Reducing the risks of the investment portfolio and maximizing its return using the genetic algorithm: A study of a sample of companies listed in the Iraq Stock Exchange

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Abstract:

The research aims to maximize the return on the investment portfolio and reduce the risk, and verify the ability of the genetic algorithm to build the portfolio in the Iraqi stock exchange for a sample of listed companies based on the monthly closing prices for five years (1/1/2015-31/12/2019). The research community represented the companies listed in the Iraqi stock exchange, as the sample amounted to eight companies listed in the Iraqi stock exchange, "the research conclusion that the genetic algorithm can deal with a large number of financial data entered does not contain any restrictions regarding the number of assets." “the ability of the genetic algorithm to achieve a trade-off between return and risk,” “the results showed that the portfolio that was built through the application of the genetic algorithm achieves less risk than the risk of the investment portfolio that was built in the usual way,” “while the researcher recommended to take advantage of this research, what it offers is the existence of a new mechanism in dealing with stocks and building investment portfolios in the Iraqi stock exchange, and following modern scientific methods and methods when building investment portfolios.

Keywords: genetic algorithm, investment portfolio, Iraq stock exchange.

Introduction:

The issue of investment portfolios is the focus of development for the investment world in the face of the new needs that have emerged for investors. Harry markowitz a Nobel laureate in economics, was one of the first to research portfolios in his article “portfolio choice” published in the financial journal in 1952. John Holland was one of the

first researchers on genetic algorithms in the 1960 and was developed by Holland and his students and colleagues at the university of Michigan in the sixties and seventies. Holland's introduction of a population-based algorithm with cross-reversal and genetic mutation was a major innovation. Then the genetic algorithm was used in various fields. The genetic algorithm was developed to build the investment portfolio from a large group of stocks listed on the Iraq stock exchange and enable investors to achieve the highest return. The algorithm selects the components of the investment portfolio, then sets the redistribution of weights and choose the best to build an investment portfolio of selected stocks. The research came in three main points, the first included the research methodology, while the second dealt with the theoretical framework of the research by addressing the genetic algorithm and building the investment portfolio. The research ended with the third point that focused on the practical side with conclusions and recommendations.

First, the research methodology

1.The importance of the research: the importance of the research is as follows: -

- Enabling investors in the Iraqi stock exchange to build investment portfolios using modern methods.
- The use of genetic algorithm in the process of building the investment portfolio works to redistribute the components of the investment portfolio.
- Focusing on the best ways to build the investment portfolio using the genetic algorithm by achieving the highest return and the lowest risk.
- The possibility of controlling the degree of investment risk in the investment portfolio helps encourage investment and leads to a better economy.

2.Research problem: The research problem can be clarified through the following questions: -

- **The first question**: is there a genetic algorithm capable of building the investment portfolio of companies listed on the Iraq stock exchange?

- **The second question** / is there a possibility for the genetic algorithm to deal with financial data in a way that leads to maximizing the return and reducing the risk?

3.Research objectives: they are represented in the following points: -

- Verify the possibility of using the genetic algorithm in building an investment portfolio to deal with financial data.
- The use of genetic algorithm in the Iraqi stock exchange for industrial companies in building the investment portfolio.
- Enable the investor to use modern methods and move away from traditional methods.
- Helping investors manage the risks of the investment portfolio and its minimization at the level of the industrial companies, the research sample, by using the genetic algorithm.

4.Research hypothesis: according to the research questions, we can put the following hypotheses: -

- There is an ability to genetic algorithm in building the investment portfolio of companies listed on the Iraqi stock exchange.
- There is a possibility of genetic algorithm in dealing with financial data in a way that leads to maximizing the return and reducing the risk.

5.Research community and sample: the study population was represented by companies listed in the Iraq stock exchange. The study sample was represented by (8) companies, including (4) industrial, (2) agricultural, (1) bank, (1) telecommunications company, and the sample was from (23) A company that has been expelled (15) for reasons that those excluded companies did not achieve the return component, which is the focus of our study. The reasons for choosing the study sample were as follows:

- The sample consisted of the shares of companies that continued to trade during the study period.
- Availability of the necessary data during the specified period.

- There is no case of merger between the selected companies during the study period.
- Companies that have achieved the portfolio return target.

Second: Theoretical framework

Investment portfolio and genetic algorithm

1: Investment portfolio

Portfolio investment is attributed to Harry Markowitz, nobel laureate in economics, who presented portfolio analysis in his article "portfolio selection" published in the financial journal in 1952 (Maginn, et al: 2007: 4). There are several definitions of the investment portfolio defined by (Mayo, 2000:6) the total assets owned by the investor and designated to transfer purchasing power to the future. He defined it (Kapoor, 2014: 1363) as a group of financial assets such as stocks, securities, bonds, debt instruments and their equivalents. A portfolio is defined as a combination of financial and non-financial assets that an investor holds (Cecchetti & schoenholtz, 2015:56).

2: The importance of the investment portfolio (Kafi, 2014:233).

- The purchasing power of the portfolio in several investment options due to the purchasing power that he enjoyed due to the collected funds.
- By diversifying in this way, the risk element is reduced in the event that one or more of these assets is unable to achieve the desired return.
- Because of the combined purchasing power, the portfolio is able to buy and sell in quantities, which can buy at discounted prices, an advantage that a single investor does not enjoy.
- The experience available to the portfolio manager is an advantage that the personal investor does not enjoy, and the resources available to portfolio managers are not possible for ordinary investors.
- The portfolio manager performs the administrative management of the portfolio, which relieves the investor of the daily follow-up of paperwork.

3: Portfolio Building Objectives

The primary objective from the investor's point of view in the process of portfolio building is to obtain return and avoid risk.

A: Return portfolio

The return is the main motive behind the movement of capital from one region to another. The expected return of a portfolio is simply the weighted average of the expected returns on the individual securities in the portfolio (Chandra, 2009: 218). The return of a portfolio differs from the return of an individual security, as it is the sum of the benefits achieved by its component securities, the latter resulting when the selling price of these securities is greater than their purchase price (Al-Hasnawi, 2018:198). The return of the portfolio is the weighted ratio of returns to all the securities that make up the portfolio, according to the following equation (Hiller, Grinblatt, 2008:102).

$$R_p = \sum_{i=1}^{n} W_i R_i$$

(Chandra ,2009:219).

…….. (1)

B: Portfolio risk

As for the second element that aims at the investor's mechanism in the process of building a portfolio, it is the risk, so investors seek to achieve the highest return in the investment portfolio in exchange for reducing risks to the lowest possible level, and that the relationship between return and risk is direct, and the risk is meant to be uncertain about obtaining the return (Levisuskaite, 2010:35). Therefore, portfolio risk is the sum of individual security differences and the combined movement with other securities in the portfolio (Ranganatham & Madhumathi, 2006: 450). The systemic portfolio risk is measured according to the following equation:

$$\beta_p = W_1\beta_1 + W_2\beta_2 + \cdots W_2\beta_2$$

…….. (2)

4: genetic algorithm

Genetic algorithms are tools of evolution that depend on natural selection and the mechanisms of genetics. In natural selection, evolution processes occur when the following conditions are met (Divya & Kumar, 2012:2102): -

- The individual is able to reproduce
- There is a group of these individuals who are able to reproduce
- Some differences in the ability to survive in the environment are associated with this diversity

Defines (Affenzeller et al, 2009:3) genetic algorithms as iterative, stochastic algorithms that cannot guarantee confluence. They are run by reaching the maximum number of generations or by finding one or more acceptable solutions. The evolution of the end criterion indicates early convergence.

As defined by (Bhattacharjya, 2013:5), genetic- algorithms are heuristic research and evolution techniques that mimic the process of natural evolution.

As (Sukono et al, 2018:4) defined genetic -algorithms as a research method that depends on the mechanisms of genetics and natural selection. Organisms can survive if they are able to adapt to the environment.

5: The basic elements of a genetic algorithm

A: Population: it is a set of Individuals who are being tested, as well as phenotypic parameters that identify individuals and some information about the research space. The aspects of the population used in the genetic algorithm are represented by the following (Sivanandam&Deepa, 2008:41): -a) The first generation of the population. b) the size of the population. The population is made up of a set of chromosomes and Table (1) shows the population in the genetic algorithm.

Table (1) population in genetic glgorithm

Population	Chromosome 1	1 1 1 0 0 0 1 0
	Chromosome 2	0 1 1 1 1 0 1 1
	Chromosome 3	1 0 1 0 1 0 1 0
	Chromosome 4	1 1 0 0 1 1 0 0

Source: Sivanandam, S. N.&Deepa, S. N.," Introduction to Genetic Algorithms", Springer, Berlin, Heidelberg 2008.

B: Individuals: individuals are divided into chromosomes and then into genes, and each gene represents one of the variables in the solution, and the chromosome must contain the necessary information about the solution it represents so that each chromosome represents a solution. Table (2) shows the chromosome genotype (Sivanandam & Deepa, 2008:39):

Table (2) chromosome genotype and Solution set Phenotype

Solution set phenotype				
Factor 1	Factor 2	Factor 3	.....	Factor n

Gen 1	Gen 2	Gen 3	.....	Gen n
Chromosome genotype				

Chromosome representation

1	0	1	0	1	0	1	1	1	0	1	0	1	1	0

C: Encoding: encoding is the process of gene representation that is based on converting the real values of variables into a series of symbols in order for the genetic algorithm to deal with them, and the process can be implemented using units (bits, numbers, decision trees, arrays or lists) (Sivanandam & Deepa, 2008:43). Classification of encryption into the following types: -

- **Binary Encoding**: it is one of the most common types of cipher (Mitchell, 1999: 116), as each chromosome in binary cipher is a sequence of bits (0 or 1). Table (3) shows the binary coding.

Table (3) Binary encoding

Chromosome A	1 1 0 1 0 0 0 1 1 0 1 0
Chromosome B	0 1 1 1 1 1 1 1 1 1 0 0

Source: Sivanandam, S. N.&Deepa, S. N.," Introduction to Genetic Algorithms", Springer, Berlin, Heidelberg, India, 2008.

- **Permutation Encoding**: it is noted in this type of coding that each chromosome is a series of numbers, which represent the number in the sequence. Table (4) shows the cross-coding.

Table (4) Permutation encoding

Chromosome A	**1 5 3 2 6 4 7 9 8**
Chromosome B	**8 5 6 7 2 3 1 4 9**

D: Fitness: it is one of the common applications of(GA) and an essential component of it, as it develops the function and aims to find a set of parameter values (Mitchell, 1999:7). Suitability is a value associated with a chromosome that confers a comparative advantage to that chromosome (Haupt & Haupt, 2004: 245).

6: Portfolio application in the life cycle of a genetic algorithm

Once the Reproduction and fitness function has been correctly identified, the genetic algorithm is developed according to the same basic architecture. It begins with the generation of an initial set of chromosomes. This initial set must also present a variety of genetic material. The gene pool should also be as large as possible so that any solution to the research space can be generated. The creation of the initial population is generally

random (Sivanandam & Deepa, 2008:31). The application of the investment portfolio can be represented by the life cycle of the genetic algorithm as follows (Gennawi, 2019:51).

- Initialization of the initial community, which is a community of chromosomes, ie the weights of the components of the investment portfolio generated randomly.
- Selection is the individuals who are selected based on their value of the fittest. The higher the value of suitability for each individual, the higher the chance of the individual appearing within the community.
- Reproduction, which is the process or the step during which the process of crossing and mutation takes place.

Replacement: replacing the members of the old society with new ones, that is, adjusting the weights of the components of the old portfolio, return and risk, and re-assigning these weights to maximize returns and reduce risks. Figure (1) shows the life cycle of a genetic algorithm.

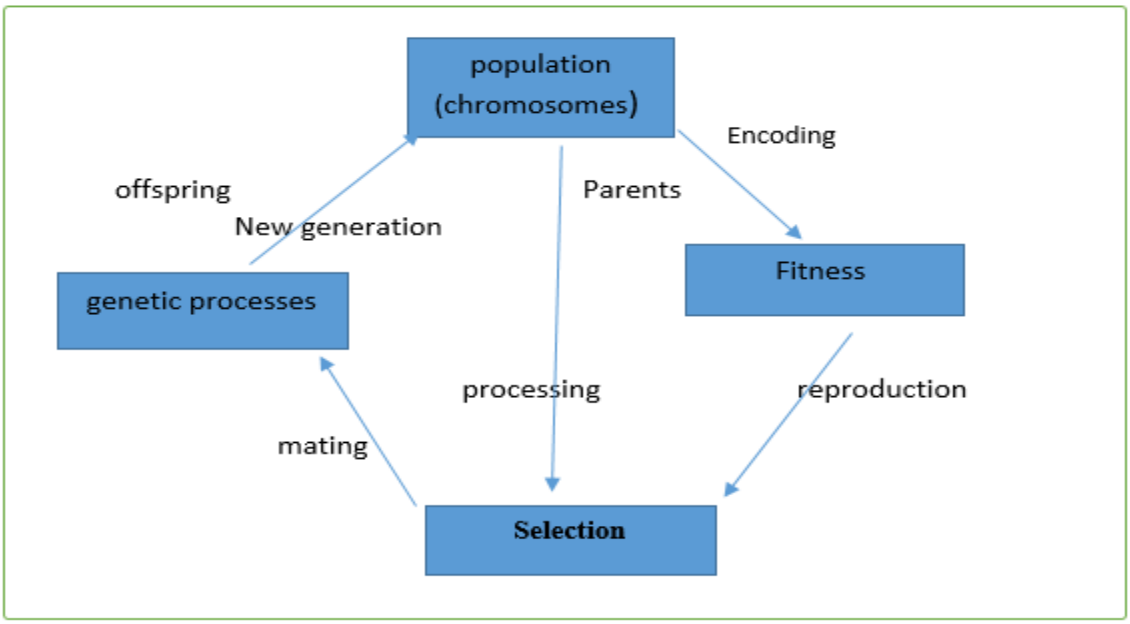

Figure (1) the life cycle of a genetic algorithm

Source: Sivanandam, S. N.&Deepa, S. N.,"Introduction to Genetic Algorithms", Springer, Berlin, Heidelberg, India, 2008.

Third, the practical aspect

1: Building the investment portfolio using the genetic algorithm

After obtaining the weighted returns and risks (chromosomes) for each study sample company. It is necessary to build a genetic algorithm, which focuses on one goal, which is to improve the performance of the weights of the components of the investment portfolio. That is, improving the values of the relative weights of its components (wi), in other words, trying to redistribute the weights among the components of the investment portfolio, which fulfills two basic conditions for building the investment portfolio: raising returns and reducing risks. Therefore, the search for a way to achieve a balance between these two components within the investment portfolio has become a necessary condition for its implementation. Thus, according to this conflict, we get the two objective functions:

- The first tries to maximize returns.
- The second attempts to minimize the risks associated with maximizing the returns.

Thus, the mathematical models of the genetic algorithm can be defined as follows: -

$$Max\ (z) = \sum_{i=1}^{n} w_i\, \overline{\mathrm{R}}_i \qquad ,\mathrm{i} = 1, \dots \dots \mathrm{n} \qquad (1)$$

$$Min\ (z) = \sum_{i=1}^{n} w_i\, \beta_i \qquad ,\mathrm{i} = 1, \dots \dots \mathrm{n} \qquad (2)$$

Subjecte

$$\sum_{i=1}^{n} w_i = 1 \qquad \sum_{i=1}^{n} w_i \geq 0 \qquad 0 \leq w_i \geq 1$$

In equation (1), $\overline{R}$ is the component of the average returns of the investment portfolio and (w) are the relative weights of those returns. In Equation No. (2), β is the component of the risk of the investment portfolio and (w) are the relative weights of those risks. Table (5) shows the limitations of the genetic algorithm.

Table (5) Limitations of the Genetic Algorithm

constraint type	The type of dealing with the constraint	the transfer	the value
≥ constraint type	**Indirect**	**Multiplied by (1-)**	**-[0]**
≤ constraint type	**direct**		**[1]**
= constraint type	**direct**		**[1,1,1,1,1,1,1…,1]**
constraint type *lower*	**direct**		**[0,0,0,0,0,0,0…,0]**
constraint type*upper*	**direct**		**[1,1,1,1,1,1,1…,1]**

2: Building an investment portfolio using genetic -algorithm

Once the reproduction and Fitness function has been correctly identified, the genetic algorithm is developed according to the same basic architecture. It begins with the generation of an initial set of chromosomes. This initial set must also present a variety of genetic material. The gene pool should also be as large as possible so that any solution to the research space can be generated. The creation of the initial population is generally random. The genetic algorithm selects stocks, then sets weights by finding an appropriate mix of return and risk, and this is evident through the work of the genetic algorithm as follows:

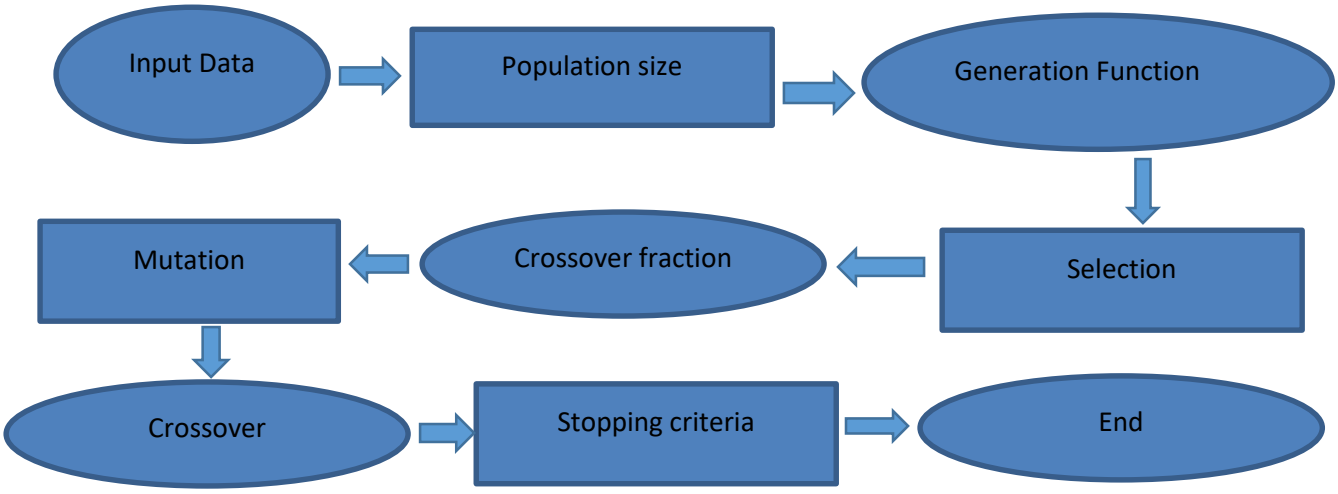

Figure (2) the genetic algorithm steps to build the investment portfolio.
Source :Researcher Preparation

Thus, the objective function that is concerned with maximizing returns (MAX 1) can be defined as follows

Z (1) =0.04172*W (1) +0.004056*W (2) +0.24172*w (3) +0.17604*W (4) +0.25116*W (5) +0.33974*w (6) +0.07958*W (7) +0.01214*W (8)

The process of maximizing returns is represented by multiplying the expected return (Ri) by the weight extracted.

As (W) are the weights within the portfolio, whose values can be determined randomly within the closed period [1-0].

It is known that the main objective of the genetic algorithm is to improve the combination of weights of returns by manipulating chromosomal genes (return, risk).

The objective function that is concerned with minimizing risk (MIN 2) can be defined as follows

Z (2) =0.04100838*W (1) +(-0.2790823) *W (2) +(0.06530228) *w (3) +0.5669026*W (4) +0.00741236*W (5) +0.1692808*w (6) +0.2621785*W (7) +0.232426*W (8)

Where the values included in the second objective function represent the values of the risk, which is expressed in the symbol beta (β). Table (6) shows the return and risk values of the investment portfolio.

Table (6) the return and risk values of the investment portfolio.

risk portfolio		return portfolio		weight	Company Code	Company name	
$*\beta_i w_i$	β_i	$*\overline{R_i} w_i$	$\overline{R_i}$	w_i			
0.001493	0.04100838	**0.001519**	0.04172	0.0364	BNOI	**National Bank of Iraq**	**-1**
-0.00099	-0.2790823	**0.0000144**	0.004056	0.003539	TASC	**Asia Cel**	**-2**
-0.01377	-0.06530228	**0.050978**	0.24172	0.210896	IM0S	**modern sewing**	**-3**
0.087072	0.5669026	**0.027038**	0.17604	0.153592	IITC	**Carpets and Tufted**	**-4**

0.001624	0.00741236	**0.055037**	0.25116	0.219132	INCP	**chemical and plastic**	**-5**
0.077714	0.1692808	**0.100705**	0.33974	0.296417	IRMC	**Ready production**	**-6**
0.011754	0.2621785	**0.005525**	0.07958	0.069432	AIPM	**Meat production and marketing**	**-7**
0.002462	0.232426	**0.000129**	0.01214	0.010592	AIRP	**agricultural products**	**-8**
0.167358		**0.240945**		%100			

The highest weight extracted for the study sample companies was obtained by the ready-made garments production company (0.296417), while the lowest weight was obtained by the Asia Cell Company (0.003539).

In Panama, the highest expected return was obtained by the ready-made garment production company (0.33974), while Asia Cell obtained the lowest expected return (0.004056).

As for the highest return achieved to the portfolio through the ready-made garment production company, it amounted to (0.100705), while the lowest return to the portfolio was through asia cell (0.000144).

The meat production and marketing company achieved the highest risk as it reached (0.2621785), while it was the lowest risk to the asia cell company (-0.2790823).

The highest risk to the portfolio was achieved through the Carpet and furniture Company, which amounted to (0.087072), while the lowest risk was achieved to the portfolio through the modern sewing company (-0.01377).

3: Genetic algorithm review

After analyzing the data and displaying the results of the genetic algorithm, different combinations of weights were obtained to express the optimal overlap ratio between the reward component and the risk component. Shown in table (7), they are renewable

weights within the investment portfolio, and choosing a good combination of weights that achieves a balance between the return component and the risk component.

Table (7) weights for the components of the investment portfolio

w_i	Company name	
0.01609	**National Bank of Iraq**	**-1**
0.00351	**Asia Cel**	**-2**
0.10911	**modern sewing**	**-3**
0.15229	**Carpets and Tufted**	**-4**
0.21726	**chemical and plastic**	**-5**
0.4439	**Ready production**	**-6**
0.04884	**Meat production and marketing**	**-7**
0.0085	**agricultural products**	**-8**

The highest weight was achieved through the genetic cycle through the process of selecting chromosomes to the ready-made garment production company (0.4439), and the lowest weight was achieved through the genetic cycle to the genetic algorithm of Asia cell (0.00351).

From the results of the weights listed in the above table, which represent the weights of the components of the investment portfolio that achieve the best balance showing the return and risk of the portfolio, among all the combinations of weights achieved in this regard, it is worth noting that all the combinations of weights generated by the genetic algorithm are much better than the combinations of the original weights. Table (8) shows the return and risk values according to the new weights.

Table (8) values of return and risk according to the new weights

risk portfolio		return portfolio		weight	Company Code	Company name	
$*\beta_i w_i$	β_i	$*\overline{R_i} w_i$	$\overline{R_i}$	w_i			
0.00066	0.04100838	**0.000671**	0.04172	0.01609	BNOI	**National Bank of Iraq**	**-1**

-0.00098	-0.2790823	**0.00000142**	0.00406	0.00351	TASC	**Asia Cel**	**-2**
-0.00713	-0.0653302	**0.026373**	0.24172	0.10911	IM0S	**modern sewing**	**-3**
0.086331	0.5669026	**0.026808**	0.17604	0.15229	IITC	**Carpets and Tufted**	**-4**
0.00161	0.00741236	**0.054568**	0.25116	0.21726	INCP	**chemical and plastic**	**-5**
0.055143	0.1692808	**0.150809**	0.33974	0.4439	IRMC	**Ready production**	**-6**
0.012805	0.2621785	**0.003887**	0.07958	0.04884	AIPM	**Meat production and marketing**	**-7**
0.001976	0.232426	**0.000103**	0.01214	0.0085	AIRP	**agricultural products**	**-8**
0.150418		**0.263233**					

By comparing the results of the genetic algorithm shown in the previous two tables, we note that there is an improvement in the component of returns and the component of risk. Where the return changed from (0.240945 to 0.263233), and therefore there is an improvement value of (0.022288). On the other hand, the risk component recorded a very clear decrease from 0.167358 to 0.150418. This indicates the power of the genetic algorithm to choose the components of the investment portfolio, and this is reflected in the amount of balance between the component of return and risk.

Conclusions:

After completing the description, analysis and testing of the hypotheses, the following can be concluded: -

1. The results showed that the investment portfolio that was built by applying the genetic algorithm approach achieves a higher return than the return on the portfolio that was built in the usual way.

2. The results showed that the portfolio that was built through the application of the genetic algorithm achieves less risk than the risk of the investment portfolio that was built in the usual way.

3. The ability of the genetic algorithm to reduce the risks of the investment portfolio that cannot be avoided in diversification, by redistributing the balance (chromosomes) of the components of the investment portfolio.

4. The genetic algorithm moved away from external influences in decision-making to choose the components of the investment portfolio through its reliance on the processed financial data represented in the monthly return of the study sample companies, and thus it is characterized by the impartiality of decision-making.

5. The algorithm selects stocks based on a fit function designed on investor fundamentals, then assigns weights to selected stocks by finding a genetically appropriate combination of return and risk based on historical data.

6. The possibility of applying the genetic algorithm in the Iraqi stock exchange for listed companies, and it showed the ability of the genetic algorithm to deal with a huge amount of random data entered.

7. The genetic algorithm showed its ability to deal with the huge amount of random data entered, and it does not contain any restrictions regarding the number of assets that make up the investment portfolio.

Recommendations: The researcher suggested the following recommendations: -

1. Increased interest in the use of genetic algorithms in all fields in general, investing in particular and decision-making, for the possibility of genetic algorithms to deal with the huge amount of random data.

2. Clarify the reason for the stability of closing prices for a significant period of time for companies listed in the Iraqi Stock Exchange, and this gives inaccurate results.

3. This study gives the addition of a new scientific possibility in the Iraqi Stock Exchange that helps investors build their investment portfolios and enables investors to deal with the random movement of stocks, which is one of the requirements for developing the Iraqi Stock Exchange.

4. Educating the investor about the necessity of dealing in the Iraqi market for securities, and this helps to develop the field of investment and the rise in stock prices.

5. The researcher recommends investors to benefit from this research, as it provides a new mechanism in dealing with stocks and building investment portfolios in the Iraqi Stock Exchange, and following modern scientific methods and methods when building investment portfolios.

6. Investors should follow scientific methods in building their portfolios and choosing stocks, and avoiding traditionalism

7. Increasing interest in the use of genetic algorithms in all fields in general, investing in particular and decision-making, for the possibility of genetic algorithms to deal with the huge amount of random data.

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