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The Application of Multi-Purpose Genetic Algorithm in Optimizing Bank's Facilities Portfolio
(A Case Study of the Granted Facilities in One of the Commercial Banks of Iran)

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ABSTRACT

Gaining maximum benefit with the minimum of risk is an aim which finance and credit institutions always want to fulfill. The present research, which was done in the framework of the granted facilities One of the commercial banks from 2010 to 2012, studies the effective interest rate, dishonoring rate of the granted facilities within the format of Islamic contracts in different sections and determines the real portfolio of granting facilities. It then determines the optimum facilities portfolio using the multi-purpose genetic algorithm. The findings show that the resulted optimum facilities portfolio is different from the current portfolio of the bank and can tackle with the different limitations and policies in granting facilities. They also indicate that the effective interest rate and the degree of efficiency of facilities based on the presented model are higher than those of the current facilities portfolio.
KEYWORDS: portfolio optimization, genetic algorithm, facilities, efficiency, dishonoring rate.

1. INTRODUCTION

Gain is the goal of any finance and credit institution or any business in general, and in this way, it is necessary to choose the best business strategy in order to reduce risk and increase the gain. Risk here means investments resulting in loss and endangering the capital. Also, wrong investments costs are instances of hidden losses caused by lack of appropriate business strategy and planning.

The reason many finance and credit institutions fail is that they do not choose the correct investment portfolio (Asgarzadeh, 2004). Since most investment in these institutions is in the form of granting facilities, choosing the right investment portfolio within the format of Islamic contracts is inevitable.

Considering this, finance and credit institutions try to invest in domains with the minimum of risk and maximum gain in order that they can save the capital and gain the most for the stake-holders (Asgarzadeh, 2008). Banks are instances of finance and credit institutions that are always looking for the optimum granting facilities portfolio. Facilities portfolio is usually created based on the year's policy-supervisory package of the banking network, made and announced by the central bank to finance institutions, and the last year's indices. In fact, these two factors are considered as the main constraints. Other constraints include managing council policies which may be announced under certain conditions.

The modern theory of Markowitz portfolio, developed by Sharpe and Lintner, has become the foundation for many researches on investment portfolio optimization. Most of the work in this context is done on optimization of stock portfolio. Because genetic algorithm produces the optimum results considering environmental variables and dominant constraints on deciding the optimum portfolio and because genetic algorithm is consistent with reality, we use this method to find the optimum solution to the problem in this paper.

2. THE GENETIC ALGORITHM

Natural evolution is a historical process and any creature changed over time is a historical creature. The nature of evolution is change. Evolution is a dynamic two-phase process of random change and option which, based on the environmental requirements, causes constant changes in members of a population. The members adapt themselves to their immediate environment through excerpting. Based on this adaptation, specific members are allowed to survive through inheritance. Change underlies evolution (Kia, 2011).

Most genetic algorithms are modified material algorithms suggested by Goldberg (1989). This algorithm has three main operators namely selection, reproduction and mutation. Genetic algorithm, generally, is a type of evolutional algorithm. Genetic algorithm is a random search and optimization method driven from Darwinian natural evolution concept and principles. In other words, we can call genetic algorithm a search method following biological evolution laws (Forouzan, 2010).

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2.1. Genetic algorithm in general

Simply put, genetic algorithm is a search method which observes succeeding generations' specifications and selects children based on the survival of the best principle. It uses genetic laws to produce children (results of a specific step in solving the problem) with better specifications (closer to what is required). For each generation, a better approximation of the final results is calculated by means of a selection of better children (the previous results). This makes new generations more consistent with the problem conditions. The competition among genes and winning of the dominant (selected by the algorithm for the next reproduction) and eliminating of the recessive (unrelated to the goal) is an efficient way to solve complicated problems.

Based on the above, there is considerable difference between genetic algorithm and most common methods of search and optimization. Four major differences are:

- Instead of searching by means of only one point, genetic algorithm uses a set of points;
- Genetic algorithm uses probability rules not natural ones;
- Genetic algorithm works on coded attributes and does not manipulate the original values (unless we have actual representation of strings);

1. In genetic algorithm there is no need for derivation or any supplementary information. The direction of search is specified by only a goal function and a method of determining fitness from raw data (Bavari & Salehi, 2009)

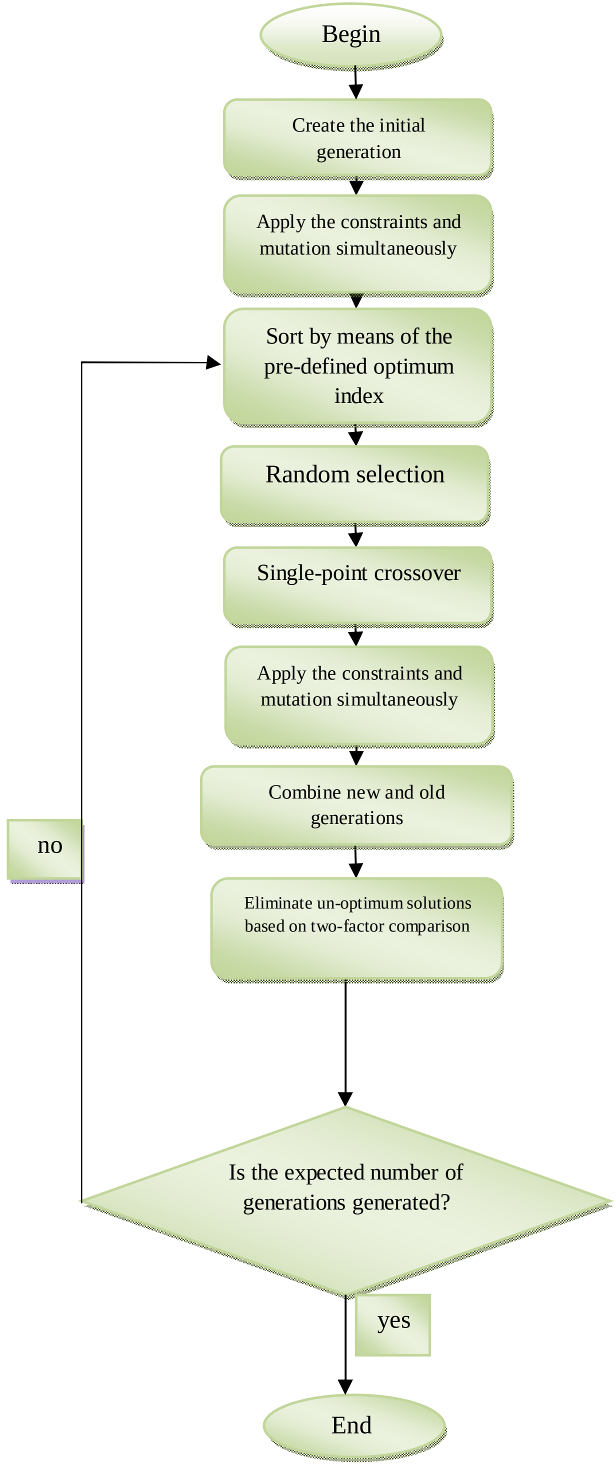
2.2. The genetic algorithm structure

The main structures in genetic algorithm are:

1. Initialization: randomly generate a population of chromosomes (initial individual solutions to the problem);
2. Fitness: evaluate the fitness of each chromosome in the population;
3. New population: a new population is generated through repeated steps until it is completed;
4. Test: if the termination condition is satisfied, stop and return the best solution from the current population;
5. Repetition: go to step 2 (fitness);

According to the above definition, and the limitations and constraints of the problem, the following process is suggested for this research:

Diagram 1. the process cycle of the suggested genetic algorithm



3. LITERATURE REVIEW

Works on optimizing investment portfolios have been done using different patterns and methods which are mostly based on mean-variance criteria. Ra'ee (1999) investigates the non-linear behavior of investors, in order to make investment portfolios with maximized efficiency and minimized risk and cost and forecast the future of stock value. Asgarzadeh (2008) represents a mathematical model for determining the optimum facilities portfolio in finance and credit institutions which uses operational research techniques. This model can determine the best combination of facilities which maximizes the profit.

Abzari, Ketabi and Abbassi (2006) suggest a model which uses linear planning in optimizing the portfolio. This model includes all the investments an investor could and would consider in making his/her investment portfolio. It uses a portfolio with 20 shares which, compared with the basic model including 9 shares, reduced unwanted risk significantly (Abzari et al., 2006).

Abdolalizadeh, Shahir and Eshghi (2004) in "using genetic algorithm in selecting a set of assets from stocks market use a specific pattern of genetic algorithm (using two-point crossover operator and mutation with movement) to select a series of assets from among different stocks. In this paper, we use the annual information of efficiency and risk from different firms as input for the model. Then we implement the suggested patterns on more than 200 stocks information in Tehran. Khaloozadeh and Amiri (2006) develop risk management methods based on the theory of value as exposed to risk in "How to determine an optimum stock portfolio in Iran's stock market on the basis of the theory of value as exposed to risk". Using genetic algorithm, they develop an optimum stock portfolio with maximum profit and constrained risk. The simulation is done for a stock portfolio containing 12 different firms in Tehran's stock market. The results show the efficiency of both risk modeling based on risk-adjusted value theory and genetic algorithm in providing the optimum weights for the stock portfolio considering constraints on risk (Abbassi, 2011).

Navidi, Nojoomi and Mirzazadeh (2010) consider the application of genetic algorithm in developing the optimum portfolio in Tehran's stock market. In it, they provide a method for assigning weights in stock portfolio using genetic algorithm; also, the optimization is based on varying size of investment portfolios.

Asgarzadeh (2007) provides a mathematical model for determining the optimum facilities portfolio in finance and credit institutions. The model determines the optimum portfolio so that, considering constraints, gain is maximized and risk is reduced.

Ra'ee and Falahpoor (2012) provide a model for active management of portfolio using VaR and genetic algorithm. Since active investment strategies do not consider the general risk in portfolio, they use genetic algorithm for optimization. The results show a better performance than Sharpe criteria and the ratio of efficiency to VaR. (Ra'ee & Fallahpoor, 2012).

Oh et al., (2008) use genetic algorithm to provide a model for optimizing management of Mutual Fund. The results show that Mutual Fund's performance is optimized using the suggested method (Oh et al., 2005).

Chang and Yang and Chang (2009) introduce an investigatory method for portfolio optimization by means of genetic algorithm and compare it with mean-variance optimization method. Using this method, they optimized the portfolio considering variance, semi variance and the mean value of absolute deviations from average (Chang et al., 2009).

4. RESEARCH METHODOLOGY

Research Data

Data in this research is from granted facilities within the format of Islamic contracts to real persons and corporations in different economic, business and industrial sections during 2010 to 2012 and in one of the business banks of Iran. The Islamic contracts considered in this paper are: interest-free loan, installment vending, Ja'aleh, civic partnership and silent partnership. These were granted in defined sections of services, commercial, housing and construction, industry and mining, agriculture and water supplying (Department general of education, Melli Bank , 2011).

Data gathering method

Data required in this research were gathered through the following:

1. Information about the granted facilities within the aforementioned forms and defined sections including: income, the extent of granted facilities and the efficiency rate was extracted from the bank's ledger. The extracted data was then classified using SQL Server 2008 and became the initial data of the research.
2. To extract the dishonoring rate from the main database, current, delayed and due balance data were extracted from 267000 granted loans. such data was then classified using Microsoft Access 2007 and became the initial data of the research.

Limitations applied

The facilities in the form of the aforementioned contracts can be granted in all of the desired sections. Table 1 shows the domain of granting any of the loans in different sections.

The limitations considered in this research are:

- Banks are allowed to grant up to 75% of their interest-free resources in the form of interest-free loans. Interest-free resources are observed as a separate parameter within the total resources every year.

In order to have a variety of solutions in this research, the percentage of granting interest-free facilities is considered to be from 25% to 75%.

- In the model, up to 100% of the total resources can be granted.
  Grantable resources of each bank are determined by the policy-supervisory package of the central bank every year. Based on this package, a percentage of each deposit is kept as a legal deposit in the central bank and the rest is dedicated to granting facilities. If banks disobey the above law, they are penalized a 36% penalty by the central bank.

Table 1. Loans in the form of Islamic contracts granted to different sections

	Section	**Industry and mining**	**Housing and construction**	**Commercial section**	**Services**	**agriculture**
Loan Type						
Ja'aleh		*	*	*	*	*
Interest-free		*	*		*	*
Installment vending		*	*		*	*
Renting with an option to buy		*	*		*	*
Forward purchasing		*			*	*
Civic partnership		*	*	*	*	*
Legal partnership		*	*	*	*	*
Silent partnership				*		
Direct investment	*	*				*
Mosaghat						*
Crop-sharing						*
Dept purchasing	*			*		*

Source: (Department general of education, Melli Bank , 2011).

Table 2. limitations applied in this research

Partnership contracts	Dealing contracts
Civic partnership	Installment vending
Legal partnership	Ja'aleh
Silent partnership	Dept purchasing
Forward purchasing	Renting with an option to buy
Direct investment	
Crop-sharing	
Mosaghat	
Up to 80%	Up to 20%

Fitness

This operator determines the extent each chromosome (solution) is optimum. Thus, the fitness operator assigns a probability to each chromosome which is the same as the probability of that chromosome combine to generate the next generation. Obviously, the optimum chromosomes have more chance of combining to make new ones. In other words, genetic algorithm needs an initial random population to begin. Thus, in the first step a number of chromosomes are generated randomly. These chromosomes are called the initial population.

Figure 1. Genetic algorithm solution matrix

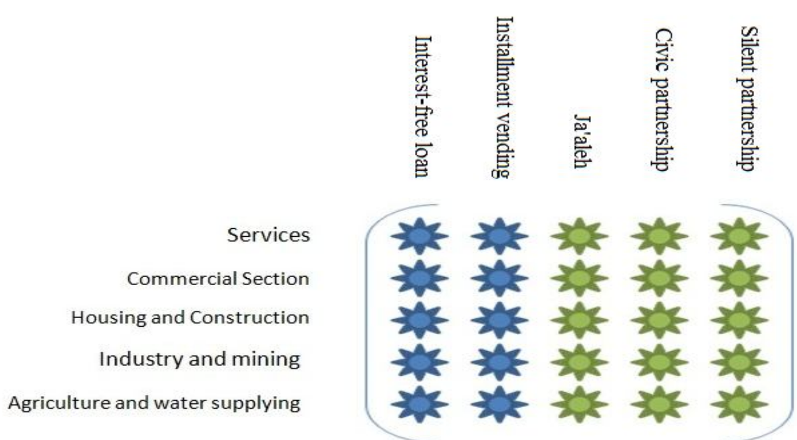
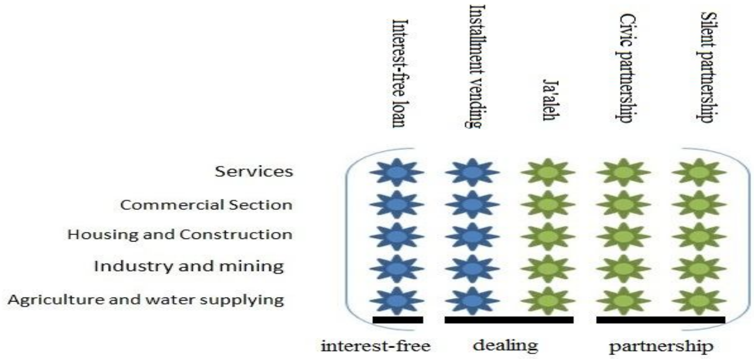


Figure 2. Genetic algorithm solution matrix division by partnership, dealing, and interest-free loan

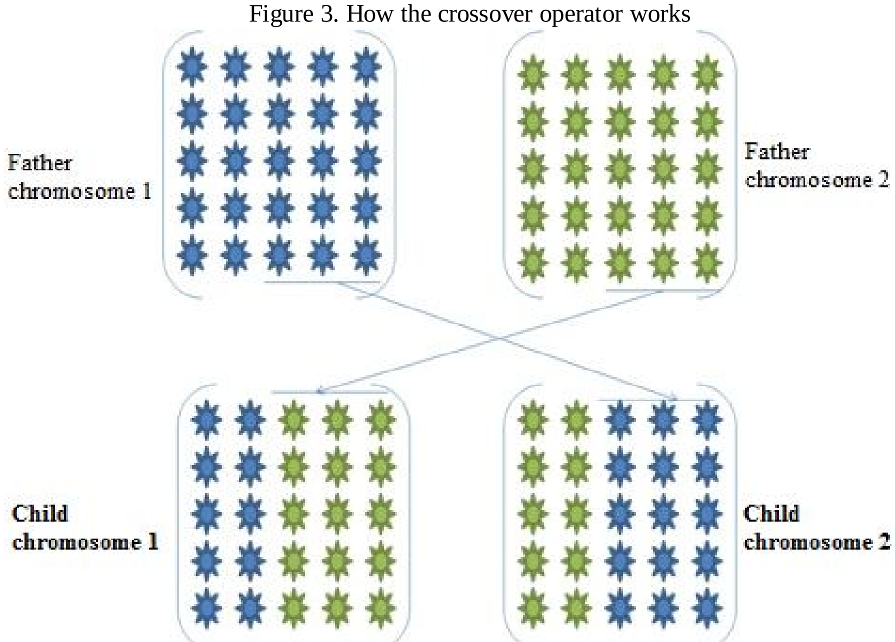


As mentioned, here we have conditions and limitations in optimization. A function is responsible for applying these limitations after the new generation has been created. The limitations are applied on different elements of the solution matrix.

Crossover

- The crossover operator combines the middle population chromosomes. This is done to find the child chromosome which is more optimized than its father;
- After selecting the chromosome couple, the crossover function combines them and makes two new chromosomes;
- In this paper, single-point crossover is used. Figure 3 shows the crossover schematically;

Figure 3. How the crossover operator works



- 2 factor comparison of chromosomes

To calculate effective interest rate and dishonoring rate of each chromosome (solution), we use the following mathematical relations:

i = section – the extent of granted facilities in the form of contract

x_i = the extent of granted facilities

r_i = effective interest rate

R (s) = effective interest rate of the portfolio

N (s) = dishonoring rate of the portfolio

$$R(s) = \sum_{i=1}^{25} (x_i * r_i)$$

$$N(s) = \sum_{i=1}^{25} (x_i * n_i)$$

Table 3. Index i different values

	Contract-section		Contract-section
1	Interest-free – services	16	Civic partnership - services
2	Interest-free – commercial	17	Civic partnership – commercial
3	Interest-free – housing and construction	18	Civic partnership – housing and construction
4	Interest-free – industry and mining	19	Civic partnership – industry and mining
5	Interest-free – agriculture and water	20	Civic partnership – agriculture and water
6	Installment vending – services	21	Silent partnership – commercial
7	Installment vending – commercial	22	Interest-free – services
8	Installment vending – housing and construction	23	Interest-free – commercial
9	Installment vending – industry and mining	24	Interest-free – housing and construction
10	Installment vending – agriculture and water	25	Installment vending – industry and mining
11	Ja'aleh – services		
12	Ja'aleh – commercial		
13	Ja'aleh – housing and construction		
14	Ja'aleh – industry and mining		
15	Ja'aleh – agriculture and water		

Solutions sorted by variable Grade, are compared based on fitness and cost. Table 4 represents different decisions in the model and how they are made:

Table 4. Solution states and how the model decides

	State	**Model behavior**
1	Solution 1 has more fitness and less cost than solution 2	Solution 2 is eliminated
2	Solution 2 has more fitness and less cost than solution 1	Solution 1 is eliminated
3	Solution 1 has more fitness and more cost than solution 2	Both solutions are retained
4	Solution 1 has less fitness and less cost than solution 2	Both solutions are retained
5	Solution 2 more fitness and more cost than solution 1	Both solutions are retained
6	Solution 2 has less fitness and less cost than solution 1	Both solutions are retained

Source: (Kumar, 2011).

In this algorithm the termination condition is the number of populations generated. 50 generations is considered enough here. Tables 5 and 6 show the input data for the duration of 3 years and table 7 represents a comparison of genetic algorithm output.

Table 5. Effective interest rate obtained from real data

2010					
Contranct/ section	Services	Commercial	Housing and construction	Industry and mining	Agriculture and water
Interest-free	5.12		5.12	5.12	5.12
Installment vending	10.81		10.73	10.47	10.92
Ja'aleh	16.47	16.33	16.71	17.93	16.12
Civic partnership	15.79	11.31	8.35	17.55	19.39
Silent partnership		22.99			
2011					
Interest-free	5.66		5.66	5.66	5.66
Installment vending	10.19		9.97	9.90	9.81
Ja'aleh	12.65	12.07	12.49	12.87	14.23
Civic partnership	18.21	18.09	16.81	17.85	18.30
Silent partnership		20.75			
2012					
Interest-free	5.42		5.42	5.42	5.42
Installment vending	10.34		10.11	10.16	9.83
Ja'aleh	8.69	8.19	9.45	9.26	9.16
Civic partnership	18.16	19.79	14.55	17.26	16.54
Silent partnership		18.39			

Table 6. Dishonoring rate obtained from real data

Contranct/ section	Services	Commercial	Housing and construction	Industry and mining	Agriculture and water
2010					
Interest-free	0.33		0.33	0.33	0.33
Installment vending	0.38		0.30	0.55	0.41
Ja'aleh	1.21	1.20	1.18	3.19	1.10
Civic partnership	0.75	0.70	1.05	0.65	1.10
Silent partnership		0.41			
2011					
Interest-free	0.78		0.57	0.67	0.66
Installment vending	0.98		0.87	0.98	0.91
Ja'aleh	1.38	1.07	1.00	0.77	1.15
Civic partnership	0.50	0.80	0.70	0.60	0.90
Silent partnership		0.09			
2012					
Interest-free	1.07		0.96	0.04	1.30
Installment vending	1.89		1.46	1.65	1.47
Ja'aleh	1.04	1.33	1.35	5.60	1.04
Civic partnership	1.00	0.61	1.44	0.75	1.30
Silent partnership		0.40			

Table 7. Calculated and current weights

2010						
Contranct/ section		**Services**	**Commercial**	**Housing and construction**	**Industry and mining**	**Agriculture and water**
Interest-free	Current weight	6.65	0	0	0	0
	Calculated weight	3.88		2.05	0.49	0.3
Installment vending	Current weight	23.86		6.02	33.45	1.7
	Calculated weight	1.32			2.18	0.17
Ja'aleh	Current weight	0.1		3.48	0.37	0.04
	Calculated weight	1.92	0.76	0.03	8.18	0.13
Civic partnership	Current weight	0.44	0.62	0.94	13.37	0.07
	Calculated weight	24.43	5.45	4.14	9.14	12.69
Silent partnership	Current weight		8.87			
	Calculated weight		22.70			
2011						
Interest-free	Current weight	6.25		0.57	0.67	0.66
	Calculated weight	1.69		1.82	0.88	0.15
Installment vending	Current weight	22.68		6.63	20.13	1.28
	Calculated weight	0.09		1.81	2.35	0.57
Ja'aleh	Current weight	1.02		4.85	0.53	0.05
	Calculated weight	0.01	0.01	0.62	0.24	7.38
Civic partnership	Current weight	1.15	0.42	1	26.97	0.38
	Calculated weight	19.13	2.96	9.23	10.21	16.44
Silent partnership	Current weight		6.66			
	Calculated weight		24.29			
2012						
Interest-free	Current weight	6.76		0.96	0.04	1.30
	Calculated weight	5.83		0.07	0.19	0.31
Installment vending	Current weight	21.30		7.48	13.29	0.83
	Calculated weight			0.37	4.88	1.29
Ja'aleh	Current weight	1.06		4.43	0.34	0.05
	Calculated weight	0.03	0.79	0.41	0.04	2.87
Civic partnership	Current weight	10.47	1.11	0.59	34.41	0.43
	Calculated weight	19.94	16.67	10.56	7.68	7
Silent partnership	Current weight		5.91			
	Calculated weight		20.42			

Diagram 2. The output of the average value of each generation based on effective interest rate and dishonoring rate for year 2010 (based on source 12)

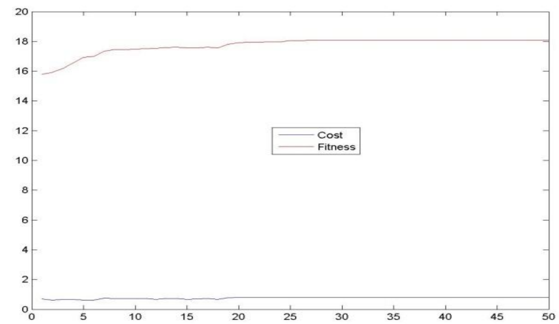


Diagram 3. The output of the average value of each generation based on effective interest rate and dishonoring rate for year 2011

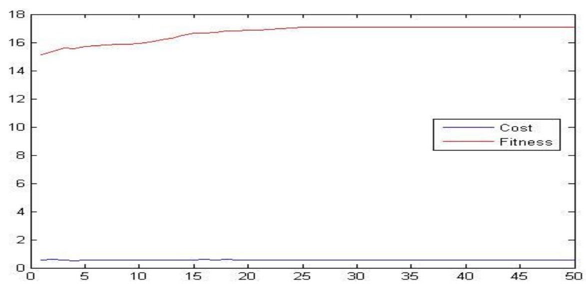
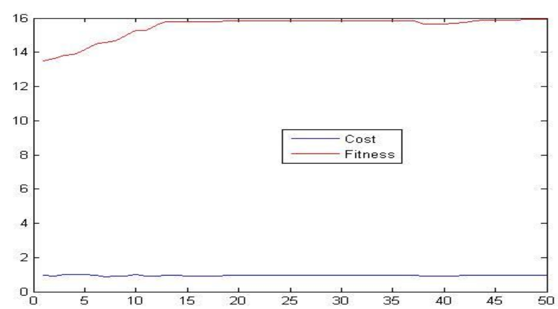


Diagram 4. The output of the average value of each generation based on effective interest rate and dishonoring rate for year 2012



Termination condition in genetic algorithm is usually based on the following:

- The number of generations created;
- The number of generations with the same optimum;
- Algorithm's execution duration.

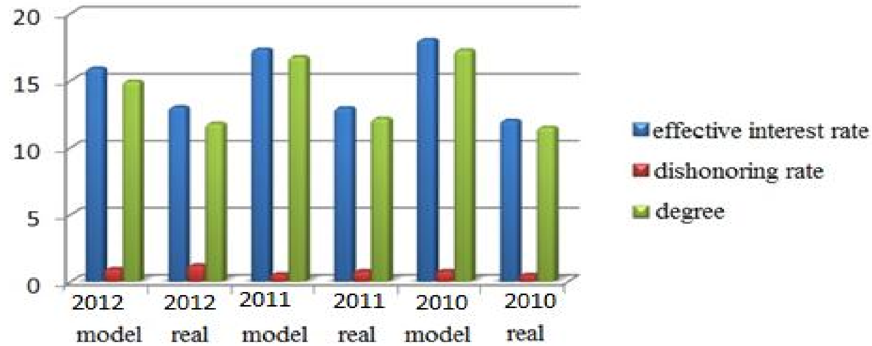
In this paper, the termination condition is the number of generations. According to diagrams 2 to 4, it is obvious that from a certain number of generations, optimization indexes of the algorithm are not changed.

Table 8. Comparing genetic algorithm output and its real values

Year	**2010**		**2011**		**2012**	
Parameter	Real	Model	Real	Model	Real	Model
Effective interest rate	12.03	18.07	12.97	17.34	13.02	15.91
Dishonoring rate	0.52	0.8102	0.80	0.58	1.23	0.96
Degree	11.51	17.26	12.17	16.76	11.79	14.95

To examine each portfolio, the real portfolio and the genetic algorithm suggested portfolio, an index called "degree" is defined. This index is equal to the subtraction of effective interest rate from dishonoring rate. Using this index we can compare the output of portfolios. Considering this degree for each portfolio we see that the fitness of the portfolio created by genetic algorithm is significantly more than the real portfolio.

Diagram 5. Comparing the performance of the facilities portfolio suggested by genetic algorithm and the current facilities portfolio



DISCUSSION AND CONCLUSION

Examining effective interest rate of optimum and real portfolios, we can conclude that finance institutions generally face problems implementing the announced policies in granting facilities.

If the limitations and constraints of genetic algorithm are defined properly, it can be helpful to such institutions in gaining more profit. The output of genetic algorithm is one generation (a set of solutions). If the first solution, which is also the best one, is not applicable, it is possible to opt for the second, the third and so forth solutions. Having a set of optimum solutions in hand is much better than having only one. The suggested model considers different limitations and, at the same time, tries to have a solution for granting facilities in different sections. The findings of this research show that the real effective interest rate is different from the effective interest rate in the optimum portfolio as the output of genetic algorithm. From 2010 to 2012, this difference is 6.04%, 4.37% and 2.89%, respectively. On the other hand, the difference between the real dishonoring rate and model's dishonoring rate from 2010 to 2012 is 0.29%, -0.22% and -0.27%, respectively. In addition, the model's performance degree, compared to real values, show that facilities portfolio suggested by genetic algorithm is higher in performance than the current portfolio.

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