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Smart Investing: Leveraging AI for Risk-Aware Financial Approach

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Abstract

Financial markets are known as one of the most complex and fascinating sectors of the world economy. Billions of dollars are traded daily in these markets and for investors and traders, they are seen as opportunities to earn profits and increase their assets. Today, the applications of artificial intelligence in asset management are not a secret to anyone. The emergence of artificial intelligence technology has opened up new ideas and models for asset management, marketing and sales development, advertising, e-commerce and store services. The current research aims to provide an investment strategy to smooth the progress of the investor company in the financial markets; Therefore, the upcoming research can be considered practical in terms of purpose. Additionally, since the present research uses mathematical models, modeling, artificial intelligence, and evaluates the portfolio optimization of the investor company with the proposed model, it is therefore a quantitative and descriptive type of research. This research evaluated the performance of the proposed model in three cases: cautious, moderate and risk-taking investor companies. The obtained results showed that for all three cases, the presented strategy works significantly better than the market index and other previous strategies. At the end of the investment period, the risk-taking portfolio had a higher value than the other portfolios. On the other hand, the conservative portfolio earned more stable and steady returns. These results revealed that the presented fuzzy planning is able to reflect the characteristics and tendencies of the investor company in the portfolio composition.

Keywords: Artificial Intelligence, Risk, Assets, Financial Markets, Management.

1. Introduction

Artificial intelligence offers a highly effective opportunity for advancing and enhancing asset management in today's world. The more artificial intelligence can be used for asset management, the more it will help the growth and development of assets (Coles et al., 2021). Artificial intelligence can increase global GDP by 14% from 2017 to 2030 (Jin et al., 2022). Gartner announced in a report that by 2024, about 75% of organizations will use some from of artificial intelligence operationally in their activities. In one of the recently announced studies, the value of the artificial intelligence market was equal to 62 billion dollars in 2020 and it is expected to experience an annual growth rate of 40.2% from 2021 to 2028. These same statistics show that the use of artificial intelligence is increasingly expanding and in the not-so-distant future all investments will leverage the applications of this intelligence to facilitate and accelerate their investment activities. (Afzali and Fuladi, 1401)

One of the fundamental aspects of financial management is the effective administration of the investment process, commonly referred to as investment portfolio optimization (Demerjan et al., 2021). An investment portfolio, or simply a portfolio, encompasses the various assets an investor holds (Posadast and Hosseini, 1402). The financial industry is increasingly adopting automation, chatbots, adaptive intelligence, algorithmic trading, and machine learning in its processes, with a significant portion of Wall Street transactions being executed through software (Anderson et al., 2022). Algorithms based on artificial intelligence can predict stock prices, (Awas, 2019), identify investment opportunities, and even be used for management (Chen et al., 2020). Of course, the use of artificial intelligence in this case has both good and bad results. For example, ARK Autonomous Technology & Robotics ETF (BATS: ARKQ) uses artificial intelligence as a research tool and has had good results, but the ETF used artificial intelligence instead of human analysts and so far, has provided poor and unacceptable results (Dolatabadi et al., 2018).

In this regard, investor companies and financial institutions play a much more prominent role, therefore, optimizing the investment process of the investor company in these markets will lead to a better circulation of national production cycles and the country's economy (Avas, 2019). In addition, such activities also increase the profit margin of the investor company, But this work requires controlling the risk in these processes and its optimal management (Liu and Zhang, 2021). Despite the valuable services of artificial intelligence in the growth and development of investment in financial markets, they still did not understand it in Iran and could not use these financial markets properly. Even platforms like Divar with a large number of users could not use artificial intelligence tools correctly, that's why users always face many challenges that are caused by incorrect data of the programmers of this platform (Alipour et al., 2018). Developing countries in the region are smartly applying artificial intelligence in all aspects of investment management; But in Iran, business managers are still facing simple challenges such as broadband and free internet, and they cannot properly use modern tools in the growth and development of investment in international financial markets. Artificial intelligence can increase the sales of companies by 50% through systemized processes, but it seems that Iran has been away from modern civilization for years and has nothing to do with modern communication technologies in business (Posadast and Hosseini, 1402).

In this regard, it is necessary and inevitable to identify and apply optimal methods to increase efficiency and reduce the risk caused by the investment company's entry into such activities; Therefore, the present research aims to smooth the progress of the investor company in the financial markets by presenting an investment strategy.

This research provides a flexible and practical strategy for optimizing the investment portfolio in the financial markets. This strategy consists of four main parts:

- Fuzzy artificial intelligence to analyze and predict the performance of financial assets.
- Mathematical model for optimizing and updating the portfolio of the investor company.
- Fuzzy planning method to incorporate special conditions and preferences of the company in the investment process.

• And the genetic algorithm to select an optimal portfolio from a large number of financial assets.
Therefore, the basic problem that this research tries to solve is to provide an optimal scientific strategy for managing the investment portfolio of the investor company in the international financial markets with the aim of increasing the yield and reducing the risk caused by the activity of the investor company in these markets. In the continuation of the research, the theoretical foundations and background will be examined in the second part. Following this, the third part will describe, the research methodology including the model, tools and concepts used is described and at the Finally, the analysis of the findings and general conclusions will be presented.

2. Literature and Research Background

Portfolio theory is founded on the seminal 1952 article by Markowitz, titled 'Portfolio Selection.' This theory addresses a fundamental question that has long preoccupied investors: How should I allocate my assets among various investment opportunities? Markowitz was the first to quantify the return and risk of financial assets using statistical measures, specifically expected return and standard deviation of return. He suggested that investors should evaluate both return and risk simultaneously and make decisions based on a trade-off between them when allocating their assets. The core principle of Markowitz's theory is portfolio diversification. The key idea is that the risk of a portfolio is not solely dependent on the risk of individual assets but also on the correlations among them. Additionally, Markowitz's work revolutionized the financial decision-making process by framing it as an optimization problem. The model he presents selects a portfolio that has less risk for a given level of return among all possible portfolios (Naeem, 2021).
The traditional models of portfolio selection, including the mean-variance model, consider only the two basic factors of risk and expected return in the portfolio selection process (Anderson et al., 2022). These models assume that all financial assets are completely liquid (assumption of absolute liquidity of financial assets). Based on this hypothesis, the investor can easily buy or sell any amount of any financial asset at any time without being affected by the price of that financial asset (Pak Meram et al., 2016). However, the liquidity of financial assets is one of the most important criteria that is considered in choosing investment opportunities. In practice, most investors tend to invest in assets that have a higher degree of liquidity (Chamanour et al., 2020).

One of the most prominent features of the new portfolio theory is the principle of diversification of financial assets. The Markowitz model tries not to put all the investor's eggs in one basket by minimizing the variance of the portfolio. Nevertheless, many empirical studies show that the portfolios calculated with this model are focused on a small number of assets (Coles et al., 2021). In other words, based on empirical research in the literature, it can be said that portfolio risk minimization alone cannot guarantee the diversity of financial assets in the portfolio (Chen and Lin, 2020).
Ferreira et al. (2017), in their research, used a fuzzy hybrid integrated framework for portfolio optimization in private banking. Their proposed approach, for personal investment securities, introduced legal aspects and investor preferences as inputs into the model and examined risk and return as the goals of this model. In their research, Liagkouras and Metaxiotis (2018) investigated the multi-period Famiangi-variance fuzzy optimization model for portfolio optimization considering transaction costs. In their research, portfolio risk was measured using the fuzzy return variance, and maximizing wealth and minimizing the cumulative risk of securities over the entire investment horizon were considered as two contradictory goals in their research; and used multi-objective genetic algorithm with adverse sorting to solve the developed model. Kaousis (2019) in his research investigated stock portfolio management with cardinality constraints and risk parity control using multi-objective particle swarm optimization. Kalisi et al. (2020) in their research used the combination of ant colony optimization algorithms, artificial bee colony optimization and genetic algorithms in order to solve the portfolio optimization model.

In their research, Behnamian and Mashrafe (2016) presented a hybrid algorithm for multi-objective optimization of the stock portfolio by means using fuzzy programming. In this research, considering the fuzzy concepts in the discussion of stock portfolio optimization, the uncertainty in this problem was modeled. Next, using the Bonnison method, the priority between each of the stocks was determined to reduce confusion in decision-making; And finally, due to the complexity of the problem, a hybrid algorithm based on variable neighborhood search and genetic algorithms was developed and compared with other solving algorithms for validation. Rai et al. (2017) in their research investigated the efficiency of investment portfolio optimization using the minimum variance and N/1 combined model. The performance of the investment portfolio resulting from the research models was evaluated using criteria such as Sharpe, Trainor, Modigliani Modigliani, Information and Sortino, and finally the TOPSIS multi-criteria decision-making method was used to rank the research models. Mohebi and Najafi (2017), in their research, investigated multi-period investment portfolio optimization with dynamic planning approach. In this research, in addition to considering the multi-period horizon and transaction cost, the absolute value of the deviation from the average is used as a measure of risk, and the limits of liquidity, cardinality, threshold and class are also included in the model; Also, the uncertainty of the data has been modeled using the scenario tree tool. Gharib and Kosha (2018) investigated the optimization of Ansar Bank's customer portfolioin the retail banking sector using genetic algorithm.

In this research, three non-linear programming models (two objective functions and one objective function) and an ideal model were used to optimize the facility portfolio of Ansar Bank's retail customers. In their research, Sina and Fallah Shams (2018) investigated the optimization of the investment portfolio with the approach of Frein's value theory in the Tehran Stock Exchange. In this research, Frein's value theory was used to measure investment risk as one of the newest measures of value at risk. The results of the research indicated that the formation of the optimal stock portfolio using Frein's value theory is not significantly different from Markowitz's mean-variance model.

Unrealistic assumptions about market behavior, not having the right tools to predict the performance of financial assets and ignoring factors such as; Transaction costs and portfolio liquidity are among the things that have caused a gap between the scientific models of portfolio optimization and what investors need in real markets. On the one hand, a significant amount of literature questions the efficient market hypothesis, and on the other hand, the documents and evidence in the literature show that investors do not always behave rationally. Therefore, the present research in a fuzzy environment simulates the mental process of reasoning and inference that technical analysts use to analyze the state of financial assets by means of an artificial intelligence.
In this way, the degree of possibility of each asset being undervalued or overvalued is determined. Based on the obtained results and the investor company's preferences, an optimization model updates the portfolio by considering the risk-free rate of return (bank interest rate), liquidity, portfolio entropy, and transaction costs. Finally, a genetic algorithm scales this model for a large number of variables.

3. Research Method

The upcoming research is applied in terms of its purpose, which seeks to manage the investor company's portfolio. Additionally, due to the fact that mathematical models, modeling, artificial intelligence, etc. are used in this research and the portfolio management of the investor company is evaluated with the proposed model, therefore, it is a quantitative and descriptive type of research.
The first goal of this research is to develop a fuzzy artificial intelligence that can predict the future returns of financial assets (such as company shares, forex market currencies, ounces of gold, future contracts, etc.). This artificial intelligence, which is designed using the applied Visual Basic programming language and in the Excel software environment, simulates the mental process of reasoning and inference of technical analysts to predict the future state of financial assets in a fuzzy environment. The purpose of this work is

to assess the potential for each financial asset to be undervalued or overvalued for each of the financial assets of the investor company for investment.

The next goal is to present a mathematical model for managing the investor's company portfolio based on the results obtained from artificial intelligence analysis. This model manages the investment portfolio of the investor company in a way, by taking into account the company's risk tolerance level and the rate of return on risk-free assets (interest rate without banking risk); which has the highest growth potential and the lowest possible risk in each investment period. The amount of entropy and liquidity of the investor company's portfolio, the cost of buying and selling financial assets and some practical restrictions, including the minimum and maximum number of stocks in the portfolio and the maximum and minimum weight of each selected stock in the portfolio; There are other cases that the model presented in this research pays attention to in order to match and coordinate with the real conditions of the financial markets.

The third goal in the current research is to develop a fuzzy planning method that provides the possibility of solving the presented model by considering the conditions and demands of the investor company. It is essential that the level of risk tolerance and also the length of the period considered for investment are among the most important preferences of the investor company, which the presented model should show sensitivity towards.

Including all these items will make the presented model computationally complex in terms of its mathematical solution. Having a non-linear objective function to minimize portfolio risk, a large number of decision variables in the problem and the presence of integer variables in the model are just some of the things that will naturally result in this complexity. Therefore, the development of an evolutionary algorithm, such as genetic algorithms to solve the presented model is the fourth goal that the leading research has considered for itself. It goes without saying that the development of this algorithm takes place in the MATLAB software environment. This research designs a fuzzy artificial intelligence called Fitas to analyze and predict the potential performance of financial assets. In fact, Fitas simulates the mental process of reasoning and inference that technical analysts in financial markets use to analyze financial assets. These analysts judge and predict the future status of the relevant financial asset based on technical graphs. Phytas also does the same thing. Fitas receives data related to the volume of transactions and the final price of financial assets and calculates technical data. Then, for each asset, it calculates one degree of possibility of being undervalued and one degree of possibility of being overvalued. Fitas artificial intelligence is coded in Visual Basic and implemented in the Excel software environment (Artenlis and Kelisi, 2018).

The presented fuzzy artificial intelligence is responsible for analyzing and predicting the performance of financial assets at the beginning of each sub-period. The presented mathematical model, fuzzy programming and genetic algorithm update the portfolio of the investor company based on the results obtained from artificial intelligence analysis. To be more Specifically, artificial intelligence calculates the degree of possibility of being undervalued and overvalued for each of the assets. Subsequently, the mathematical model, fuzzy programming, and genetic algorithm update the company's portfolio based on these degrees of possibility, taking into account the investor company's preferences, portfolio liquidity, transaction costs, and bank interest rates.

4. Research Findings

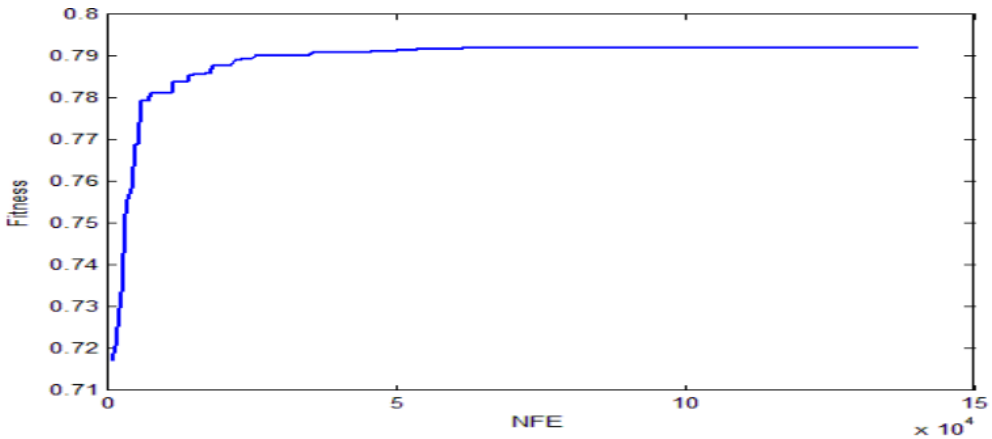
This research evaluates the performance of the proposed strategy using established criteria, including portfolio value at the end of the period, compound return, average monthly return, Sharpe ratio, and information ratio. The results are then compared with the market index and the outcomes of a buy-and-hold strategy.The desired investment period is divided into 20 one-month sub-periods and we assume that the investor company updates its portfolio at the beginning of each sub-period using the fuzzy planning model for updating the portfolio of the investor company. Additionally, the expected returns of the companies' shares and the covariance between them are calculated based on their monthly returns in the last 10 months

leading up to the portfolio update date. Therefore, we have: monthly = T and T = 10. To calculate the illiquidity of the assets, the monetary volume of their daily transactions during the last 60 days leading to the portfolio update date has been used. In this way, we have: daily T= and T=60.
In the continuation of the research, the degrees of possibility of being expensive, the degrees of possibility of being cheap, the expected return and the illiquidity of the financial assets of the investigated company for each of the 20 sub-periods were predicted and calculated by Fitas artificial intelligence.
Considering that the characteristics and preferences of the investor company will significantly affect on the composition of the optimal portfolio, this research evaluates the performance of the proposed model in three cases: cautious investor company, moderate investor company and risk-taker investor company. A prudent investor company does not seek to obtain very high returns, but aims to achieve stable and durable returns and is not willing to take too excessive risk. On the other hand, the risk-taker investor company seeks to maximize returns and is willing to take substantial risks to achieve this. The average investor company is between these two extremes and aims to achieve a moderate return by accepting a reasonable level of risk. According to the characteristics of the investor company in these three hypothetical cases, the weights of the objective functions for each case have been determined as shown in Table (1).

Table 1: Weight of objective functions for three hypothetical investors

	W_F	W_S	W_I	W_C	W_M
Cautious	40%	40%	10%	5%	5%
Moderate	50%	30%	10%	5%	5%
Risk Taker	60%	20%	10%	5%	5%

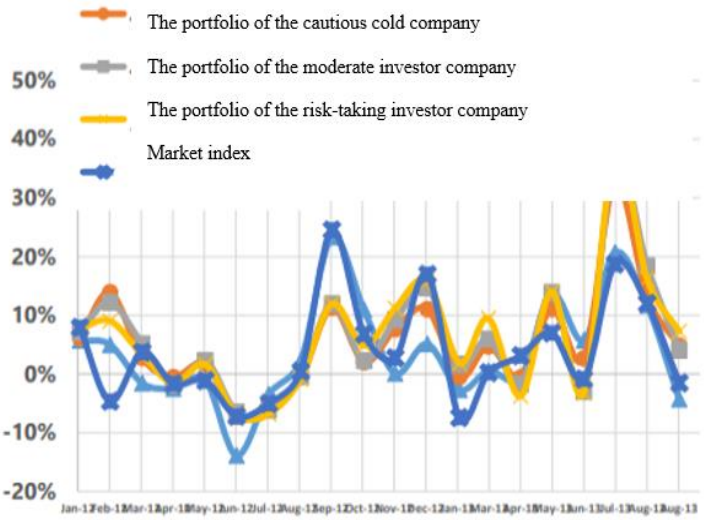
The values of WF and WM are determined according to the efficiency of the target market and the duration of the sub-periods. The more efficient the target market, the less important WF and the more important WM. Also, as the time interval between successive portfolio updates increases, WF decreases and WM increases. Therefore, as table (1) also shows, considering the duration of one month under the periods, which is considered as a relatively short horizon, the current research has given more weight to the predictions of the Fitas artificial intelligence system. Since the number of decision variables of the problem is equal to 40, the number of members of the main population is considered to be about ten times that and NPOP=400. The selection pressure parameter in the merit-based selection method is $\beta=7$ and in the competitive selection method, the number of members is set to m=3. PC, PM, and nmu parameters are set to 0.8, 0.6, and 0.5, respectively. The parameter $\gamma=0.5$ is set for the combination process. The stopping condition for the first algorithm that calculates the productivity table is 80 repetitions and the second algorithm that identifies the optimal portfolio is considered equal to 250 repetitions. Because the first algorithm faces only one objective function each time and converges faster. By considering these parameters, the algorithm identified the optimal portfolio of each sub-period for cautious, moderate and risk-taker investor companies. Graph (1) shows how the genetic algorithm converges to find the optimal portfolio in one of the sub-periods. According to this figure, the algorithm has been able to satisfy it to close to 0.8 with approximately 150,000 objective function evaluations (NFE).



Graph 1: Improving the amount of the objective function by the genetic algorithm

The portfolio optimization model was implemented over a period of 20 months and its results were reported in the previous section. This part of the research evaluates the performance of the model. The criteria used to evaluate the performance of the model are: portfolio value at the end of the period, compound return, lowest monthly return, highest monthly return, average monthly return, Sharpe rate and information rate. In addition, this research considers the index of the 50 most active companies in the financial markets as a basis. Also, the performance of the purchase and maintenance strategy is also compared with the performance of the model.

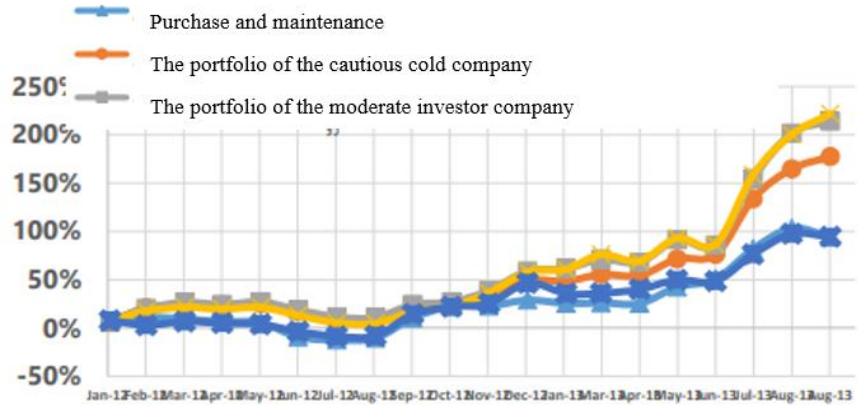
Graph (2) shows the monthly return of the portfolio of the investor company in three hypothetical states (cautious, moderate and risk-taker) compared to the market index. As it can be seen, more or less, the yield from the investor's portfolio follows the market index. However, in a certain period around July 2013 there is a significant difference between the returns of the model and the market index. This period coincides with the US presidential election, which typically has a significant psychological impact on prices.



Graph 2: Monthly returns

In this way, in the periods when political factors have played a more prominent role than usual and as a result the market mistakes in the pricing of financial assets have intensified, the model presented in this research has shown better performance. Therefore, it can be concluded that Fitas artificial intelligence, which was designed with the aim of determining the possibility of undervalued and overvalued assets using technical analysis, has well recognized the mistakes of the market in the pricing of financial assets. In the

same way, the portfolio update model has also been able to use the market fluctuations, which were mainly caused by the emotional decisions of traders, by using Fitas predictions, and achieved returns significantly higher than the market index. Graph (3) shows the cumulative return of the portfolios produced by the proposed method compared to the cumulative return of the portfolio of the buy and hold strategy and the market index. The significant difference between the value of the investor company's portfolios and the market index in this graph also shows that the presented method has significantly beaten the market and achieved higher returns. In addition, the presented portfolios, in terms of the Sharpe rate and the information rate, which adjust the return to risk, have also completely outperformed the market index and the buy-and-hold strategy. Table (2) shows the details of the results related to these criteria. On one hand, this highlights the inefficiency of the market, which can be exploited through technical analysis. On the other hand, it shows that Fitas artificial intelligence has been able to simulate the reasoning and inference process of technical assets market analysts.



Graph 3: Cumulative return

Table 2: Model performance evaluation results

		Avn Is the Average Number of Assets in The Portfolio	Min MR Minimum Monthly Return	AMR Average Monthly Return	Max MR, The Maximum Monthly Return	SD, Standard Deviation of Monthly Returns	EPV Value of The Portfolio at The End	SR Sharp Rate	IR Information Rate	XF Average Risk-Free Asset Weight in The Portfolio
Market Index	-	-	-7.46%	3.72%	24.5%	8.53%	1.94	0.299	-	-
Buy and Hold Index Portfolio	-	10	-13.9%	%3.73	%23.34	8.66%	1.94	0.296	0.004	-
Model Portfolios Presented in This	Cautious	8.6	-7.28%	5.55%	32.76%	8.48%	2.77	0.517	0.274	11.3%

	Moderate	7.05	-6.51%	6.33%	37.07%	9.86%	3.14	0.522	0.369	7.6%
	Risk Taker	6.05	6.99%-	6.47%	38.32%	10.14%	3.22	0.523	0.383	3.7%

5. Discussion and Conclusion

Investing in various matters has always been a crucial strategy for company growth and to avoid stagnation. Companies that do not leverage AI are missing significant opportunities. Artificial intelligence can enhance both the development and implementation of investment strategies. This research aims to introduce a novel approach for managing an investor company's portfolio in financial markets. Specifically, the proposed strategy integrates fuzzy artificial intelligence, a mathematical programming model, a fuzzy programming method, and a genetic algorithm. The strategy proposed in this research segments the investment horizon of the company into shorter sub-periods. At the beginning of each sub-period, the company's portfolio is updated based on the technical status of financial assets. To achieve this, the research developed a fuzzy artificial intelligence system in the initial stage. This AI system simulates the reasoning and inferences employed by technical analysts in financial markets. This work was done with the aim of determining the possibility of asset prices being higher and lower than their intrinsic value. In the second stage, the present research developed a mixed non-linear multi-objective fuzzy programming mathematical model with integer variables to update the portfolio of the investor company according to the degree of possibilities calculated in the first stage and according to the specific conditions and preferences of the investor company. This model considered the risk (variance), liquidity and entropy of the investor's portfolio. Also, he considered transaction costs with different rates for buying and selling assets and optimized the investor company's portfolio in the presence of a risk-free asset. However, the solution of the presented model was associated with computational complexity. The existing standard methods and software lacked the necessary computing power to solve this model. Therefore, in this research and in the third stage, a genetic algorithm was designed to solve the model in the presence of a large number of decision variables (financial assets). Artificial intelligence, fuzzy mathematical programming model and genetic algorithm presented in this research are all innovative and have never had a similar example in the literature.

This study tested the model for three investment modes: cautious, moderate and risky. The obtained results showed that for all three modes, the presented strategy significantly outperforms both the market index and previous strategies. At the end of the investment period, the risk-taker portfolio had a higher value than other portfolios. Despite experiencing a slower rate of asset growth. The more risk-averse the investing company is, the more diverse the portfolio is selected by the model. These results reveal that the presented fuzzy planning is able to reflect the characteristics and tendencies of the investing company in the portfolio composition.

The main achievement of this research is an investment portfolio management strategy in financial markets for the investor company. Thus, the principal recommendation of this research is to employ this strategy to enhance the profit margin of the investor company's investment activities in international financial markets. Nevertheless, the findings of this research can be used by the company in other cases. Including:

- Providing services related to the investment process in domestic and foreign financial markets (such as consulting services) for the clients of the investing company.

- Providing software and setting up analytical websites (especially technical analysis) using the artificial intelligence presented in this research (for the company's customers or for sale to the general public).
- Using the strategy presented in this research to invest in international financial markets such as forex.

Researchers always face limitations in their research. One of the main pillars of research is access to statistics and information. Fortunately, there has not been much problem in this field. Today, financial market data is easily accessible through related websites and software. But the main problem that existed in the development of Fitas artificial intelligence (which is designed with the aim of simulating the reasoning process and inference of financial analysts) was the lack of cooperation of experts and active institutions in the field of technical analysis. Unfortunately, the common culture among these people is that they generally refuse to share their findings with others.

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