenue if not properly managed. The expected return and risk in the choice of portfolio cannot be accurately predicted. Considering this impossibility and given the limitations faced by the banking system, this article uses the concept of interval numbers in the Fuzzy Set Theory to extend the Markowitz mean variance model to a non-linear interval multi-objective model. Three strategies were presented in this model, including optimistic, pessimistic, and mixed strategies, and the Genetic algorithm was used to solve the model. This model was ultimately examined at Keshavarzi Bank to determine the optimal credit portfolio. The results showed that this bank's current credit distribution model is different from the estimated optimal model. The present findings can provide managers with a roadmap for choosing the optimal portfolio consistent with the bank's preferences according to different estimates of return and risk, thus leading to the proper management of loans.

Keywords: Portfolio optimization, Agricultural credit, Interval programming, Bank

INTRODUCTION

The allocation of financial credits and facilities to clients for economic activities is one of the most important responsibilities of banks. Banks provide the financial resources obtained from their depositors as bank facilities and try to maximize their gains by providing applicants with these facilities in order to generate revenue for themselves and their depositors (Makian *et al.,* 2010). Banks' inability to properly manage their loan portfolios can lead to a credit crisis. Credit crisis is predominantly caused by inappropriate lending over a period of time that imposes loss on the lending institutions and investors. This issue has led to the development of more formal and accurate methods of optimization of credit payment and the minimization of the risk of loans. As such, the optimization of the credit portfolio has become a basic tool for increasing profits, reducing potential risks, and making managerial decisions about financial institutions (Metawa *et al.,* 2017).

Portfolio optimization is the process of finding the best combination of assets with the purpose of minimizing risk and increasing return in an investment (Kalayci *et al.,* 2019). In 1950, Harry Markowitz presented the basic portfolio model that became the foundation for modern portfolio theories and revolutionized finances (Rezaei *et al.,* 2016; Kalayci *et al.,* 2019).

Credit and financial institutions always try to make investments in areas with the lowest risk and highest return in order to survive in the capital market and also make the greatest profit(Asgarzadeh, 2006). Like other financial and credit institutions, Keshavarzi Bank also needs to determine the optimal credit lending portfolio, given its major role in supplying the credit needs of the agricultural sector. Considering the limitations of Iran's banking industry and the lack of variety in bank products, the main source of income for banks is the income from interest on bank facilities(mehrara and sadeghian, 2008). One of the ceaseless questions on this subject is the share that each economic sector should have, which highlights the importance and necessity of examining the credit portfolio. Given the limitations faced by the banking system, the present study seeks for the first time to provide bank managers and officials with an appropriate model to help find the best method of credit allocation to applicants in different economic sectors by considering different strategies. Given the crucial nature of such solutions and due to the lack of studies on banks based on this approach, this study offers an innovative assessment and uses non-linear interval multi-objective programing incorporating the meta-heuristic Genetic algorithm to solve the proposed model.

The publication of Markowitz' modern theory in 1952 led to a major revolution in portfolio optimization. Mathematical models and operational research are among the activities that have enabled portfolio optimization change in recent years. Many studies have been conducted on this subject. The results of some of them are discussed in this section. Using a linear programming model, Jao (2001) presented a model for the optimal allocation of bank credits in Hong Kong using bank credit limitations, legal constraints, etc. The results showed that the optimal model obtained is different from the current model of credit distribution to various economic sectors. In a study using a linear multi-objective programing model, Caplin and Kornbluth (2004) allocated the credits of several financial institutions in the US in the efforts to implement investment plans according to the risk and insecurity of these sectors. Their results showed that, compared to the multi-objective programing model used for the said financial institutions, the investment plans determined by the classic linear programing model have a higher profitability and a significantly greater risk. Chang *et al.,* (2009) investigated stock portfolio optimization using the genetic algorithm. Their main objective was to examine the efficiency of the genetic algorithm in solving the problem of stock portfolio optimization using different risk models. Their results showed that a smaller-scale stock portfolio is more efficient. In another study, Dia (2009) tried to choose an optimal portfolio of financial assets or stocks using a four-stage method under data envelopment analysis. Once the model's inputs and outputs were selected and decision-makers' preferences were determined, he used data envelopment analysis to calculate the efficiency of each examined financial asset, which enabled him to select the optimal portfolio in tune with the decision-makers' preferences. The results showed that, in agreement with similar studies conducted on this topic, the adopted technique could be easily used by investors for choosing the optimal portfolio. Rahnamay Roodposhti *et al.,* (2014) used the genetic algorithm to optimize the stock portfolio of investment funds. Their results showed that the genetic algorithm performs better than traditional methods. Moreover, the greater and bigger is the diversity of the portfolio, the more significant will be the performance of the genetic algorithm over the linear method. In an applied study, Agarana *et al.,* (2014) examined the optimization of loan portfolio management in Nigeria using goal programing. Given that the optimal portfolio they obtained is different from the present model, and taking into account the bank's objectives and the results obtained from the research, they suggested that using the optimal model can lead to the proper management of loans. In another study, Qin (2015) attempted to solve the problem of choosing a mixed stock portfolio by considering uncertain and random returns concurrently. The stock portfolio return variance in this study was based on the uncertainty theory. Relevant mean-variance models were introduced and analytical solutions were obtained for two samples of assets. The calculations showed the significance of the estimated model and the possibility of its use for choosing the optimal stock portfolio. In one study, Chao

Table 1.The amount of facilities paid to different sectors

row	Economic sector	2009	Percentage share	2010	Percentage share	2011	Percentage share	2012	Percentage share	2013	Percentage share	2014	Percentage share
x1	natural resources	140	0.2	192	0.2	143	0.1	175	0.1	408	0.2	220	0.1
x2	Gardening	4348	6.4	6093	6.5	7966	5.5	11182	7	14709	7	17389	7
x3	Carpet weaving and handicrafts	441	0.7	689	0.7	1183	0.8	1128	1	1485	0.7	1748	1
x4	fisheries and aquaculture	1127	1.7	1599	1.7	2764	1.9	3515	2	3773	1.8	4578	2
x5	Hospitality	391	0.6	618	0.7	553	0.4	238	0.1	388	0.2	465	0.2
x6	Agriculture	14115	20.8	22171	23.5	27907	19.4	29365	18	43604	20.7	53217	21
x7	Aviculture	4338	6.4	5990	6.4	10603	7.4	14925	9	17549	8.3	20860	8
x8	agricultural machinery	287	0.4	4071	4.3	5771	4	5941	4	9206	4.4	14220	6
x9	agriculture related industries	6601	9.7	2957	3.1	11638	8.1	13440	8	16848	8	23262	9
x10	activities unrelated to agriculture	1871	2.8	2434	2.6	4172	2.9	3554	2	10543	5	11316	4
x11	water and soil	1701	2.5	3135	3.3	4709	3.3	5818	4	5505	2.6	5494	2
x12	Greenhouse	929	1.4	2076	2.2	4263	3	5209	3	5720	2.7	6784	3
x13	beekeeping and silkworm	96	0.1	258	0.3	352	0.2	1309	1	690	0.3	384	0.2
x14	Business Services	7444	11	12519	13.3	3856	2.7	11467	7	13698	6.5	15053	6
x15	Animal husbandry	9045	13.4	13441	14.3	22201	15.4	26873	16	32000	15.2	35698	14
x16	Agricultural Services	13657	20.2	13330	14.1	34538	24	29685	18	30921	14.7	36687	14
x17	Agricultural Commerce	1220	1.8	2666	2.8	1243	0.9	1734	1	3183	1.5	6276	2
	Total Facility	67749	100	94238	100	143862	100	165556	100	210230	100	253651	100

The numbers are in billion Rials

Table 2. Upper and lower limit of returns (%)

Economic sector	Return	
	lower limit of returns	upper limit of returns
natural resources	865/0	906/0
Gardening	924/0	967/0
Carpet weaving and handicrafts	921/0	944/0
fisheries and aquaculture	921/0	939/0
Hospitality	864/0	896/0
Agriculture	910/0	914/0
Aviculture	960/0	969/0
agricultural machinery	975/0	981/0
agriculture related industries	913/0	923/0
activities unrelated to agriculture	878/0	906/0
water and soil	899/0	925/0
Greenhouse	0/946	948/0
beekeeping and silkworm	941/0	949/0
Business Services	899/0	923/0
Animal husbandry	898/0	908/0
Agricultural Services	948/0	955/0
Agricultural Commerce	925/0	959/0

et al.,(2019) examined the use of the Markowitz portfolio theory in finding the optimal stock market portfolio. Their results showed that investors cannot entirely trust this theory for investing and should instead modify the Markowitz model based on the real conditions and their experiences in order to reduce investment risks. In an article entitled "A comprehensive review of deterministic models and applications for mean-variance portfolio optimization" Kalayci *et al.,* (2019) reviewed 175 articles on portfolio optimization published in the past two decades and carried out a comprehensive examination of the models and actual limitations. Their results showed that most researchers use weighted sum methods for portfolio optimization due to the limitations of Markowitz' mean-variance model and the conditions of the real world. In a study to optimize the facilities portfolio of the micro clients of an Iranian bank, Gharib and Koosha (2019) used three non-linear programing models (two-objective functions and one-objective function) plus goal programing. Considering the number of constraints, variables and the nature of the models, an meta-heuristic genetic algorithm was used to solve the problem. Their results showed that the optimal solutions presented with the actual amounts of facilities allocated by the bank to the micro-banking group produced better results in terms of profit and default risk.

MATERIALS AND METHODS

The present research is an applied study because it aims to be used by the banking system. Data were collected from 2009 to 2014. Since the main source of fluctuations in the bank's expected income is the fluctuation in the ratio of collection of credit for facilities given out, the ratio of collection of credits awarded to each economic activity to what should be collected was taken as the return criterion and its variance as the risk.

The mean historical return is usually taken as the expected return on an asset, which creates a definite return on each asset; however, using it as the expected return has two major defects. First, when historical data are considered for a long period, the return from recent years is closer to the current return on the asset. In other words, the asset's recent data are more influential than its past data. Second, when the historical data of an asset are insufficient due to the lack of information, the estimation of the statistical parameters will not be accurate. Given these reasons and the uncertainty about the estimate, it would be better to take the expected return on an asset as an interval amount instead of the mean of historical data (Fang and Wang, 2006).

In the present study, financial reports and historical data were used to determine the interval range of the expected return. The minimum expected return from the arithmetic mean of historical returns and arithmetic mean of recent returns is taken as the lower bound while the maximum amount of these two factors is taken as the upper bound of the expected return.

Formulation of the objective function

There is no expectation of the precise prediction of return and risk in a fuzzy environment. The investor therefore often decides according to his own financial experience

Table 3. The share of each activity in the optimistic strategy

	α	β		X1	X2	X3	X4	X5	X6	X7	X8	X9
Portfolio1	0.5	0.5	Rial	2616/987	1336/351	1289/386	4426/193	1333/681	25592/529	6771/228	17224/507	5558/108
			Share of each section(%)	1/38	0/71	0/68	2/34	0/70	13/52	3/58	9/10	2/94
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	2475/666	3355/739	39057/656	14226/817	2973/071	23956/844	35683/318	1458/008	
			Share of each section(%)	1/31	1/77	20/63	7/51	1/57	12/65	18/85	0/77	
Portfolio1	0.5	0.5		X1	X2	X3	X4	X5	X6	X7	X8	X9
			Rial	1500/522	1056/656	2135/258	2140/038	2336/456	28728/316	12589/233	10859/365	7285/822
			Share of each section(%)	0/79	0/56	1/13	1/13	1/23	15/17	6/65	5/74	3/85
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	2409/119	2813/116	38505/548	16981/195	903/766	21592/106	35236/451	2263/122	
			Share of each section(%)	1/27	1/49	20/34	8/97	0/48	11/40	18/61	1/20	
Portfolio3	0.75	0.25		X1	X2	X3	X4	X5	X6	X7	X8	X9
			Rial	2268/127	2095/678	1528/207	1864/564	1536/228	27243/967	12157/684	12199/849	6937/401
			Share of each section(%)	1/20	1/11	0/81	0/98	0/81	14/39	6/42	6/44	3/66
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	1860/528	1644/929	36413/475	24890/811	2621/542	21042/598	31567/354	1463/147	
			Share of each section(%)	0/98	0/87	19/23	13/15	1/38	11/11	16/67	0/77	

The numbers are in billion Rials

and intuition. Accordingly, assuming that the expected return and risk are interval numbers, objective functions can be shown as follows (Nahvi, *et al.,* 2020):

Where $\boldsymbol{Max}\ \widetilde{\boldsymbol{R}}(x) = \sum_{i=1}^{N} \widetilde{\boldsymbol{R}}_i x_i$

$$\boldsymbol{Min}\ \widetilde{\boldsymbol{\sigma}}^2(x) = \sum_{i=1}^{N}\sum_{j=1}^{N} \widetilde{\boldsymbol{\sigma}}\boldsymbol{ij}\ \boldsymbol{xi}\ \boldsymbol{x} \quad \text{(Eq.(1)}$$

$$\widetilde{\boldsymbol{R}}\ (x) = [Ril,\ Riu]$$

$$\widetilde{\boldsymbol{\sigma}}^2(x) = [\sigma^2_{ijl},\ \sigma^2_{iju}]$$

Then

$$\boldsymbol{\sigma 2}_{ijl} = \frac{1}{N}\sum_{i=1}^{N}(\boldsymbol{Rit} - \boldsymbol{Ril}) \times (\boldsymbol{Rjt} - \boldsymbol{Rjl})$$

$$\boldsymbol{\sigma 2}_{iju} = \frac{1}{N}\sum_{i=1}^{N}(\boldsymbol{Rit} - \boldsymbol{Riu}) \times (\boldsymbol{Rjt} - \boldsymbol{Rju})$$

Where *xi* the proportion invested in the asset *i*, $i = 1, \cdots, n$, $\sigma 2_{ijl}$ is the lower limit of covariance between the *i*-th and *j-th* asset, and $\sigma 2_{iju}$ isthe upper limit of covariance between the *i*-th and *j*-th asset.

Model (1) is a multi-objective interval nonlinear programing model in which the weighted sum method is used to convert the multi-objective model into a single-objective optimization problem. In this method, introducing the α and β coefficients into the objective function makes the Markowitz mean-variance model more applicable, as shown below:

$$\boldsymbol{Min}[\ \boldsymbol{\alpha}\ .\ \widetilde{\boldsymbol{\sigma}}^2(\mathrm{x}) - \boldsymbol{\beta}\ .\ \widetilde{\boldsymbol{R}}\ (\mathrm{x})] \quad \text{(Eq. 2)}$$

Therefore, the objective function of model (2) is converted into interval equations (3), (4), and (5).

$$\boldsymbol{Min}\ \mathbf{Fl} = \boldsymbol{\alpha}\sum_{i=1}^{N}\sum_{j=1}^{N}[\boldsymbol{\sigma}\mathbf{2ijl}] - \boldsymbol{\beta}\sum_{j=1}^{N}[\mathbf{Riu}] \quad \text{(Eq. 3)}$$

$$\boldsymbol{Min}\ \mathbf{Fr} = \boldsymbol{\alpha}\sum_{i=1}^{N}\sum_{j=1}^{N}[\boldsymbol{\sigma}\mathbf{2iju}] - \boldsymbol{\beta}\sum_{j=1}^{N}[\mathbf{Ril}] \quad \text{(Eq. 4)}$$

$$Min\ F(x) = \lambda Fr(x) + (1 - \lambda)\ Fl(x) \quad \text{(Eq. 5)}$$

In which α and β are the risk and return weights and λ the pessimistic index on a scale of 0 to 1, and the model is solved by assigning different values (between 0 and 1) to them, and the investor chooses a different model based on the different estimates of return and risk.

***Model limitations*:** The most important constraints of the bank under study in providing credit

Table 4. The share of each activity in the pessimistic strategy

	α	β		X1	X2	X3	X4	X5	X6	X7	X8	X9
Portfolio1	0.5	0.5	Rial	1457/758	2975/921	874/059	4143/965	1827/095	25542/113	6197/505	12577/524	5277/553
			Share of each section(%)	0/77	1/57	0/46	2/19	0/97	13/49	3/27	6/64	2/79
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	2616/951	2302/941	37526/816	10201/017	1293/067	35543/264	36480/518	2498/022	
			Share of each section(%)	1/38	1/22	19/82	5/39	0/68	18.77	19.27	1/32	
Portfolio1	0.5	0.5		X1	X2	X3	X4	X5	X6	X7	X8	X9
			Rial	1107/833	386/071	3893/113	2808/143	1471/321	25235/316	9623/425	10360/371	1181/167
			Share of each section(%)	0/59	0/20	2/06	1/48	0/78	13/33	5/08	5/47	0/62
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	3439/341	3031/365	39718/929	10467/514	2867/808	37714/986	34022/683	2006/703	
			Share of each section(%)	1/82	1/60	20/98	5/53	1/51	19.92	17.97	1/06	
Portfolio3	0.75	0.25		X1	X2	X3	X4	X5	X6	X7	X8	X9
			Rial	787/951	1639/379	3606/732	3400/202	2263/397	24535/465	6552/202	11510/661	2961/471
			Share of each section(%)	0/42	0/87	1/90	1/80	1/20	12/96	3/46	6/08	1/56
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	1288/721	2944/018	38361/366	11302/002	2522/962	35099/392	38637/777	1922/391	
			Share of each section(%)	0/68	1/55	20/26	5/97	1/33	18.54	20.41	1/02	

The numbers are in billion Rials

to clients involved in economic activities include:

$$\sum_{i=1}^{N} Xi \leq B \text{(Eq.6)}$$

Budget constraints: The sum of the various facilities in Rial allocated by the bank to its different economic activities.

In which B is the sum of credits in Rial.

Credit policy constraints: These constraints are determined by the boards of directors of Keshavarzi Bank and Central Bank.

The facilities to deposits ratio constraint: This limitation is determined by the bank's board of directors. It evaluates the extent to which the bank can facilitate loans from these deposits.

$$\frac{\sum_{i=1}^{N} Xi}{\sum C} \leq \%80 \qquad \text{(Eq. 7)}$$

In which C is the sum of the deposits.

Central Bank's legal constraints: Central Bank's guidelines require specialized banks to allocate a maximum of 10% of their total facilities to those activities of applicants that fall outside their specialization. This constraint is formulated as follows:

$$\frac{X10}{B} \leq \%10 \qquad \text{(Eq. 8)}$$

The Capital Adequacy Ratio constraint: The Capital Adequacy Ratio (CAR) is one of the performance evaluation indicators of banks and financial and credit institutions that is determined by the Monetary and Credit Council for the purpose of evaluation of banks' and credit institutions' risk management, and is calculated as follows:

$$\frac{H}{\sum_{i=1}^{N} Xi+G} \geq \%8 \qquad \text{(Eq. 9)}$$

In which H is the owners' equity (basic capital) and G is other

Table 5.The share of each activity in the mixed strategy

	α	β		X1	X2	X3	X4	X5	X6	X7	X8	X9
Portfolio1	0.5	0.5	Rial	1412/382	2372/838	3312/337	3898/001	2259/231	28823/511	9002/142	14064/493	7355/912
			Share of each section(%)	0/75	1/25	1/75	2/06	1/19	15/22	4/75	7/43	3/8
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	3480/722	2438/823	37671/924	13058/853	1711/991	23312/341	33791/129	1369/459	
			Share of each section(%)	1/84	1/29	19/90	6/90	0/90	12/31	17/85	0/72	
Portfolio1	0.5	0.5		X1	X2	X3	X4	X5	X6	X7	X8	X9
			Rial	2013/826	1073/404	1401/219	2825/193	495/064	28229/105	5272/471	17059/083	5373/039
			Share of each section(%)	1/06	0/57	0/74	1/49	0/26	14/91	2/78	9/01	2/84
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	1164/413	3584/076	36019/518	13193/515	2150/611	32962/863	33953/372	2565/317	
			Share of each section(%)	0/61	1/89	19/02	6/97	1/14	17/41	17/93	1/35	
Portfolio3	0.75	0.25		X1	X2	X3	X4	X5	X6	X7	X8	X9
			Rial	805/925	1830/794	3123/939	1610/927	1513/194	30343/359	9601/854	3364/471	7236/577
			Share of each section(%)	0/43	0/9	1/65	0/85	0/80	16/03	5/07	1/78	3/82
				X10	X11	X12	X13	X14	X15	X16	X17	
			Rial	3054/598	1414/973	39670/101	8981/561	2886/985	33200/811	39711/109	984/911	
			Share of each section(%)	1/61	0/75	20/95	4/74	1/52	17/54	20/97	0/52	

The numbers are in billion Rials

risk-weighted assets.

The constraint on the maximum and minimum shares of each activity: This constraint includes the maximum and minimum shares of each activity from the awarded facilities.

$Xi \leq D$ (Eq. 10)

$Xi \geq F$ (Eq. 11)

In which D is the maximum share of each activity and F the minimum share.

Since budget constraints and the ratio of facilities to deposits constraint had been allocated greater Rial value than the CAR constraint, their effect on the

Optimal portfolio selection model : Given the aforementioned points, portfolio selection optimization models are examined from three perspectives, namely optimistic, pessimistic and mixed investment strategy perspectives (Nahvi, et. al., 2020).

Model 1: optimistic strategy : The lower bound of risk minus the upper bound of return is minimized with this strategy . In other words , the investor calculates the optimistic return and risk.

(Eq. 12)

$$Min\ \mathbf{Fl} = \alpha \sum_{i=1}^{N} \sum_{j=1}^{N} [\sigma 2ijl] - \beta \sum_{j=1}^{N} [\mathbf{Riu}]$$

subject to

$$\sum_{i=1}^{17} Xi \leq 189336089818750$$
$$X10 \leq 18933608981875$$
$$Xi \leq 0.21$$
$$Xi \geq 0.001$$

Model 2: Pessimistic strategy: In contrast to the previous model, in this strategy, the upper bound of risk minus the lower bound of return is minimized. In other words, the investor calculates the pessimistic risk and return on assets.

(Eq. 13)

$$Min\ \mathbf{Fr} = \alpha \sum_{i=1}^{N} \sum_{j=1}^{N} [\sigma 2iju] - \beta \sum_{j=1}^{N} [\mathbf{Ril}]$$

subject to

$$\sum_{i=1}^{17} Xi \leq 189336089818750$$
$$X10 \leq 18933608981875$$
$$Xi \leq 0.21$$
$$Xi \geq 0.001$$

Table 6. Summary of optimal portfolio results

Strategy		Α	β	Λ	*Risk	*Return
Optimistic	Portfolio1	5/0	5/0	-	246858628974907	89010
	Portfolio2	25/0	75/0	-	116998111661157	133466
	Portfolio3	75/0	25/0	-	364383152868117	44521
Pessimistic	Portfolio1	5/0	5/0	-	517007367135256	87981
	Portfolio2	25/0	75/0	-	231028857792110	131928
	Portfolio3	75/0	25/0	-	687000428890779	44020
Mixed	Portfolio1	5/0	5/0	1/0	[262697520418072, 685694102098760]	[88149, 88923]
	Portfolio2	5/0	5/0	5/0	[272897244417013,476377154219263]	[88103, 88842]
	Portfolio3	5/0	5/0	9/0	[291690585422862, 420172043090129]	[87855,88588]

The numbers are in billion Rials

Model 3. Mixed strategy: This model is a mixture of the optimistic and pessimistic strategies in which the investor seeks to balance the asset's return and risk performance.

$$Min\ F(x) = \lambda Fr(x) + (1 - \lambda)\ Fl(x) \qquad \text{(Eq. 14)}$$

$$\boldsymbol{Min\ F(x) = \lambda[\alpha \sum_{i=1}^{N}\sum_{j=1}^{N}[\sigma 2iju] - \beta \sum_{j=1}^{N}[Ril] + (1 - \lambda)[\alpha \sum_{i=1}^{N}\sum_{j=1}^{N}[\sigma 2ijl] - \beta \sum_{j=1}^{N}[Riu]}$$

subject to

$$\sum_{i=1}^{17} Xi \leq 189336089818750$$

$$X10 \leq 18933608981875$$

$$Xi \leq 0.21$$

$$Xi \geq 0.001$$

RESULTS AND DISCUSSION

In the present study, the optimal credit portfolio was determined using multi-objective interval nonlinear programing and the Genetic algorithm. Using meta-heuristic algorithms requires the proper adjustment of the related parameters. Since the inappropriate adjustment of these parameters leads to poorer results in relation to the algorithm's potential ability, using efficient techniques to adjust these parameters is essential. The Taguchi test method was used in the present study for this purpose.

The Kolmogorov-Smirnov test was also used to ensure the normal distribution of return, which is essential when applying variance as a measure of risk. The results showed the significance level to be >0.05, indicating the normal distribution of the returns.

Considering the study's main objective, attempts were made to determine the optimal credit portfolio of Keshavarzi Bank in various economic activities and examine the bank's current performance in terms of the share of each activity from the credits. Table 1 thus presents a study of the current portfolio and optimal portfolio resulting from the purposed model, the amount of facilities given and the share of each economic activity from them over the studied years. As shown, the facilities paid have increased from 67,749 billion Rials to 253,651 billion Rials.

Table 2 presents the upper and lower bounds of return on various economic activities, as extracted from the financial reports and historical data that comprise the study's input data.

***The results of implementing the Genetic optimization algorithm*:** The proposed algorithm was implemented using MATLAB. The results of the optimal model solution using the Genetic algorithm in optimistic, pessimistic, and mixed scenarios are presented in Tables 3 to 6. According to the optimistic strategy shown in Table 3, activities Greenhouse, Agricultural Services, Agriculture, Animal husbandry and, beekeeping and silkworm have the highest share of the credits awarded and activities Carpet weaving and handicrafts, Hospitality, Gardening and Agricultural Commerce have the lowest share. Moreover, according to the pessimistic strategy shown in Table 4, activities Greenhouse, Agricultural Services, Animal husbandry, Agriculture and agricultural machinery have the highest share of the credits awarded and activities natural resources, Hospitality, Gardening and Agricultural Commerce have the lowest share. Finally, according to the mixed strategy shown in Table 5, activities Greenhouse, Agricultural Services, Animal husbandry, Agriculture and beekeeping and silkworm have the highest share of the credits awarded and activities natural resources, Gardening, Hospitality and Agricultural Commerce the lowest. Table 6 presents the level of risk and return with these three strategies. Considering that the main objective of bank managers is the minimization of risks and the maximization of return, a model will be chosen that can produce the lowest risk and highest return. Based on the results in these tables, portfolio 1 is recommended to be chosen in the mixed strategy and portfolio 2 in the optimistic and pessimistic strategies, since they have lower risks and higher returns.

CONCLUSION AND RECOMMENDATIONS

The main objective of the present article was to develop a model and solve the problem of optimal credit portfolio in Keshavarzi Bank. Multi-objective interval nonlinear programingwas therefore used to present a model for portfolio optimization. This model contains all three strategies: Optimistic, pessimistic, and mixed. The results showed that, in the estimated optimal model, the share of the economic activities fluctuated under different strategies, which indicates a difference from Keshavarzi Bank's current credit distribution model, which is caused by the inclusion of risk in the proposed model. In the optimal model obtained, activities Agriculture, Agricultural Services, Animal husbandry and Greenhousehave the highest share in the optimal portfolio composition in almost all the cases. Meanwhile, in the bank's current credit distribution model, greenhouse activity has a small share. Given the growth in the greenhouse industry and its role in increased productions, employment in the agriculture sector and the management of water resources, the Ministry of Agriculture's main policy is to expand greenhouses, for which it awards appropriate facilities to applicants. Increasing the share of this activity from the facilities given by the bank thus seems reasonable. The present findings confirm the need for the allocation of a greater share to this activity. The present findings also agree with previous findings regarding the optimal model obtained showing differences with the bank's current credit distribution model(Jao, 2001; Agarana *et al.,* 2014; Gharib and Koosha, 2019).

The results can provide bank managers with a roadmap, so that they can have different estimates of return and risk based on the three noted strategies and choose their own model according to the importance of each strategy and based on the different risk and return estimates. It can be argued that the portfolio selection models discussed above can include the managers' attitude toward a variety of investments, but can also take the bank's preferences in specific conditions into account, which then leads to proper loan management.

Based on the present findings and in order to make the proposed approaches practical, concentrating loans in certain economic activities should be avoided so as to reduce credit risks, and periodical (annual) assessments of the concentration of activities is recommended in order for the credits to be awarded according to the proposed model. Furthermore, since the definitive model cannot show the actual change in the total return on investment and the entailed risk, the interval model presented in this study should be used to resolve this issue, as it has greater flexibility than the definitive model.

REFERENCE

Agarana, M.C., S.A. Bishop and O.A.Odetunmibi (2014). Optimization of banks loan portfolio management using goal programming technique.*International Journal of Research in Applied, Natural and Social Sciences*, 2(8):43-52.

Asgarzadeh, Gh. (2006). Mathematical Modeling to Determine the Optimal Composition of Credit Facility Portfolios in Financial and Credit Institutions. *AndishehSadegh Quarterly*, 23:107-130.

Caplin, D.A. and J.S.H. Kornbluth (2004).Multiobjective investments planning under uncertainty.*Omega*, 3(4):423-441.

Chang T.J., S.C. Yang and K.J. Chang (2009).Portfolio optimization Problems in Different Risk Measures Using Genetic Algorithm. *Expert Systems with Applications*, 36: 10529-10537.

Chao, X., X. Tao and L. Zeng (2019). Application of Markowitz's Portfolio Theory in Obtaining the Best Portfolio in the Stock Market. Advances in Social Science, *Education and Humanities Research*, 309:119-122.

Dia, M. (2009). A portfolio selection methodology based on data envelopment analysis. Information *Systems and Operational Research*, 47(1):71-79.

Fang, Y. and SH. Wang (2006). An Interval Semi-absolute Deviation Model For Portfolio Selection. Fuzzy Systems and Knowledge Discovery: *Third International Conference*. September 24-28.

Gharib, I. and E. Koosha (2019).Optimization of Ansar bank's Customer Loan portfolio using genetic algorithm (Case study of Ansar Bank).*Journal of Financial Management Strategy*, 7(27):147-164.

Jao, Y.C. (2001). Linear programming and banking in hongkong. *Journal of Business Finance and Accounting*, 7:489-500.

Kalayci, C.B., O. Ertenlice and M. Anil Akbay (2019).A comprehensive review of deterministic models and applications for mean-variance portfolio optimization.*Expert Systems with Applications*, 125:345-368.

Makiyan, S.N., A. Nasersadrabadi and A. Sarlak (2010). Analysis of Bank Allocation of Resources in Uncertainty Conditions Using Fuzzy Logic, A Case Study: Agricultural Bank, Tehran. *The Journal of Economic Policy*, 2(4):57-79.

Mehrara, M. and S. Sadeghian (2008). Determining the optimal composition of loans in economic sectors (Case Study of Saman Bank). *Financial Economics*. 5:82-102

Metawa, N., M. Kabir Hassan and M. Elhoseny (2017). Genetic Algorithm Based Model For Optimizing Bank Lending desicion .*Expert Systems With Applications*, 80:75-82.

Nahvi, A., M. Ghorbani, M. Sabouhisabooni and A. Dourandish(2020). Portfolio optimization of bank credits with interval returns: Empirical evidence from Iran. *Banks and Bank Systems, 15(4):49-68*

Qin, Z. (2015). Mean-variance model for portfolio optimization problem in the simultaneous presence of random and uncertain returns.*European Journal of Operational Research*, 245:48

Rahnamayroodposhti, F., K. Chavoshi and E. Saber (2014). Optimization of portfolio Constituted from mutual funds of Tehran stock exchange using genetic algorithm. *Quarterly Investment Knowledge*, 3:217-231.

Rezai, A., N. Hakimipor, A. Narimani and M. Yazdankhah (2016). An Investigation of Risk Structure on the Agriculture Sector using the Optimizing of Combination paid loans to different economic Sectors in Iran's Bank. *Journal of financial Economics*, 10(34):115-130.

Yang, X.SH. (2010). Nature-Inspired Metaheuristic Algorithms. 2nd edition, Luniver Press, United Kingdom