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Economic and Mathematical Approaches to the Development of a Financial Asset Management Model of the UAPF

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ABSTRACT

This study delves into the optimization of investment portfolios within the Unified Accumulative Pension Fund in Kazakhstan, employing the Quasi-Sharp model as a pivotal tool. Through a meticulous analysis of the UAPF's investment portfolio evolution, this research scrutinizes shifts in asset allocation and their ramifications on investment returns. The Quasi-Sharp model, a tailored adaptation of the Sharpe model, is harnessed to ascertain the optimal equilibrium between profitability and risk in pension asset management. The STATA program was used to calculate the indicators. Results divulge the imperative role of diversification across various asset classes in mitigating risk while maximizing returns. Optimal investment portfolios are meticulously crafted, considering an array of financial instruments such as stocks, bonds, and bank deposits. The findings underscore that while stocks proffer higher potential returns, bonds offer stability and lower risk. Additionally, bank deposits exhibit stable returns, albeit with limited growth prospects. The study revealed that the maximum expected return with a risk limit of less than 5% could be provided by a portfolio including shares of Halyk Savings Bank of Kazakhstan, Kcell, and KazTransOil in the ratio of 57%, 32%, and 11%, respectively. Key recommendations for investors encompass regular monitoring of market dynamics, diligent assessment of risk tolerance, and recourse to professional advice when warranted. This study furnishes invaluable insights for pension fund managers and investors endeavoring to augment portfolio performance while adeptly managing risk within the Kazakhstani market landscape.

KEYWORDS: Quasi-Sharp Model, Pension Assets, Investments, Profitability, Market Portfolio, Single Portfolio, Funding, Securities, Stocks, Bonds

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Экономико-математические подходы к разработке модели управления финансовыми активами ЕНПФ

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АННОТАЦИЯ

Данное исследование посвящено оптимизации инвестиционных портфелей в рамках Единого накопительного пенсионного фонда (далее - ЕНПФ) Казахстана с использованием квази-модели Sharp в качестве ключевого инструмента. На основе тщательного анализа эволюции инвестиционного портфеля ЕНПФ в этом исследовании рассматриваются изменения в распределении активов и их влияние на доходность инвестиций. Для определения оптимального соотношения между доходностью и риском при управлении пенсионными активами используется квази-модель Шарпа, специально адаптированная к модели Шарпа. Для расчета показателей использовалась программа STATA. Результаты свидетельствуют о важной роли диверсификации по различным классам активов в снижении рисков при максимизации доходности. Оптимальные инвестиционные портфели составляются тщательно с учетом широкого спектра финансовых инструментов, таких как акции, облигации и банковские депозиты. Результаты исследования подчеркивают, что, в то время как акции предлагают более высокую потенциальную доходность, облигации обеспечивают стабильность и снижают риск. Кроме того, банковские депозиты демонстрируют стабильную доходность, хотя и с ограниченными перспективами роста. Исследование показало, что максимальную ожидаемую доходность при лимите риска менее 5% может обеспечить портфель, включающий акции Народного сберегательного банка Казахстана, Kcell и КазТрансОйла в соотношении 57%, 32% и 11% соответственно. Основные рекомендации для инвесторов включают регулярный мониторинг динамики рынка, тщательную оценку толерантности к риску и обращение к профессиональным консультациям, когда это оправдано. Это исследование дает бесценную информацию управляющим пенсионными фондами и инвесторам, стремящимся повысить эффективность портфеля при умелом управлении рисками в условиях казахстанского рынка.

КЛЮЧЕВЫЕ СЛОВА: модель Квази-Шарп, пенсионные активы, инвестиции, доходность, рыночный портфель, единый портфель, финансирование, ценные бумаги, акции, облигации

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INTRODUCTION

Financial asset management within pension systems plays a key role in ensuring financial stability and the effective functioning of these systems. Economic and mathematical approaches provide comprehensive tools for developing models that help optimize pension fund management, as well as maximize profitability and minimize risks. Based on the principles of economic theory and mathematical methods of analysis, researchers and practitioners strive to develop models that take into account many factors affecting financial markets and the long-term prospects of pension systems. For example, in the United States, various models have been developed to predict financial markets and assess the long-term prospects of pension systems. The Capital Asset Pricing Model (CAPM) is used to estimate the expected return on assets based on their systematic risk. Portfolio management models such as Modern Portfolio Theory (MPT) are also widely used, which help investors optimize the risk-return ratio. Models for assessing the financial stability of the banking system are widely used in Switzerland. Value at Risk (VaR) models are used to determine the risks and potential losses of banks in various scenarios. Models are also being developed to optimize capital and liquidity management. These models include forecasting asset returns, determining the optimal investment portfolio, risk management, and financial stability assessment (Sakalauskas et al., 2023; Saadeldin et al., 2021; Tang, 2022).

The impact of investment costs on the effectiveness of a pension fund is crucial, as high costs and inefficiency can significantly reduce the welfare and consumption of beneficiaries by reducing the net rate of return on investment. This is becoming especially relevant after the financial crisis and the aging of the population, which have created problems for pension funds around the world. Consequently, there is increasing pressure on pension funds from the public and politicians to improve the efficiency of their activities and transparency of their spending structure (Bikker & de Dreu, 2006).

Understanding investment costs is essential for pension funds and has broader implications for financial markets. These costs play a vital role in determining the optimal asset allocation decisions of pension funds, which can significantly impact market liquidity and asset prices. Since pension funds are among the largest institutional investors worldwide, with assets totaling trillions of dollars, their investment decisions have significant implications for global financial markets. For example, in 2022, the assets of pension funds in OECD countries amounted to 51.5 trillion US dollars. The United States had the most significant pension market in the OECD region, with $35 trillion in assets, accounting for 67.9% of the total OECD volume. Their asset and liability management (ALM) strategies aim to secure long-term obligations to retirees. Several ALM methods include stochastic programming, dynamic programming, portfolio theory, and stochastic modeling. A new approach, the robust optimization method, offers an effective solution to account for uncertainty, especially in cases where errors in estimation can distort the results (OECD, 2023).

The assessment of Kazakhstan's public pension savings system in comparison with the practice of pension asset management in developed countries within the framework of the OECD is an important task. The main objective is to emphasize the importance of having a diversified structure of pension savings, reducing dependence on public pension assets, and creating additional support for individual pension portfolios.

There is a possibility that pension savings may decrease due to the low return on investments since the investment of pension assets has restrictions following the legislation of the Republic of Kazakhstan. Official data indicate that as of December 1, 2023, the UAPF achieved a yield of 8.11% in Kazakhstani tenge, corresponding to the official inflation rate. However, if such indicators persist, the state pension system of Kazakhstan may face significant unsecured obligations, potentially leading to insufficient financial support for future pensioners (UAPF, 2023).

Therefore, the Government of Kazakhstan needs to take proactive measures and not passively wait for the impending problem of inadequacy. Studying the experience of developed countries in the field of pension asset management, diversification of pension portfolios, reducing investment risks, increasing market competitiveness and professionalism, as well as facilitating the implementation of group and individual pension programs is crucial. These actions are aimed at ensuring a sufficient level of retirement income for residents of Kazakhstan after retirement.

In particular, the stock market of Kazakhstan can lead to model errors and unpredictable portfolio losses. This is primarily due to the dynamics and peculiarities of the development of these markets, which are characterized by instability and impulsiveness of profitability, the strong influence of internal information, the imperfection of the

regulatory framework, and the dominant influence of raw materials industries on the overall dynamics of development. Therefore, it is essential to study the issue of increasing the profitability of pension assets using mathematical modeling. This study aims to develop a model for managing the financial assets of the UAPF through an economic and mathematical approach.

LITERATURE REVIEW

Academics and financial experts are very curious about three main types of models: physical, analog, and mathematical. Physical models recreate the spatial aspects of a phenomenon, while analog models make comparisons between phenomena to build physical representations. Mathematical models, on the other hand, describe phenomena using equations. The model's accuracy in representing a phenomenon depends on the accuracy of the mathematical equations used to describe it.

Mikrakhor and Krincene (2014) describe the model as a theoretical construct that simplifies real-world situations in equations, offering a concise alternative to lengthy explanations. Economics extensively uses mathematical functions and models, including supply and demand functions, budget functions, production capability curve functions, and others.

Effective management of financial assets of pension systems is the subject of extensive research in the fields of economics, finance, and management. Various aspects of this problem are considered in the works of scientists and practitioners applying economic and mathematical approaches to analysis and modeling.

Much attention is paid to using average returns and deviations to assess effectiveness in the literature devoted to the study of pension asset management. So Randall and Satchell (1997) compare different asset portfolios of pension funds based on their average returns and income variance using standard analytical tools similar to those developed by Markowitz. In addition, they point out that pension funds cannot afford to incur significant losses, even if they often earn smaller amounts of money. Models overlook this asymmetry and focus solely on average returns and deviations.

Pension funds prefer fixed-income securities, especially government bonds, as these instruments are considered to minimize risk. This strategy corresponds to the goal of preserving the pension fund's assets while striving for stable profitability.

In general, the problem of effective management of UAPF investment assets is typical at the present stage for developing and developed economies. Since the assets of the pension fund are one of the sources of investment, investment assessment methods are used to assess the effectiveness of management. These methods are divided into two groups: discounting-based and non-discounting (statistical). In our opinion, they are more effective in evaluating real investments. The assessment of pension asset financing structures by the criterion of profitability and risk can be carried out based on the classical model of the American scientist Markowitz. However, the Markowitz model has limitations because it does not consider the losses of pension funds with low returns on investment activities.

The critical provision of Markowitz's theory is the investor's ability to form a portfolio in which a combination of expected return and risk level would ensure maximum satisfaction of the need and minimize the risk at the desired return. In addition to the portfolio theory of G. Markovitz, the model of the price of capital assets is considered (Zhantaeva et al., 2016).

The CAPM model, also known in the literature as the Sharpe model, is used to select assets from the entire set, and then an optimal portfolio is formed using the G. Markowitz model. However, the models of G. Markowitz and W. Sharp were developed during periods of stable economic growth and the stock market. They work well in foreign markets characterized by more monotonous development dynamics, and the Markowitz and Sharp models are not directly applicable to emerging markets.

One of the critical areas of research is optimizing investment strategies of pension funds to maximize profitability and minimize risks. The authors present the basic concepts of modern portfolio theory and investment analysis methods that can be applied to pension asset management (Wang, 2023).

Today, when researching methods of forecasting financial markets and their impact on successful investment, they have more often begun to consider the psychological factor (Plummer, 2009; Shiller, 2003; Aljifri, 2023). However, it is worth noting that the psychological aspects of investing also play an essential role, and taking them into account can be vital to making effective investment decisions. For a more complete understanding of financial markets, it is necessary to consider both forecasting methods

and psychological factors influencing investor behavior.

In addition, considering the basic mathematical models used to analyze and evaluate financial instruments, the emphasis is on derivatives (Simons et al., 1994; Yang et al., 2023). However, it should be noted that the use of mathematical models may be limited and does not always consider all aspects of the complexity of financial markets. It is essential to remember that fundamental financial markets can be subject to a high degree of uncertainty and variability, which mathematical models may not always capture.

The authors also study the financial stability problems of pension systems and propose approaches to their management (Asher, 2014). However, effective risk management in pension funds requires mathematical models and a broad understanding of the social and economic factors affecting the long-term prospects of pension systems.

In general, these works represent an essential contribution to the understanding and analysis of financial markets and pension systems. However, to get a complete picture, it is necessary to consider various factors, including mathematical models and psychological and social aspects.

Esentai and others (2020) propose investing pension assets in healthcare institutions in ecologically disadvantaged regions of Kazakhstan through public-private partnerships. This approach can improve the well-being of pensioners in different regions. Nevertheless, it is essential to realize the complexity and versatility of solving regional imbalances and economic problems. Updating roadmaps should cover factors such as income levels, poverty levels, investment climate, economic growth, and unemployment problems. Moreover, solving complex problems that hinder regional development requires comprehensive strategies.

All over the world, pension funds place part of their assets in government bonds, while many countries allow investments in various financial instruments. Investments in shares of highly rated companies, mutual funds, real estate, and other profitable assets are popular in countries with reliable financial systems and reasonable supervision. Such investments provide stable long-term returns and contribute to economic growth by efficiently using capital concentrated in pension funds. Diversification allows pension funds to achieve higher annual returns than the average national asset portfolio.

Despite the limited scientific research on Kazakhstan's national pension system, initiatives such as the Global Pension Statistics Project have begun to collect relevant data. However, there is a need for more comprehensive research to obtain country-specific information and policy recommendations. This research aims to address this gap by offering a comparative analysis of the effectiveness of Kazakhstan's public pension system and relevant policy recommendations, drawing lessons from successful models such as the Canadian pension system.

RESEARCH METHODS

This methodology describes the process of calculating stock returns and the quasi-Sharp coefficient using Microsoft Excel. For the analysis, data on stock closing prices and the risk-free rate from September 2022 to September 2023 were collected. The data was obtained from the financial portal Kase. kz. The yield of short-term government bonds can represent the risk-free rate data. For unstable stock markets, the model was modified and named the "Quasi-Sharp" model (Zhantaeva, 2013). The basis of this model consists of the relationship of a single paper taken not with a stock index, as in the Sharpe model, but with the profitability of the entire single portfolio consisting of these assets.

The main assumptions of the Quasi-Sharp model are as follows:

1) The yield of a security is calculated as the mathematical expectation of returns.

2) A portfolio consisting of all the securities in question in the same proportion is taken as a reference single portfolio. In the Sharpe model, a benchmark (reference portfolio) is a market portfolio that a stock index can describe. For the Kazakh market, this is the KASE index; for the Russian stock market – the RTS index (RTSI); for the American stock market – the S&P500, NASDAQ – 100.

3) The yield of a security is directly proportional to the yield of a single portfolio. The same assumption holds in the Sharpe model for a market portfolio.

4) The risk of a security is calculated as the level of change in the yield of a security depending on the change in the yield of a single portfolio. Similarly, the calculation for the Sharpe model depends only on the market portfolio.

5) The average yield of a single portfolio is taken as a risk-free rate and not government obligations, as in the Sharpe model.

The relationship of the yield of a security with the yield of a single portfolio and the risk of this security in the Quasi-Sharp model is described using a linear regression function.

The yield formula (1) of the security is as follows:

$$R_i = \bar{R}_i + \beta_i(R_{sp} - \bar{R}_{sp}) \quad (1)$$

where:

R_i - the yield of the i-th security;

$\bar{R}_i$ - the average yield of the i-th security;

β_i - the regression coefficient in the profitability equation;

R_{sp} - profitability of a single portfolio;

$\bar{R}_{sp}$ - the average yield of a single portfolio.

The regression coefficient shows how much a security's profitability level will change when the profitability of a single portfolio changes per unit of its measurement. The higher the beta coefficient value, the more the yield of a security changes with fluctuations in the yield of a single portfolio. This coefficient, as in the Sharpe model, is called risk. However, the overall risk in the "Quasi-Sharp" model consists of the risk of a decrease in profitability, with a drop in the profitability of a single portfolio and residual risk (), calculated as the standard deviation of the yield of security from the regression line. Residual risk is also defined as the risk of non-compliance with the regression line.

Taking into account the determination of the profitability of the i-security according to formula (2) and the total risk, the profitability of the investment portfolio in the Quasi-Sharp model and the risk are calculated using the following formula (2):

$$R_p = \sum_{i=1}^{N}(\bar{R}_i * W_i) + (R_{sp} - \bar{R}_{sp}) * \sum_{i=1}^{N}(\beta_i * W_i) \quad (2)$$

where:

R_p - profitability of the investment portfolio

W_i - weight (share of the i - th security in the portfolio), $W_i \geq 0$;

$$\sum_{i=1}^{N} W_i = 1$$

$$\sigma_p = \sqrt{\sum_{i=1}^{N}(\beta_i * W_i)^2 * \sigma_{sp}^2 + \sum_{i=1}^{N}(\sigma_{ri}^2 * W_i^2)} \quad (3)$$

where:

σ_p - the risk of the investment portfolio

σ_{sp} - standard deviation (risk) of a single portfolio

σ_{ri} - residual risk (st. deviation of the *i*-paper relative to the regression line).

Taking the profitability of the portfolio (3) as a target function and aiming it to the maximum, introducing restrictions on risk -, the search for the optimal portfolio based on the "Quasi-Sharp" model can be formulated as follows (4):

$$\sum_{i=1}^{N}(\bar{R}_i * W_i) + (R_{sp} - \bar{R}_{sp}) * \sum_{i=1}^{N}(\beta_i * W_i) -> max$$

$$\sqrt{\sum_{i=1}^{N}(\beta_i * W_i)^2 * \sigma_{sp}^2 + \sum_{i=1}^{N}(\sigma_{ri}^2 * W_i^2)} \leq \sigma_{reg} \quad (4)$$

$$W_i \geq 0$$

$$\sum_{i=1}^{N} W_i = 1$$

Then, the inverse problem of forming an optimal portfolio will be to minimize the overall risk of the portfolio at a fixed level of return (R_{reg}) by formula (5):

$$\sqrt{\sum_{i=1}^{N}(\beta_i * W_i)^2 * \sigma_{sp} + \sum_{i=1}^{N}(\sigma_{ri}^2 * W_i^2)} -> min$$

$$\sum_{i=1}^{N}(\bar{R}_i * W_i) + (R_{sp} - \bar{R}_{sp}) * \sum_{i=1}^{N}(\beta_i * W_i) \geq R_{reg} \quad (5)$$

$$W_i \geq 0$$

$$\sum_{i=1}^{N} W_i = 1$$

To calculate the yields of the Central Bank on a monthly basis, "Quasi-Sharp" model formula will be used:

$$R_i = \frac{P_i - P_{i-1}}{P_{i-1}} \quad (6)$$

We calculate the average return value for the selected period for each type of stock using the average value function.

Based on the definition of a single portfolio as a set made up of used shares taken in equal proportions, the formula for the profitability of a single portfolio for the period t will be equal to the average yield of the i-th securities included in the portfolio (7):

$$R_{sp}^t = \frac{\sum_{i=1}^{N} R_i^t}{N} \quad (7)$$

where:

R_{sp}^{t} - the profitability of a single portfolio for the period t;

R_{i}^{t} - the yield of the *i-th* security in the period t;

N - the number of securities that make up the portfolio.

Based on the profitability of a single portfolio for each month, we will determine the average profitability of a single portfolio for the year:

$$\bar{R}_{sp} = \frac{\sum_{t=1}^{T} R_{sp}^{t}}{T} \quad (8)$$

where:

R_{sp} - the average return for the entire period T.

R_{sp}^{t} - the sum of all periods t.

The beta coefficient (β), which indicates the degree of dependence (or sensitivity) of the stock's yield on changes in the yield of a single portfolio, is calculated for each i -th security using the following formula:

$$\beta_i = \frac{\sum_{t=1}^{T}[(R_i^t - \bar{R}_i) * (R_{sp}^t - \bar{R}_{sp})}{\sum_{t=1}^{T}(R_{sp}^t - \bar{R}_{sp})^2} \quad (9)$$

To determine the overall risk using the Quasi-Sharp model, it is still necessary to calculate the residual risk, which represents the spread of profitability relative to the regression line, which is measured by the following value:

$$\sigma_{ri} = \frac{\sum_{t=1}^{T}(R_i^t - \bar{R} - \beta_i * (R_{sp}^t - \bar{R}_{sp}))^2}{T} \quad (10)$$

In order to form an investment portfolio from these securities, it is necessary to calculate the risk of the single portfolio itself:

$$\sigma_{sp} = \sqrt{\frac{\sum_{t=1}^{T}(R_{sp}^t - \bar{R}_{sp})^2}{T}} \quad (11)$$

This methodology provides a comprehensive framework for calculating stock returns and the quasi-Sharp coefficient using Microsoft Excel. By analyzing data on stock closing prices and the risk-free rate from September 2022 to September 2023, obtained from the financial portal Kase.kz, the methodology adapts to the unique characteristics of unstable stock markets through the «Quasi-Sharp» model. This model, modified from the traditional Sharpe model, uses the yield of an entire portfolio as a benchmark rather than a stock index, allowing for a more nuanced understanding of security performance. The approach emphasizes the relationship between individual securities and the portfolio yield, incorporating assumptions about yield calculation, portfolio composition, and risk assessment. By focusing on the average yield of a single portfolio and adjusting for residual risk, the methodology offers a robust tool for optimizing investment portfolios with targeted yield and risk profiles.

RESULTS AND DISCUSSION

Before proceeding with the calculations, it is crucial to thoroughly analyze the current investment activities of the Non-State Pension Funds (NPFs). As of November 1, 2023, the total volume of pension assets amounted to KZT 17,220.0 billion, marking an increase of KZT 2,551.6 billion or 17.4% since the beginning of 2023. This growth indicates robust investment activity and effective asset management within the NPFs.

In 2023, government securities of the Republic of Kazakhstan continued to dominate the investment portfolio, accounting for 49.6% of the total assets, compared to 45.3% in 2012. This preference for government securities underscores a strategic emphasis on stability and low-risk investments. However, the share of non-governmental securities issued by domestic issuers and international organizations has significantly decreased from 28.4% in 2012 to 19.6% in 2023. This reduction of 8.8% reflects a shift away from potentially higher-yielding but riskier assets towards more secure options.

Additionally, the proportion of deposits in second-tier banks has declined from 7% in 2012 to 1.9% in 2023, indicating a move away from banking deposits, possibly due to lower interest rates or higher perceived risks. Conversely, the share of government securities from foreign countries has risen sharply from 5% in 2012 to 16.5% in 2023, an increase of 11.5%. This shift highlights a diversification strategy aimed at mitigating domestic risks and capturing potential returns from more stable foreign governments.

The evolution of the pension fund investment portfolio demonstrates a significant transition towards more stable and manageable instruments. While this strategy reduces exposure to risk, it may also limit the potential for higher returns. Despite this conservative approach, net investment income has shown a continuous upward trend from 2012 to 2023, driven by the increasing interest rate over the same period. This indicates that the NPFs have managed to achieve growing profitability,

balancing the need for stability with the goal of income generation.

Overall, the current investment strategy reflects a cautious yet progressively profitable approach, ensuring that pension assets are safeguarded while still generating substantial returns. This analysis underscores the importance of adaptive investment strategies that respond to changing economic conditions and market dynamics to maintain the growth and security of pension assets.

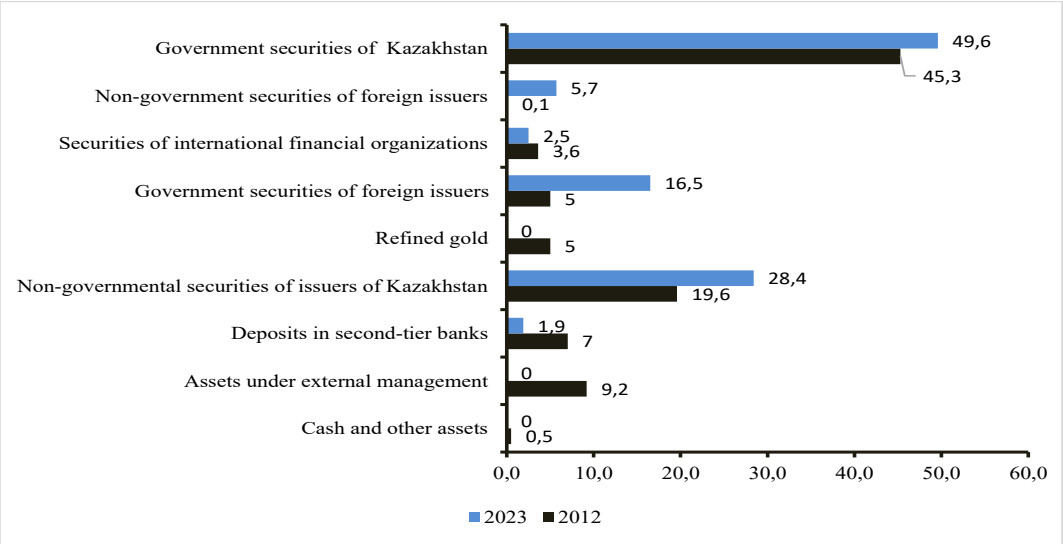

Figure 1. Structure of the UAPF investment portfolio for 2012 and 2023, %

Note: compiled by the authors based on the data of the UAPF

In the initial stages, the growth in interest rates was relatively small, but in recent years, it has accelerated significantly. However, the investment yield of pension assets is lower or at the level of inflation, which indicates that it is necessary to change the asset management strategy (Figure 2).

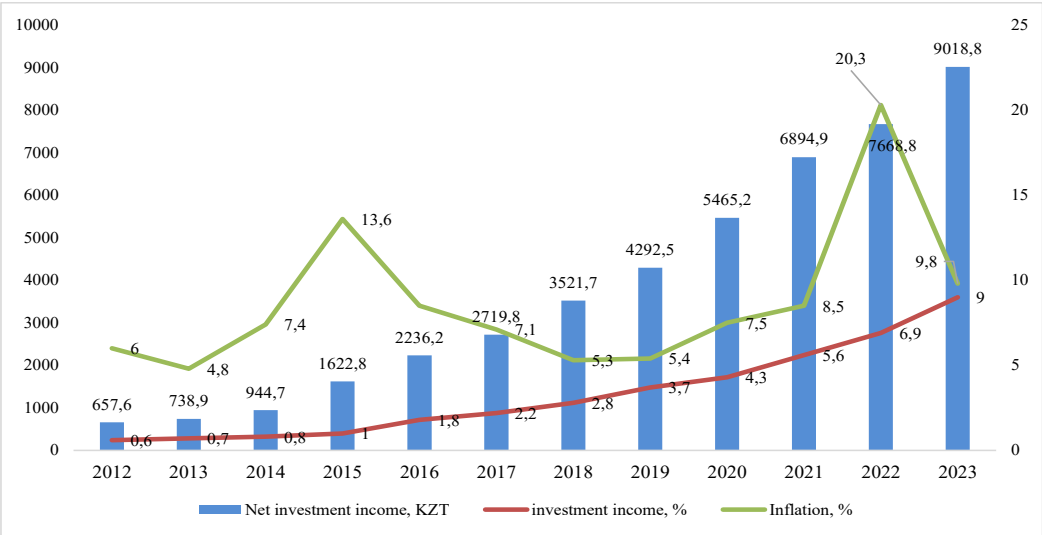

Figure 2. Indicators of UAPF investment activity and inflation, 2012-2023

Note: compiled by the authors based on data from the UAPF

The application of the "Quasi-Sharp" model to form an optimal aggressive portfolio involves selecting the most liquid stocks listed on the official website of the Kazakhstan Stock Exchange (KASE). The chosen stocks for this portfolio are KazTransOil JSC (KZTO), AO Bayan Sulu (BSUL), KEGOC JSC (KEGC), Halyk Savings Bank of Kazakhstan (HSBK), NurBank JSC (NRBN), Kcell JSC (KCEL), and Bank Center Credit JSC (CCBN). By leveraging the Quasi-Sharp model, the portfolio is optimized to balance potential returns with an acceptable level of risk, focusing on these high-liquidity securities to maximize investment performance within the aggressive strategy framework.

The results of calculations of the profitability of securities and a separate portfolio for the beginning (2013) of the considerd period and final year (2023), as well as their corresponding average values, are presented in Table 1.

Table 1. Calculation of the yields of securities and a single portfolio

Year	Month	Deposit Rate	Monthly Return Ri	Portfolio Return	Average Deposit Rate	Analysis
2013	January	3.0	-0.200	-0.200	3.725	Significant initial drop in returns by -20%.
2013	Febrary	2.4	0.125	0.125	3.725	Recovery with a 12.5% gain.
2013	March	2.7	0.074	0.074	3.725	Continued positive return of 7.4%.
2013	April	2.9	0.069	0.069	3.725	Stable growth with a 6.9% increase.
2013	May	3.1	0.129	0.129	3.725	Strong positive growth of 12.9%.
2013	June	3.5	-0.029	-0.029	3.725	Small decline of -2.9%.
2013	July	3.4	0.235	0.235	3.725	Significant positive spike of 23.5%.
2013	August	4.2	0.024	0.024	3.725	Moderate positive return of 2.4%.
2013	September	4.3	0.093	0.093	3.725	Stable growth with a 9.3% increase.
2013	October	4.7	0.043	0.043	3.725	Minor positive return of 4.3%.
2013	November	4.9	0.143	0.143	3.725	Strong positive return of 14.3%.
2013	December	5.6	0.143	0.143	3.725	Consistent strong return of 14.3%.
2023	January	14.5	0.000	0.000	14.5	No change in returns (0%).
2023	Febrary	14.5	0.000	0.000	14.5	Stable but no growth (0%).
2023	March	14.5	0.000	0.000	14.5	No return change (0%).
2023	April	14.5	0.000	0.000	14.5	Flat return (0%).
2023	May	14.5	0.000	0.000	14.5	Continues flat return (0%).
2023	June	14.6	0.007	0.007	14.5	Small positive return of 0.7%.
2023	July	14.7	0.007	0.007	14.5	Minor gain of 0.7%.
2023	August	14.6	-0.007	-0.007	14.5	Small negative return of -0.7%.
2023	September	14.2	-0.027	-0.027	14.5	Significant negative return of -2.7%.
2023	October	14.6	0.028	0.028	14.5	Positive recovery of 2.8%.
2023	November	14.6	0.000	0.000	14.5	No return change (0%).
2023	December	14.6	0.000	0.000	14.5	Stable but flat return (0%).
Average 2013	-	-	0.064	0.064	3.725	2013 shows an overall average return of 6.4%, outperforming the average deposit rate of 3.725%.
Average 2023	-	-	0.0008	0.0008	14.5	2023 demonstrates a very low average return of 0.08%, significantly underperforming compared to the high average deposit rate of 14.5%.

Source: compiled by the authors based on KASE (2023)

In 2013, the portfolio exhibited considerable fluctuations, with significant declines in January (-20%) and June (-2.9%). Despite these drops, there were strong gains in July (23.5%), November (14.3%), and December (14.3%). The overall average return for 2013 was 6.4%, well above the average deposit rate of 3.725%, indicating robust portfolio performance.

In 2023, the portfolio returns were largely flat for the first half of the year, with minor gains in June (0.7%) and July (0.7%). Notable negative returns were observed in August (-0.7%) and September (-2.7%), offsetting some of the small gains. The average return for 2023 was extremely low at 0.08%, significantly lower than the average deposit rate of 14.5%, indicating poor portfolio performance relative to deposit rates.

The analysis concludes that in 2013, the portfolio's average return of 6.4% indicates strong performance, making it a better investment option compared to the average deposit rate of 3.725%. In 2023, with an average return of just 0.08%, the portfolio significantly underperformed relative to the high average deposit rate of 14.5%, suggesting that deposits would have been a more favorable investment option. This analysis provides a clearer understanding of the performance dynamics and the comparative advantage of investment options for the years 2013 and 2023.

Next, results for the Central Bank's profitability and risks are provided in Table 2

Table 2. Summary results of the Central Bank's profitability and risks

Name	β_i - coefficient	Average return (%)	Residual risk (%)
KZTO	0,8746	13,58	0,46
BSUL	0,0450	9,17	0,19
KEGC	2,6892	10,67	2,00
HSBK	3,7420	8,81	1,27
NRBN	0,3547	11,39	0,20
KCEL	1,7377	13,41	1,89
CCBN	0,1669	12,15	0,47

Note: compiled by the authors

All parameters of the Quasi-Sharp model have been calculated, enabling us to determine the optimal portfolio that maximizes profitability within a specified risk limit. With a risk limit set at less than 5%, the analysis using the Excel add-in "Solver" indicated that the maximum achievable return is 12%. This return can be realized by structuring the pension assets as follows: 57% in ordinary shares of Halyk Savings Bank of Kazakhstan, 32% in Kcell JSC, and 11% in ordinary shares of KazTransOil JSC. While shares of KEGOC JSC and Bank Center Credit JSC showed the highest profitability values, they also had the highest risk coefficients. Consequently, a balanced pension asset structure was selected, comprising various bonds available in the UAPF and members of the representative list of KASE series indices in 2023.

The initial single portfolio (initial structure) with equal shares included the following government and corporate bonds (Table 3).

Table 3. Structure of a single bond portfolio

The Issuer	Commodity code	Weighted average yield, in % per annum
Ministry of Finance of the Republic of Kazakhstan (GSB)	SLO	11,97
Ministry of Finance of the Republic of Kazakhstan (GSB)	SALTO	13,15
JSC "Kaspi Bank"	CSBN	8,5
JSC National Managing Holding "Baiterek"	BTRK	11,99
JSC "First Heartland Jusan Bank"	TSBN	10,28
JSC "Kazakhstan Housing Company"	KZIK	8,15
JSC "Development Bank of Kazakhstan"	BRKZ	6,96
JSC "Kazakhstan Sustainability Fund"	KFUS	9,68
JSC "National Company of Kazakhstan Temir Zholy"	TMJL	16,95

Note: compiled by the authors

Based on the Quasi-Sharp model, the structure of pension asset funding was determined as follows: JSC National Managing Holding «Baiterek» (BTRK) – 30%, JSC «Development Bank of Kazakhstan» (BRKZ) – 30%, JSC «First Heartland Jusan Bank» (TSBN) – 30%, and JSC «Kaspi Bank» (CSBN) – 10%. This allocation results in a yield of 11.75% with a risk limit of no more than 3%. Currently, as follows from the composition of the pension assets of the UAPF, up to 6% of assets are invested in banks.

In Figure 3, there is data on deposit rate over the considered period, according to the National Bank of the Republic of Kazakhstan (Figure 1) for long-term investments, since pension assets are long-term deposits.

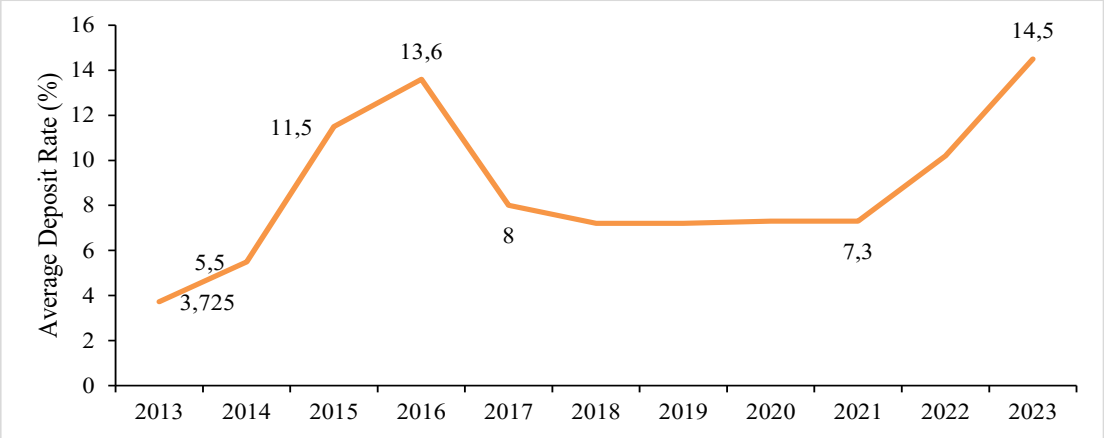

Figure 3. Dynamics of the deposit rate on average for second-tier banks for 2013-2023

Source: compiled by the authors based on National Bank (2023)

Based on the provided figures, the analysis reveals notable trends and fluctuations in deposit rates for second-tier banks in the Republic of Kazakhstan. The annual average deposit rate from 2013 to 2023 exhibited significant variability, with a peak of 14.5% in 2023. This period saw substantial increases in 2015 (11.5%) and 2016 (13.6%), followed by a decline and stabilization around 7.2% to 7.3% from 2017 to 2019. The standard deviation for the annual average deposit rate during this period indicates fluctuations around the mean rate, reflecting changes in economic conditions and monetary policies. Next in Figure 4, , there is data on monthly deposit rate in 2013 and 2023.

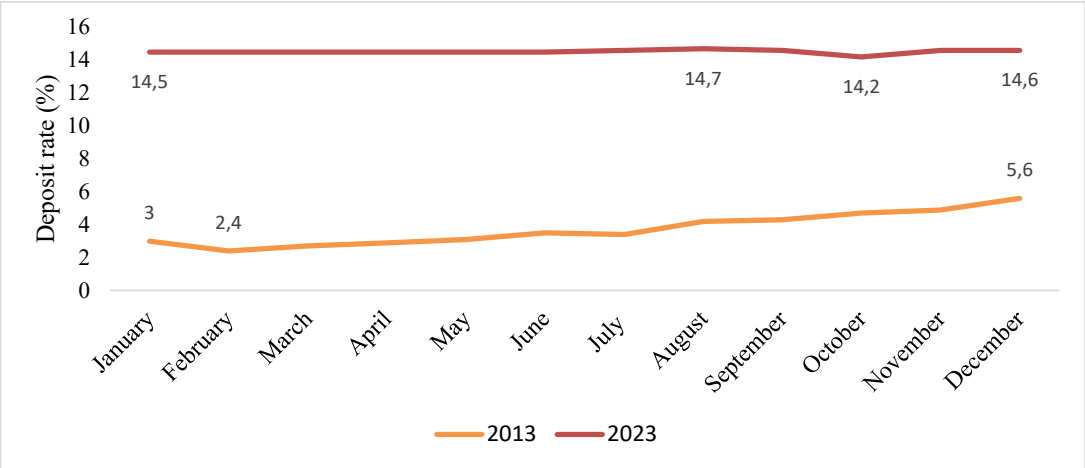

Figure 4. Dynamics of the monthly deposit rate for second-tier banks in 2013 and 2023

Source: compiled by the authors based on National Bank (2023)

The monthly deposit rates for 2013 started at 3.0% in January, fluctuating throughout the year with a low of 2.4% in February and a high of 5.6% in December. This upward trend suggests increasing returns for deposit investments over the year, likely influenced by market conditions and banking policies.

In contrast, the monthly deposit rates for 2023 remained consistently high, starting at 14.5% in January and maintaining this level with slight variations, peaking at 14.7% in August and dipping slightly to 14.2% in October. The stability and elevated rates in 2023 indicate a high-interest-rate environment, driven by factors such as inflationary pressures or aggressive monetary policies aimed at attracting deposits.

The data demonstrate that the yield on deposit investments in the Republic of Kazakhstan can reach up to 14.5%, with minimal fluctuations observed in 2023. This consistent high rate suggests that the first variant of the funding structure, focusing on liquid stocks, can potentially bring a maximum return of 11.2% with an acceptable risk level of no more than 5%. Meanwhile, the second variant, based on bond funding, offers a yield level below 13.75%, with an acceptable risk level of no more than 3%. These findings provide critical insights into the investment landscape and risk-return profiles for different funding structures in Kazakhstan's banking sector.

The third option is deposits in banks, which also cannot exceed the 15.98% yield threshold; the risks of investing in this case are difficult to assess, and the issue of the relationship between the UAPF and banks needs to be sufficiently worked out.

The low profitability of investments in pension savings is also explained by the narrowness of the stock market by types of securities and restrictions on the structure of investments in pension assets.

The findings underscore a notable transition towards more conservative investment instruments, particularly government securities, over the examined period. This shift reflects a broader global trend observed in pension fund management strategies, wherein a preference for stable assets is evident amidst economic uncertainties. Notably, the allocation towards non-governmental securities and deposits in second-tier banks witnessed a considerable decline, indicative of a strategic move towards mitigating portfolio risk.

Moreover, the analysis reveals a persistent challenge concerning yield performance vis-à-vis inflation rates. Despite an upward trajectory in net investment income and interest rates, the investment yield of pension assets consistently lags behind inflation levels. This discrepancy underscores the imperative for reassessing asset management strategies to ensure portfolio returns remain commensurate with inflationary pressures.

Furthermore, the study employs the Quasi-Sharp model to propose optimal portfolio structures, leveraging the performance of selected stocks and bonds listed on the Kazakhstan Stock Exchange. Through rigorous quantitative analysis, the model facilitates the identification of portfolio compositions that maximize returns while adhering to predefined risk thresholds. Applying such advanced asset management techniques underscores the necessity for pension funds to embrace sophisticated quantitative methodologies in navigating dynamic financial markets effectively.

Regarding theoretical implications, the findings align with established investment frameworks such as Modern Portfolio Theory (MPT) and Efficient Market Hypothesis (EMH). The emphasis on diversification and risk-return trade-offs resonates with MPT principles, advocating for portfolio optimization strategies that balance risk exposure with return potential. Conversely, identifying opportunities for outperformance challenges the assumptions of EMH, suggesting the presence of inefficiencies in the market that can be exploited through active management and strategic asset allocation.

CONCLUSION

In conclusion, it is necessary to emphasize the critical results of the study aimed at achieving the goals related to Kazakhstan's pension system.

In the course of the study, a comprehensive analysis of the effectiveness of pension asset management within the framework of the pension system of Kazakhstan was carried out. Using modern economic and mathematical analysis methods, the key factors influencing the profitability and risks of investing in pension assets were identified.

An essential result of the study is the identification of optimal portfolio structures that ensure a balance between profitability and risk in the conditions of the Kazakh financial market. Applying the Quasi-Sharp model allowed us to identify the most effective portfolio diversification strategies that maximize expected returns with a minimum level of risk.

In addition, the study revealed the competitiveness of various investment instruments available to pension funds, such as stocks, bonds, and bank deposits. The analysis showed that a

variety of investment instruments helps to reduce risks and increase the stability of the profitability of pension assets.

Based on the study results, specific recommendations are presented to improve the efficiency of pension fund management in Kazakhstan. These recommendations include changes in the legal and regulatory framework for investing, the introduction of portfolio diversification strategies, and improved risk management and corporate governance practices to ensure the pension system's sustainability and long-term financial sustainability.

Thus, the study's results emphasize the need for active actions on the part of the state and pension funds to ensure adequate pension provision for the population in the future. By applying modern asset management methods and adaptive investment strategies, it is possible to increase the efficiency of pension asset management and ensure a sustainable financial future for pensioners.

AUTHOR CONTRIBUTIONS

Conceptualization and theory: AA; research design: AA, AZ and KK; data collection: AZ and KK; analysis and interpretation: AA, AZ, AG and KK; writing draft preparation: AZ, AG and KK; supervision: AZ and AA; correction of article: AA, AZ and AG; proofread and final approval of article: AZ, AG and KK. All authors have read and agreed to the published version of the manuscript.

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