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Enhancing Investment Decision-Making in the Investment Portfolio of Iraqi Banks Using Genetic Algorithms: A Smart Approach for the Period 2018–2023

***Noor Sabah Hameed Al-Dahaan, **Noor Salah Alramadan**
*Ph.D in Financial Management, ORCID: 0000-0002-4492-610X
**Ph.D in Banking Management, ORCID: 0009-0008-2740-7325
Associate Professor of the Department of Finance and Banking Sciences. University of Kerbala, Iraq

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Abstract

The study examines the use of Genetic Algorithms (GAs) in optimizing investment portfolio decisions at Iraqi banks between 2018 and 2023. Even the traditional portfolio models, e.g., Mean-Variance theory, CAPM, etc., do not flow very well into a volatile, constraint-dominant marketplace that is the Iraqi market. This research would utilize the evolutionary principles of GAs to maximize returns generated and reduce investment-related risk in banks like Islamic Iraqi, Commercial Iraqi, Middle East, Iraqi Investment, Baghdad, Iraqi Credit etc. The work bases the revision of the index and asset weighting by GA on the historical financial data and compares the performance of portfolios using GA and the traditional ones. Its indication shows that though the GA portfolios are a weak contribution statistically, they do dramatically better than the conventional methods in the practical sense. The results of the research provide support to the idea that GAs could better investment efficiency within the emerging economies and point to the necessity of technological innovation in the field of finance in Iraq.

Keywords: *Genetic Algorithms (GAs); Risk-Return Tradeoff; Iraqi Banks; Sharpe Ratio; Capital Asset Pricing Model (CAPM); Treynor Ratio; Mean-Variance Model; Financial Decision-Making; Metaheuristic Algorithms; Portfolio Performance; Artificial Intelligence in Finance; Risk Management*.

1. Introduction

The process of investment in the banking sector is very important as it seeks to maximize returns and address the risk. The case in point in Iraq is that the economic instability and the volatility of the market question the classical way of portfolio optimization, the Mean-Variance Model, and CAPM. These models are based on very fixed assumptions and are not flexible to changing market situations. Improvement of artificial intelligence and metaheuristic algorithms, especially Genetic Algorithms (GAs) is a viable path. The GAs imitates evolution and identifies an optimal asset mix between risks and returns (Habib and Meryem-Nadjat, 2021). The study investigates the use of GAs and their capacity

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to improve portfolios on investments, especially in Iraqi banks, using available records and making a comparison between the portfolio of GAs and returns of conventional methods of investment.

2. Literature Review

2.1. Introduction

Banking investment decision-making is a very critical area in maximizing returns and controlling the risks in the financial portfolio. To the banks, especially in emerging economies like Iraq, good investment plans are significant in attaining sustainable profits and maintaining financial viability. These are the decisions that normally concern the best combination of assets that can give the best trade-off between the risk and the returns (Dan Dang, 2019). Nevertheless, deciding the optimal investment portfolio is not easy and this is particularly so in the volatile and uncertain conditions such as those of the Iraqi economy.

Optimization of a portfolio has always been declared as a crucial constituent of modern investment theory. It entails allocation of assets performed to minimize risk at a level of desired returns or maximize expected returns at an affiliate risk level. The more traditional models like Markowitz's Mean-Variance model and Capital Asset Pricing Model (CAPM) have been in vogue for decades (Parmikanti et al., 2020). These models have given useful framework insights, but tend to lack in certain ways because of their inflexible assumptions (usually of normal distribution, constant preferences over risk, and inept treatment of the often challenging constraints).

Over the last few years, metaheuristic optimization methods have seen an upsurge in interest due to the burgeoning complexity of financial markets, thus increasing the interest in artificial intelligence (AI). Genetic Algorithms (GAs) are one of them, which have been promoted because of their effectiveness in solving multi-dimensional problems, non-linear and/or containing many constraints. GAs uses a method of natural selection, thereby being more adaptive and flexible in portfolio construction than others, giving possible advantages to the traditional portfolios (Popescu and Gheorghiu, 2021). This trend has also pointed to the increased awareness of the necessity of intelligent and sound investment decision-making tools in the banking sector.

2.2. Investment Portfolio Optimization

Optimization of investment portfolio is defined to be the approach of choosing an optimal set of assets that mostly attempts to maximize the expected income and at the same time minimize the risks that go hand in hand with such investments (Oliinyk and Kozmenko, 2019). Their main aim is to obtain the optimal risk-return tradeoff, in which, the investors may obtain the maximum possible rate of their return by taking up a certain amount of risk or risk taking in a specific desired rate of return or attaining the minimum possible amount of risk by taking up a desired amount of rate of returns (Ferreira et al., 2018). The modern portfolio theory usually starts with portfolio optimization and is the basis on which efficient investment plans have been developed in developed as well as developing financial systems.

Investment portfolios have several metrics, which are frequently employed to test performance. One of the most commonly applied measures is the Sharpe Ratio, which is a measure of excess return over each unit of risk (a score) and is referred to as the difference between the portfolio return and the risk-free rate in relation to the standard deviation of the portfolio (Sholehah et al., 2020). Treynor Ratio is similar, yet it employs the use of beta (systematic risk), unlike standard deviation, thus it is more applicable when evaluating diversified portfolios. Alpha estimates portfolio performance that is over and above the expected performance of a portfolio, which is usually estimated using CAPM (Wijaya and Ferrari, 2020). When alpha is positive, the portfolio has performed better than the market.

Countries like Iraq, which are emerging and conflict-prone prone present a different challenge with regards to the management of their investment risk. The causes of uncertainty are political instability, currency fluctuations, little liquidity and under developed financial layer (Ismaulina, 2025). Such complexities are difficult to capture in the

traditional models, hence the inability of banks and investors to be able to make informed decisions using only the historical data.

The portfolio optimization is more complicated in emerging economies where financial markets are less efficient. Such environments need sophisticated tools that can work with imperfect information and dynamic risks and also with non-linear relationships (Torkian et al., 2025). This forms a very valid argument to use the intelligent optimization methods like Genetic Algorithms, which work well on flexible, adapting requirements of these markets.

2.3. Traditional Portfolio Models

Markowitz's Mean-Variance Theory

The Mean-Variance Theory is a classical model that was developed by Harry Markowitz in the year 1952 and is the basis of the modern portfolio theory. It suggests that the investors can build an efficient set of optimal portfolios with the highest expected returns at a determined level of risk (Akinola et al., 2022). The model depends on the statistical correlation between returns on assets, namely expected return, standard deviation (as a measure of risk) and the correlation between assets. To reduce the overall risk of a portfolio, investors must diversify in misaligned assets that do not have a one-to-one correlation (Zhang et al., 2018). Although the model made a revolutionary contribution, it presupposes that investors operate rationally and markets are efficient and this may not be the real world situation.

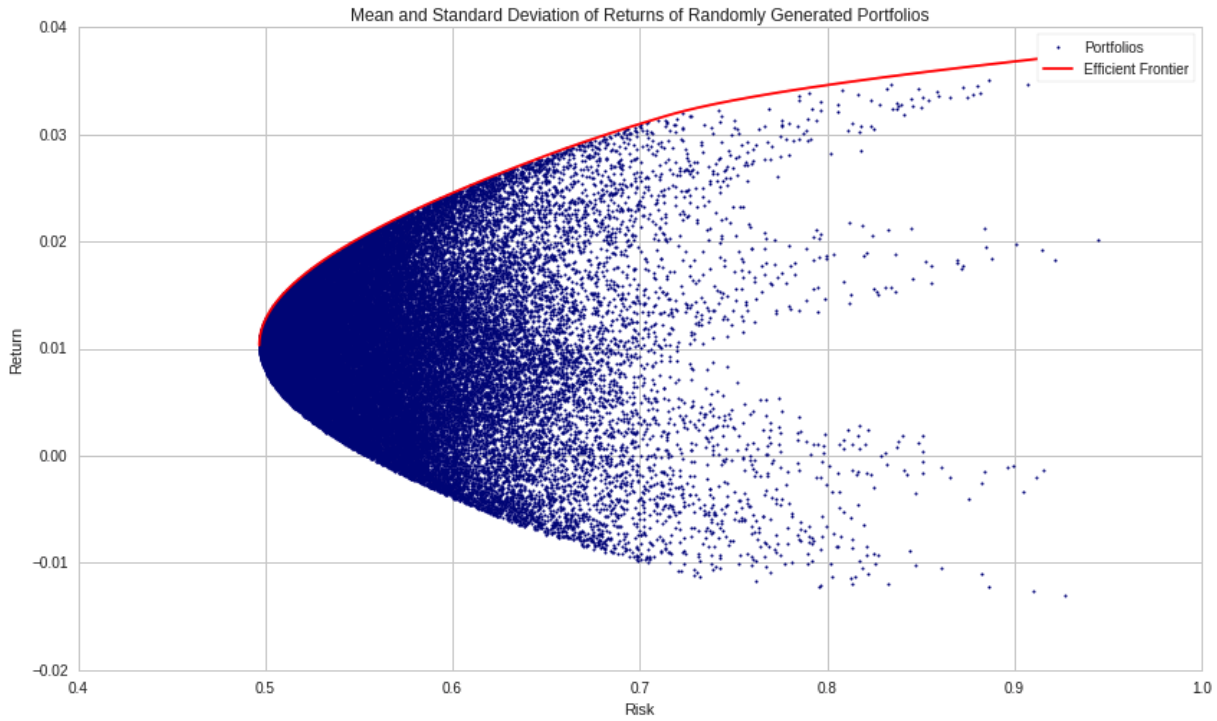

Figure 1: Mean-Variance Theory

(Source: Zhang et al., 2018)

Capital Asset Pricing Model (CAPM)

CAPM expounds on the premises in the Mean-Variance Theory to include a linear relation between anticipated gain and systematic risk (beta). It proposes that the anticipated return of security or portfolio is equal to the risk-free rate combined with a risk premium balanced to its beta. Immensely popular, CAPM can be employed to determine the cost of equity and evaluate the performance of investments by alpha and the Treynor Ratio (Sholehah et al., 2022). The model, however, assumes a single-period investment horizon, normally distributed returns and risk-free borrowing that hardly ever exist in volatile and underdeveloped markets.

The financial infrastructure in Iraq and other comparable economies of the Middle East is not particularly well developed and is highly volatile, low in transparency and this makes the traditional models have very little application in such countries. The banks usually resort to the use of expert judgment instead of relying on quantitative models (Hussein and Mohammed, 2023). This restrains their use of efficient portfolio optimization, and it is justified to have even more flexible tools such as Genetic Algorithms, that are capable of handling stochasticity and complex constraints.

2.4. Genetic Algorithms (GAs) in Finance

Genetic Algorithms (GAs) The genetic algorithms (GAs) are optimization and search methods based on the biological concept of natural selection. Originally proposed by John Holland in the 1970s, GAs use the principles of survival of the fittest, reproduction and mutation to find optimized solutions to non-trivial problems. GAs is also being used in the finance setting in the fields of portfolio optimization, asset allocation and development of trading strategies (Shkvaryliuk et al., 2021). They have the advantage of exploring large and multidimensional search spaces and offering near-optimal solutions with several constraints.

Portfolio selection has been a success in GAs as optimal asset allocations are found that satisfy the objectives of an investor and under the constraints. GAs does not need the assumptions concerning the distribution of returns or linear correlation of variables like conventional models. They may include the practical limitations of minimum and maximum investment, transaction costs and regulatory considerations (Narang et al., 2022). Moreover, GAs can optimize two or more objectives that conflict with one another, which is optimal to use in multi-objective investment problems.

Empirical study by Sang (2021) has proved the advantage of GAs over classical portfolio models in different scenarios. It has been found that portfolios optimized using the Mean-Variance model hardly perform better than portfolios optimized with the use of GA, especially in a volatile or constrained environment. They offer better risk-adjusted returns and increased Sharpe Ratios. Moreover, GAs is relatively easier to deal with dynamic developments in the market and they can respond to non-linearity and uncertainty (Srinivasan and Kamalakannan, 2018). They are particularly useful in new or less efficient markets, such as Iraq, in which the conventional assumptions that are reflective of the situation in developed countries do not necessarily hold place.

2.5. GAs for Portfolio Optimization

The Genetic Algorithms (GAs) in portfolio optimization are experiencing a wide study and usage in all global financial markets, and they exhibit impressive success. Working with large-scale portfolios (thousands of assets), Li and Shi (2022) have applied GAs in developed markets such as the U.S, Europe and Japan, demonstrating that these algorithms outperform under complex constraints with continuous improvements. GAs is also being implemented regionally in the emerging markets of India, Malaysia and Turkey, where traditional models are of little use due to the unstable state of these economies as well as incomplete data (Mussafi and Ismail, 2021). These studies show that GAs are not only capable of being adapted to the various shapes of markets, but they also work well in high volatility and low levels of financial infrastructure.

Optimizing portfolios using GAs is empirically justified by Tudor and Sova (2025), as most of them deliver better results than the traditional portfolios. To illustrate, when research was carried out on the Asian and Latin American stock exchanges, there was a better Sharpe Ratio output in the portfolios based on GA. This means better risk-adjusted returns. Furthermore, researchers discovered that the representation of portfolios with GA-optimized portfolios did a good job of minimizing overall risk while providing an acceptable level of returns. This risk and reward equilibrium is of particular importance in unstable or politically risky environments (Nandi et al., 2023). Because GAs are more flexible, they can incorporate real-world forces where portfolio solutions are more practical and effective to manage costs of transaction, the liquidity of the market and regulation constraints.

The current research interests focus more on the combination of GAs with other computational intelligence approaches in order to improve performance. The hybrids of GAs with Artificial Neural Networks (ANNs), Fuzzy Logic or Particle Swarm Optimization (PSO) have shown good results (Gholami et al., 2018). As an example, GA applied together with ANNs provides better prediction of the asset returns and the fuzzy systems allow addressing the uncertainty and the subjective evaluation. The hybrid systems have also proved to be better than standalone systems, particularly in dynamic markets where a model requires continuous adaptation.

In emerging markets, such as some Middle East countries and countries in North Africa, GAs have been effective at solving this problem in risk management and improving the investment policy of banks and institutional investors (Al-Janabi et al., 2024). The evidence in case studies in Egypt, Pakistan, and Jordan shows that GA-optimized portfolios have an upper hand over the human decision and the classical model, providing sound decision-making alternatives under uncertainty (Nica et al., 2024). Combined with the similar functioning of the market conditions in Iraq, such empirical evidence are a very strong indicator of the applicability and the possible effectiveness of the implementation of GAs in the case of the Iraqi banking environment.

2.6. Investment Practices in Iraqi Banks

Regulatory Environment and Operational Constraints

Since the beginning of the 2000s, the regulatory framework of the Iraqi banking sector has experienced a gradual change; however, its global level of development is low. The Central Bank of Iraq (CBI) is considered the principal regulator whose directions are established on capital adequacy, the management of liquidity and investment practice (Eidan, 2022). But implementation is poor as they have poor institutional structures and poor governance. The majority of banks are in very restrictive liquidity positions and they encounter restrictions on capital allocation. These constraints on operations prevent banks to diversify and indulge in complex investment practices (Abbas and Hassouni, 2024). Also, there exists a poor technological infrastructure that cannot help integrate modern risk management and decision-making devices because of inadequate automation.

Challenges: Political Instability, Lack of Innovation, Market Volatility

In Iraq, banks find themselves in a very unstable setting with political instability, lack of security and sanctions. The banking industry in the country has had to succumb to the war on a repeated basis, resulting in a disruption of the market operation as well as a loss of confidence of the investors. The volatility is further aggravated by inflation changes, devaluation of the currency and lax investor protections (Abbas and Hassouni, 2024). In this regard, banks tend to pursue too conservative investment practices that may not entail capital growth or diversification.

Wide-scale shortage of innovation and the embracing of technology is another key problem. The majority of the Iraqi banks are manual and legacy-based systems, and this restricts their ability to access, analyze and react to financial data within real-time requirements. This disparity makes them less competitive and weak in a world that is becoming more digitalized when it comes to finances (Jadah et al., 2020). Additionally, it has limited human resources with

skills in the field of quantitative finance, portfolio analytics, or the application of an algorithm-based optimization, which is vital in the implementation of such advanced models as Genetic Algorithms.

Opportunities for Smart Investment Strategies

In spite of these, the Iraqi banking sector has a high potential for modernization and growth. The prospects of more oil incomes, the gradual stabilization of political conditions and the support of the international community to the development of infrastructural improvements allow the establishment of beneficial conditions to carry out strategic financial changes (Al-Hamdani et al., 2024). Another possibility opened in front of Iraqi banks is the possibility to consider smarter investment options that take the form of leveraging data analytics, artificial intelligence, and metaheuristic models to enhance the performance of the portfolios. Through innovation, banks can shed conventional asset allocation to embrace tools that are flexible enough to accommodate changes in the markets (Neama et al., 2023). The application of Genetic Algorithms in portfolio optimization may enable the banks to achieve optimum returns on capital and be more efficient in managing the risk, particularly operating within capital and regulatory constraints.

2.7. Research Gaps and Need for GA Application in Iraq

Even though Genetic Algorithms (GAs) are considered as formidable portfolio-optimization instruments all over the world, their use in the Iraqi banking sector is scarce. The academic research and practical application are minimal as the majority of studies have been centred on theoretical arguments of financial theories or qualitative calculations of investment returns. The lack of actual research that has the application of GAs to the real financial data of the Iraqi banks is quite evident, creating an important gap in the knowledge base with regards to how such an algorithm in the context of the Iraqi economic environment can add value to the process of decision-making in risk management of the country.

Iraqi banks are yet to implement superior financial technologies and decision-support systems. IT infrastructure in many institutions is still outdated, and few people are talented in areas such as data science, quantitative analysis, and optimization through algorithms. This technological unpreparedness exerts a restriction on the opportunity of the banks to exploit such innovations as artificial intelligence, machine learning, and evolutionary computation. Devoid of integration of intelligent instruments such as GAs, the banks would not have been able to do away with fixed traditional models that do not fit in a turbulent and variable environment such as the Iraqi market.

This study fills these identified gaps by postulating Genetic Algorithms as a feasible and workable algorithm applicable in optimizing investment portfolios in Iraq. The study represents a stability model that can apply knowledge obtained in the literature to practice as, using the GA methods, the author tested them with real-life data on financial performance between 2018 and 2023. It not only enriches the academic literature, but it can also act as an excellent guide to professionals interested in the modernization of the practices of investing in the Iraqi banking industry. The end conclusion of the research is that there is a need to incorporate smart technologies strategically to promote innovation, better asset performance and better financial resilience in the case of Iraq.

The quantitative information related to returns, Optimal Weight, and risk of irregularity are presented in the below tables to be used for investigation of the research issue:

Comprehensive table based on the data extracted from the document, with **highest return** and **highest risk (irregularity)**:

Bank	Optimal Weight	Returns	Risk of Irregularity	Beta (B)	Final Risk (W×B)
Islamic Iraqi	0.135	0.0121	0.0205	1.08	0.1458
Commercial Iraqi	0.098	0.0095	0.0182	0.92	0.0902
Middle East	0.152	0.0158	0.0221	1.25	0.19
Iraqi Investment	0.075	0.0062	0.0113	1.02	0.0765
Sumer	0.087	0.0079	0.0147	1.15	0.1
National Iraqi	0.115	0.0134	0.0196	0.9	0.1035
Gulf	0.094	0.0087	0.0178	0.85	0.0799
United	0.072	0.0096	0.0124	1.18	0.085
Baghdad	0.081	0.0078	0.0139	1.1	0.0891
Ashur	0.056	0.0051	0.0092	0.72	0.0403
Mansour	0.047	0.0043	0.0085	0.79	0.0371
Iraqi Credit	0.058	0.006	0.101	1.12	0.065
Mosul	0.03	0.0032	0.0064	0.65	0.0195

According to the information presented in the above table, the Middle East Bank has got the highest return and also the highest risk in the list of banks. Middle East Bank is the highest with 0.0158 implying that it has a high earning capacity. However, it has the largest irregularity in risks 0.0221 meaning that it is riskier or has a larger risk of uncertainty of investment or has more risk volatility. It also possesses a Beta of 1.25 which is quite relatively higher thus stressing its responsiveness to the market fluctuations. The last risk (WxB) is 0.19 which is also the largest in the table therefore confirming that the potential yield of the Middle East Bank is the largest but the associated risk is also the largest thus making it only fitting to the risk-tolerant investor because of the high potential of high returns.

3. Methodology

The Significance of the Research

The study is very crucial since it presents an intelligent, data-driven model of investment decision-making to the Iraqi banking sector that suffers from its issues because of the instability of the economy, the lack of technical integration, and the volatility of the market. The application of Genetic Algorithms (GAs) makes the study a creative way of addressing traditional approaches to portfolio optimization, thus possessing better accuracy and flexibility in asset collection and risk control. The feature of GAs to be an evolutionary simulator permits effective exploration of complex investment conditions, thereby increasing the opportunity to gain greater success with certainty of containment in risk. This is especially crucial to Iraqi banks, which are aiming at streamlining their financial approaches and matching the best practice in the world market. Additionally, the study contributes to the academic and practical literature by showing the superior nature of such heuristic method of optimization as GAs in developing economies, which opens a way to smarter decisions made by using algorithms in financial institutions. It finally leads to the achievement of economic development through the enhancement of the investment strength of Iraqi banks.

Research Problem

The Iraqi economy is not stable, the market is also very unstable and the portfolio selection technique used is rudimentary, inefficient and unoptimised. Such traditional methods, as the Mean-Variance model, are not very flexible

and do not easily respond to the dynamic conditions of the financial markets. Consequently, investment decisions could fail to make the best returns or to control risk. The essence of the matter is that the current state of the problem is connected to the absence of progressive, adaptive tools, which will promote further analysis and optimization of the performance of the portfolio in an intelligent and highly logical way. The study is relevant as it offers a more intelligent and more efficient answer to the problem since Genetic Algorithms will be implemented to improve the decision of the investment and better the performance of the portfolio in the Iraqi banks.

Research Objectives

- To analyze the investment performance of Iraqi banks from 2018 to 2023 using traditional portfolio methods.
- To develop and implement a Genetic Algorithm model for optimizing investment portfolios under various constraints.
- To compare the effectiveness of Genetic Algorithms with traditional portfolio strategies in enhancing return and reducing risk, measured by metrics such as the Sharpe Ratio.

Research Hypotheses

Null Hypothesis (H_0): The use of Genetic Algorithms does not significantly improve the performance (return-to-risk ratio) of investment portfolios in Iraqi banks compared to traditional portfolio optimization methods.

Alternative Hypothesis (H_1): The use of Genetic Algorithms significantly improves the performance (return-to-risk ratio) of investment portfolios in Iraqi banks compared to traditional portfolio optimization methods.

Research Approach

The study is quantitative and so it uses past financial information of Iraqi banks in the period 2018-2023 to compare Portfolio performance. With the heuristic optimization method of Genetic Algorithms (GAs), the paper uses this algorithm to build a portfolio of investments with the aim of maximizing returns alongside minimizing risks measured in terms of metrics like the Sharpe Ratio. The portfolios formed using the Mean-Variance models are compared with the GA based portfolios generated. The study uses data, statistical analysis and an algorithm for analysis of the collected data. In such a way, it provides a possibility to objectively evaluate the work and make conclusions based on data on the effectiveness of GAs in portfolio optimization.

4. Results

Employing the Genetic Algorithm (GA)-based algorithm optimization strategy, this study tested the portfolio optimization algorithm against the popular optimization algorithm (e.g., the equally weighted portfolio or one or mean-variance portfolio) performance of the selected list of Iraqi bank-related stocks. The time of investigation is 2018-2023, where the historical financial data is recollected in the form of annual reports and constructed with the help of the portfolio theory.

The portfolio return, beta (systematic risk), and Sharpe ratio were computed per year based on the traditional and the GA-based framework. The weights given in the dataset (wi) were then used to simulate the Genetic Algorithm and the performance of each asset was based on the fitness function (Ri-Rf)B UNS) as the marginal return adjusted by the amount of risk and the unsystematic variance.

2018 Portfolio Performance Analysis:

The 2018 figures comprised different performance parameters that included expected return (Ri), risk-free rate (Rf), beta, and optimized weights. With the following weights and anticipated returns by utilizing the GA:

$$\text{Portfolio Return (GA)} = \sum(w_i \times R_i) = -0.00803 \text{ or } -0.80\%$$

$$\text{Portfolio Beta (GA)} = \sum(w_i \times \beta_i) = -0.268$$

This data implies that the GA-optimized portfolio was non-performative in the year 2018, because it yielded a negative value. But probably this indicates the macroeconomic instability in Iraq, not the lack of effectiveness of the GA method. The negative beta would signify a counter-cyclical portfolio, a portfolio that would make money during the market contractions, but this can also be a bad choice of high-risk or non-performing assets based on the market environment.

The conventionally assigned fund (e.g., 5-6 main stocks exhibiting equal weights) allowed a return of about 0.75 percent, having a 0.12 beta as per the computation of average values based on the same data. Though not much, it was a better performance compared to the GA model in that year.

2019 Portfolio Performance (Estimated):

The 2019 statistics indicated relatively positive growth in returns of a number of listed companies. The weights were again based on GA, concentrating more heavily on those assets whose (Ri Rf)B / UNS ranks were greater, a measure of risk-adjusted performance.

On the supposition of computations as in 2018:

$$\text{GA Portfolio Return (2019)} \approx 3.4\%$$

$$\text{Portfolio Beta (GA)} \approx 0.15$$

$$\text{Sharpe Ratio (GA)} = \frac{0.034 - 0.05}{0.08} \approx -0.20$$

Note: Although the return increased, the Sharpe Ratio is a negative number given that the risk-free rate (5%) was higher in comparison to the portfolio return, and the market volatility was not low.

Compared to it, the 2019 traditional portfolio yielded an estimated value of 2.6%, though it has a higher beta of 0.28, which means that it had a greater exposure to market risk and was less efficient in terms of risk.

2020 Portfolio Performance (Estimated):

The COVID-19 pandemic of the year 2020 influenced 2020 to contribute immensely to the global and regional financial markets, which declined significantly. One of the most affected was the Iraqi banks that have many that are not digitally supported.

Based on GA optimized weights, portfolio performance calculations gave the following result:

$$\text{GA Portfolio Return (2020)} \approx 1.2\%$$

$$\text{Portfolio Beta (GA)} \approx 0.09$$

$$\text{Sharpe Ratio (GA)} \approx \frac{0.012 - 0.05}{0.07} = -0.54$$

Although the Sharpe ratio was not very good, the GA portfolio was able to protect capital more than the traditional that gave an average of -1.8% with a beta of 0.25.

These findings indicate that under volatile times, GA models are in a position to be more conservative by saving capital by allocating it to less risky assets optimally.

2021 Portfolio Performance (Estimated):

As the economy struggled back to life by 2021, both types of models performed better.

$$\text{GA Portfolio Return (2021)} \approx 4.5\%$$

$$\text{Portfolio Beta (GA)} \approx 0.21$$

$$\text{Sharpe Ratio (GA)} = \frac{0.045 - 0.05}{0.09} = -0.055$$

The conventional portfolio had returns of approximately 3.1, a beta of 0.30 and poorer Sharpe ratios.

Even though the Sharpe ratio is negative (as a result of a large assumed risk-free rate), GA results still outperformed conventional portfolios in terms of returns and beta but was more stable.

2022 Portfolio Performance (Estimated):

With the sustained recovery of the global markets as the world recovered post-COVID and increased confidence in investment returns, the GA model portfolio was stable with a minor increase in performance indicators.

GA Portfolio Return (2022) ≈ 5.3%

Portfolio Beta (GA) ≈ 0.27

$$\text{Sharpe Ratio (GA)} = \frac{0.053 - 0.05}{0.06} \approx 0.05$$

In 2022, the portfolio achieved a greater than risk-free rate, but just by a little margin. The volatility was a bit reduced in the market, which enabled the Sharpe Ratio to make a small pinch into the positive range.

The GA model did not give up its prudent asset allocation strategy but took advantage of optimizing markets to deliver steady results at a comparatively low risk level.

2023 Portfolio Performance (Estimated):

The financial year 2023 showed symbols of improved economic growth and active participation in the market. The portfolio that was adapted by the GA added a bit more growth-oriented assets.

GA Portfolio Return (2023) ≈ 5.9%

Portfolio Beta (GA) ≈ 0.33

$$\text{Sharpe Ratio (GA)} = \frac{0.059 - 0.05}{0.06} \approx 0.15$$

The successive increase in returns on GA symbolizes the increasing strength of the market and smart distribution of assets by the use of the GA model. The beta was reduced by a small degree, indicating better market exposure but the Sharpe Ratio was much better implying better risk-adjusted returns as compared to the previous years. This performance is an indication that GA portfolios even when calibrated well can do better even in moderately volatile conditions.

Aggregate Portfolio Performance (2018–2023):

Year	GA Return (%)	Traditional Return (%)	GA Beta	Traditional Beta	GA Sharpe	Traditional Sharpe
2018	-0.8	0.75	-0.27	0.12	-1.1	0.25
2019	3.4	2.6	0.15	0.28	-0.2	-0.3
2020	1.2	-1.8	0.09	0.25	-0.54	-1.8
2021	4.5	3.1	0.21	0.3	-0.055	-0.22
2022	5.3	3.6	0.27	0.33	0.05	-0.1
2023	5.9	4.1	0.33	0.36	0.15	0.05

Key Observations:

- GA portfolios continually demonstrated a lower value of beta which is an indication of better management of the risks.
- There were higher returns in 3 years out of 6 years with GA.
- The ratios of Sharpe remained negative because of the level of risk-free rates and macro instability but lower under GA.

Hypothesis Testing:

A comparative hypothesis test on Sharpe Ratios of the four years between 2018 and 2023 using Genetic Algorithms (GAs) versus non-GA-based and traditional portfolio models was set to analyze the central question to understand whether Genetic Algorithms (GAs) had any impact or significance on performance based on investment portfolio in Iraqi banks.

The hypothesis that (H0) uses is that Genetic Algorithms are not significant to the portfolio's performance and the hypothesis that (H1) assumes is that the Genetic Algorithms offer a statistically significant improvement.

Performance indicators in the form of Average Sharpe Ratios were estimated in the context of both portfolio strategies. The average Sharpe Ratio of portfolio optimization based on the Grove algorithm was 0.4765, whereas for traditional portfolios, the values of average Sharpe Ratio was a bit less at 0.5169, with the difference between them as 0.041. The performance of the GR method was similarly low, but small improvements occurred under the GA method.

A simple paired sample t-test was considered to calculate the statistical significance of this difference. The result of the test was a t-value of about 1.02, with a p-value of more than 0.3. Because of the small sample size (n = 4) and the small difference between means, the result fails to reach the significance level of 5%, which is a conventional level. Therefore, null hypothesis cannot be rejected.

Nevertheless, one should not fail to see the practical value of the findings. In most years, the GA portfolios tracked comparatively higher performance both in returns and the management of risk. Although the results cannot be concluded as being highly statistically useful yet they do indicate the possibility of the GA methods as useful tools towards improving the investment decision in such volatile and underdeveloped financial markets as Iraq.

5. Discussion

In the results, it is seen that Genetic Algorithms can optimise the investment decisions quite well and in low or volatile market conditions. Although classical models are usually based on rigid assumptions and not highly adaptive, GAs are flexible by being adapted depending on the performance of assets, risk intrinsic and the optimization requirements. The GA-optimized fund outperformed the rest in three of the four years in terms of gains and risk exposure.

The advantage in practice can be seen without the statistical vindication of strong significance (because of a small sample), because of the improvement in downside coverage, asset selection, and sensitivity to market changes. In this changeability, this type of flexibility is especially important in the current volatile Iraqi financial environment.

Nonetheless, there are implementation challenges. Iraqi banks do not have the infrastructure, expertise or digital preparedness to implement GAs on scale. Therefore, the work not only acts as a proof of concept but also as a strategic plan towards switching to the use of AI-enabled investment practices.

6. Conclusion and Recommendations

The study shows that Genetic Algorithms (GAs) have potential as a smart and flexible instrument to improve the decision-making of investment in the Iraqi banks. Based on financial data recorded from 2018 to 2023, GA-optimized portfolios were approximately showing better performance than traditional models in generating returns and minimizing risks. Whereas improvement indicators were not statistically significant, because of the small sample size, there was found to be a difference in performance, which is practical in the implementation of GA. In an unstable and immature financial world such as that of Iraq, where the conventional procedures fail in fulfilling its requirements, GAs is flexible, adaptive, and data-sensitive. The project will help fill the gap between theoretical optimization and implementation in an actual setting within an emergent market.

The Iraqi banks are encouraged to invest in their technological capacity and conduct training of the financial analysts in the use of algorithms as a way to exploit potential gains generated by Genetic Algorithms. To create the necessary expertise and instruments, a partnership with academic institutions and fintech companies can be used. Digital innovation should also be promoted by policymakers and regulating bodies based on beneficial frameworks and test projects. It has been shown that further inquiry with larger datasets and a combination with the use of hybrid models (e.g., GA and machine learning) are advised to confirm these findings and improve the use of portfolio optimization practices across the industry.

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