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"A Quantitative Evaluation of Asset Allocation Optimization Using Monte Carlo Simulation"

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Abstract

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In the realm of finance, portfolio management plays an important role in linking financial goals to market uncertainties. This study examines how optimizing asset allocation through Monte Carlo Simulation (MCS) can strengthen and maintain investment portfolios. Traditional securities portfolio management models, such as the modern Securities Portfolio Theory (MPT) and the capital Asset Pricing Model (CAPM), often struggle to take into account the complexities of modern markets characterized by increased volatility and global interconnectedness.

The study examines how MCS can transform portfolio management by offering a detailed view of investment results through statistical probability analysis. By modelling market scenarios, MCS allows portfolio managers to assess the risks and returns associated with asset allocation strategies, thereby improving the investment decision-making process.

From the point of view of methodology, this study uses an approach based on the analysis of investment data from the Unified Accumulative Pension Fund of Kazakhstan (UAPF) for the past ten years. This research uses historical data on returns by asset class to build a correlation matrix and simulate 10,000 market scenarios, predict possible outcomes and evaluate risk indicators such as cost at risk (VaR) and conditional cost at risk (CVaR). The results obtained indicate that portfolios optimized using MCS demonstrate risk-adjusted returns compared to portfolios managed using other approaches.

The study shows that the use of Monte Carlo simulation is useful for improving investment portfolios, as it allows you to get an idea of the relationship between risk and profitability.

This method helps to navigate the uncertainty in the market, which leads to the creation of effective investment portfolios. The results show how MCS can improve planning and management by offering suggestions for integrating this advanced analytical method into real-world portfolio management practices.

Keywords: investment management, Monte Carlo simulation (MCS), risk-adjusted asset return distribution, financial markets, investment approaches.

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List of abbreviations

MPT - modern portfolio theory

CAPM - Capital Asset Pricing Model

VaR - Value at Risk

CVaR - Conditional Value at Risk

MCS - Monte Carlo simulation

AI - artificial intelligence

UAPF - Unified Accumulative Pension Fund

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Introduction

In the realm of finance, portfolio management serves as a practice that bridges the gap between ambitious financial goals and the unpredictable nature of market fluctuations. In addition to maximizing profits, it is also necessary to focus on protecting investments from the uncertainties that define markets. The key point is to make informed decisions that are consistent with investors' risk tolerance and the goals of creating a sustainable portfolio that can withstand market challenges over time.

In today's increasingly globalized environment, markets are more interdependent than ever before. Events in one part of the world can affect all markets, creating both opportunities and obstacles. Portfolio managers must navigate the conditions of strained relationships, economic changes and technological advances that can lead to market volatility.

Against this background, there is a reassessment of traditional securities portfolio management tools and strategies.

The drive to create adaptive investment portfolios has sparked a growing interest in using quantitative methods to gain a deeper understanding and create more reliable decision-making mechanisms. One of the main activities of the company is the development of investment portfolios that can be adapted to various conditions. One such method that attracts attention is Monte Carlo Simulation, known for its ability to model the uncertainties and randomness inherent in markets.

Monte Carlo simulation based on problem solving offers an approach to optimized asset allocation. By modelling market scenarios based on data and statistical probability analysis, this method allows portfolio managers to assess the risks and returns associated with different asset allocation strategies in different market conditions. This method of portfolio

optimization marks a shift away from deterministic approaches that provide a more nuanced understanding of potential investment outcomes.

This study is devoted to the study of how Monte Carlo modelling can transform the management of a securities portfolio by improving the processes of optimizing asset allocation. The goal is to uncover how this advanced quantitative tool can revolutionize the investment decision-making process, ultimately improving the efficiency and sustainability of investment portfolios. The purpose of this study is to propose ideas and strategies for portfolio managers based on the study of the basics, historical evolution and practical applications of Monte Carlo modelling.

Throughout this research, we explore the world of achievements and changing market trends, emphasizing the crucial role of innovative portfolio management strategies in achieving investment prosperity. Delving into the possibilities of Monte Carlo simulation, this dissertation aims to contribute to practical discussions on optimizing asset allocation, helping portfolio managers navigate the turbulent waters of the global financial market.

1.1 Research Problem

The problem facing portfolio management today lies in the often unpredictable nature of global financial markets. This complexity is further compounded by the problems of forecasting market changes and mitigating investment risks in an environment characterized by increased volatility and pervasive uncertainty. While traditional asset allocation models form the basis of modern portfolio theory (MPT), conceptualized by Markowitz (1952), they often find it difficult to understand the complexities and volatility of modern financial markets. Traditional models in finance often use data and standard deviation to assess risk. This approach may not fully reflect the complex and unpredictable nature of market returns. This discrepancy points to a gap between portfolio optimization concepts and the real

problems faced by portfolio managers, emphasizing the need for more advanced tools capable of effectively dealing with the unpredictability of investing.

Relying solely on performance in making investment decisions, as is customary in traditional models, may not always be reliable due to the constantly changing dynamics of markets and external factors such as geopolitical tensions, changes in economic policy and technological advances that can quickly affect market conditions.

As a result, there is a growing interest in methodologies that incorporate elements and provide accurate modelling of future yield uncertainties. In the field of strategies, Monte Carlo simulation stands out as a tool that allows you to model various economic and market scenarios to assess potential outcomes when making asset allocation decisions. This method has been recognized for its ability to offer a flexible approach to risk management and profitability improvement, reflecting the unpredictable nature of markets.

While the concept is attractive in theory, the application of Monte Carlo simulation in real portfolio management poses challenges such as requirements, model definition, and effective interpretation of results for decision-making purposes. Therefore, it is important to assess how effective Monte Carlo modelling is for optimizing asset allocation within the framework of modern portfolio management methods in order to bridge the gap between quantitative models and their practical use in investment strategies.

1.2 Problem Background

The financial landscape of the 21st century has been markedly changed as a result of a confluence of factors, including rapid technological progress, major geopolitical changes and profound shifts in the economy. The changes taking place in the markets have led to a new level of complexity and interconnectedness. This progressive situation creates problems for the management of investment portfolios in terms of making decisions about where to invest assets and how to deal with risks. The unpredictability caused by these factors requires a

reassessment of portfolio management practices, which are under close scrutiny for their ability to protect investments during market downturns.

Traditional approaches to securities portfolio management based on Markowitz's modern Portfolio Theory (MPT) and Sharpe's Capital Asset Pricing Model (CAPM) have historically offered a way to manage risks and returns. However, these models assume simplified market conditions and overlook the complexities arising from emerging markets, digital financial services, and rapid information exchange. The static nature of these models does not fit well with modern financial markets driven by instant global communication and algorithmic trading.

In this situation, Monte Carlo simulation stands out as a modelling tool that allows you to take into account randomness and uncertainty in market behaviour using statistical processes (Glasserman, 2004). This method allows you to model scenarios that offer a series of outcomes based on probabilities rather than a single fixed forecast. The ability to model the dynamics and assess the impact of various risk factors on asset returns is especially valuable in modern portfolio management practice (Broadie & Glasserman, 1997). Despite its peculiarities, the practical use of Monte Carlo simulation in real-world situations of securities portfolio management remains relatively unexplored, since existing research focuses more on its theoretical foundations rather than on practical implementation strategies (Clewlow & Strickland, 1998). The correspondence between the potential of Monte Carlo simulation and its actual application in securities portfolio management highlights the research task; There is an urgent need to assess how effective Monte Carlo simulation is to optimize asset allocation in a way that is both theoretically sound and practically feasible. This assessment plays an important role in developing approaches to portfolio management that can navigate uncertainty in modern financial markets, thereby providing better guarantees against market volatility and downturns (Fabozzi, Focardi, & Kolm, 2010).

1.3 Research Aim and Objectives

The main purpose of this study is to evaluate how Monte Carlo simulation can contribute to optimizing asset allocation in portfolio management in a changing global financial landscape. The research aims to bridge the gap between theory and practice by using the Monte Carlo simulation capabilities to solve the complexities and uncertainties present in modern markets. In addition, this study aims to explore both the fundamentals and practical applications of the Monte Carlo method in modelling, with a particular focus on optimizing asset allocation. By exploring how this modelling method can account for scenarios and market conditions, it offers a more comprehensive framework for predicting potential investment outcomes.

The purpose of this study is to understand how Monte Carlo simulation can improve portfolio performance by modelling the distribution of returns and assessing the impact of market events. It also aims to highlight the challenges and constraints faced when implementing Monte Carlo simulation in real-world portfolio management, such as requirements, model specifications, and interpretation of simulation results. In addition, the goal is to offer recommendations for portfolio managers on integrating Monte Carlo simulation into their asset allocation strategies to enhance portfolio sustainability and efficiency. This includes providing recommendations and strategies for using Monte Carlo simulation in investment decision-making processes to improve portfolio results in conditions of market uncertainty.

1.4 Research Question/Hypothesis

The Research question is designated as follows: how Monte Carlo simulation affects the risk and return profiles of pension fund portfolios compared to conventional asset allocation methods?

There are two hypotheses set to address the Research Question:

H0: there is no significant difference in the risk-adjusted returns between pension fund's portfolios employing traditional asset allocation methods and Monte Carlo simulation;

H1: Using Monte Carlo simulation by pension funds for asset allocation exhibit higher risk-adjusted returns in comparison to traditional asset allocation methods.

2. Literature review

The world of investment portfolio management has changed under the influence of advances in concepts, technological advances and a dynamic global economy. This review examines the basic principles of portfolio management, the importance of Monte Carlo simulation in asset allocation and real-world data demonstrating its effectiveness, as well as briefly describes traditional asset allocation strategies.

2.1 Traditional strategies of portfolio management

The creation of the Modern Portfolio Theory (MPT) by Harry Markowitz (1952) was a turning point in the field of financial economics. Professor Markowitz put forward the idea of diversification as a method of optimizing portfolio profitability while simultaneously managing risks, radically changing investors' understanding of portfolio formation. His effective frontier model illustrated how investors can find a balance between risk and return to achieve optimal portfolio allocation.

Developing the principles of MPT, Sharpe (1964) introduced the Capital Asset Pricing Model (CAPM), which further improved understanding of risk and profitability in the markets. CAPM has proposed a formula for calculating the expected return on assets based on their bet risk score. This model has played a role in explaining how market prices reflect risk and how investors are compensated for taking risks.

Although MPT and CAPM laid the foundation for portfolio management, their assumptions such as yield distribution and constant volatility have been criticized over time.

Benoit Mandelbrot (1963) was one of the first to question the idea of distributing returns in the markets. He suggested that markets have "tails" indicating that extreme events occur more often than expected in the distribution. This understanding has shed light on the limitations of modern portfolio theory (MPT) and the capital Asset Pricing model (CAPM) in reflecting the complexities of global markets.

In addition, Rachev and Mittnik (2000) presented models as an alternative to the assumption of normal distribution in financial modelling. Their research has shown that financial returns can be better represented by distributions with tails offering an accurate assessment of risk in financial markets.

Criticism of MPT and CAPM has sparked interest in developing adaptable portfolio optimization methods. This includes studying risk models such as Value at Risk (VaR) and conditional Value at Risk (CVaR), which aims to provide a clearer understanding of potential losses under adverse market conditions.

Moreover, the development of finance has led to an understanding of investor behaviour and market dynamics, calling into question the assumption of rational actors inherent in MPT and CAPM. This field examines how cognitive biases and emotional reactions can influence decision-making, thereby influencing market outcomes.

In his study Jorion (2007) presents an exploration of Value at Risk (VAR), its methodologies and its practical uses in financial scenarios. A paper by Rockafellar and Uryasev (2002) delves into the concept of CVaR offering an approach to its calculation and showcasing how it can be utilized in optimizing portfolios and assessing risks.

Behavioural finance has expanded the range of tools for portfolio optimization, calling into question the traditional rational model. Daniel Kahneman and Amos Tversky (1979) studied behavioural finance and explored how cognitive biases and emotional reactions influence decision-making. In their research Kahneman and Tversky criticized the theory of expected

utility. Their theory has shed light on phenomena such as the effect that, as a rule, causes risk aversion in scenarios with guaranteed profits and the desire for risk in situations with losses. It also introduces the concept of decision weight as a substitute for probabilities in evaluating outcomes, recognizing that people often give weight to low probabilities and less weight to high probabilities.

2.2 Monte Carlo Simulation for Portfolio Optimization

The use of Monte Carlo simulation (MCS) has led to progress in portfolio development and management. Through modelling uncertainties in financial markets and modelling various market conditions, MCS has become an invaluable tool for analyzing investments and fine-tuning portfolios. Glasserman (2004) provides an overview of MCS methods illustrating their application in risk assessment, option pricing, and portfolio optimization. This research explains how MCS can help assess the probability distribution of portfolio returns, allowing investors to make informed decisions in the face of market uncertainty.

A study by Brodie and Glasserman (1997) highlighted the practical benefits of using MCS to evaluate financial instruments, especially American-style securities. Their study demonstrated the adaptability of MCSs in terms of accounting for the complexities of option pricing, while emphasizing its ability to guide asset allocation strategies. This study laid the foundation for research on the application of MCS in effective portfolio management.

Clewlow and Strickland (1998) contributed to this discussion by exploring the role that MCS plays in incorporating various risk factors and economic scenarios into the portfolio management process. Their understanding of how MCS can be applied in modelling highlights the flexibility of the method and its ability to improve the decision-making process in portfolio management.

2.3 Empirical evidence and practical application

Despite the established advantages of MCS in asset allocation, empirical verification of its superiority over traditional methods in the real world of portfolio management remains an important area of study. Studies on the use of MCS often emphasize the importance of model selection assumptions that determine modelling parameters and interpretation of modelling results (Lopez de Prado, 2018).

While MCS has the potential to improve portfolio management, its widespread adoption is fraught with obstacles. These problems include the cost of conducting extensive modelling, the difficulty of developing accurate models that reflect the intricacies of the financial market, and the need to attract specialized specialists to effectively interpret and use the simulation results. In addition, the dynamic nature of markets requires updating and adjusting simulation models to ensure their relevance and accuracy (Taleb, 2007).

2.4 Review of comparative studies

A comparison of asset allocation methods with methods improved by Monte Carlo simulation (MCS) has aroused interest in the financial research community. MCS is highly regarded for its ability to model market behaviour and assess how various risk factors affect portfolio performance.

According to Fabozzi et al. (2010), the use of MCS provides an advantage in portfolio management by allowing careful investigation of risk return profiles in various simulated market scenarios. This approach can lead to the creation of effective portfolios, especially in conditions characterized by significant uncertainty and volatility.

Prado et al. (2016) explore the nuances of the microstructure of the market, exploring the impact of high-frequency trading on market stability.the impact of free trade on the stability of the market. Their research highlights the usefulness of MCS for analysing and reducing the

risks associated with trading dynamics, demonstrating its adaptability to changing market trends.

Furthermore, Bosch-Príncep et al. (2002) emphasized in their research the effectiveness of using Monte Carlo simulation to model paths of factors impacting pension funds. Their study recommends that investment managers integrate Monte Carlo simulations into their risk assessment approaches to enhance their ability to forecast and handle the risks linked to asset liability mismatches.

Also, Cong, F. and Oosterlee, C. W. (2016) in their study show how Monte Carlo simulation helps in adjusting pension fund portfolios amidst market uncertainties. The researchers suggest that Monte Carlo simulation offers an approach for optimizing pension fund investments.

Additionally, Zenios, S. A. et al. (1998) provided strategies for overseeing fixed income investment portfolios of retirement funds by utilizing Monte Carlo simulation to address uncertainties in interest rates. In this research it was proved that Monte Carlo simulation is an effective tool in navigating the intricacies of fixed income portfolios, in the context of retirement funds.

In the research conducted by Mulvey, J. M., Simsek, K. D. and Zhang, Z. (2006) it was proved that using Monte Carlo simulation, alongside stochastic programming, greatly enhances the investment results of pension plans. This research emphasizes the real world advantages of incorporating simulation methods in managing pension funds.

The seminal study was conducted by Brinson, G. P., Hood, L. R. and Beebower, G. L. in 1986. emphasizes the primacy of asset allocation over security selection in influencing

portfolio performance. They proposed Monte Carlo simulation as a critical tool for realistic scenario analysis, supporting the strategic emphasis on asset allocation.

Pimentel, L. F., & Santiago, L. P. (2015) analyzed how dynamic investment approaches perform for retirement funds in developing economies through Monte Carlo simulation. These adaptable strategies, supported by simulation, show adjustment to fluctuating markets resulting in enhanced results for retirement funds.

The study of Sihombing, T. (2004) analyzed how Monte Carlo simulation with linear programming can improve portfolio performance by optimizing portfolio weights. This method offers an approach to enhance portfolio diversification and effectively manage risks by incorporating Monte Carlo in asset allocation.

Detemple, J. B. and & Garcia, R. (2003) discussed how effective and reliable Monte Carlo methods can be when it comes to improving portfolios, comparing them to the traditional optimization techniques. In complex financial markets Monte Carlo methods offer a strong option for portfolio optimization.

In 2013 McCarthy, D. and Miles, D. studied how various asset allocation approaches impact the risk and returns of company pension funds. According to their research Monte Carlo simulation is crucial for identifying the optimal asset allocation in pension funds.

Ang (2014) presents a detailed perspective, recognizing the advantages of MCS in asset allocation, as well as cautioning against limitations. Ang mentions that the effectiveness of Monte Carlo simulation (MCS) in portfolio optimization depends on the accuracy of the models and the available computing resources, pointing out the problems associated with its implementation.

In their study Letterman and Winkelmann (1998) delve into the real-world application of MCS in asset allocation as part of investment strategies. They highlight the importance of

MCS to identify correlations and volatility across markets, offering a framework for international portfolio diversification.

Based on this discussion, Lo (2017) examines the limitations of theories in the context of complex market dynamics. Lo supports the adaptive market hypothesis, suggesting that MCSs adaptability and scenario-based analysis make it a valuable tool in a changing environment.

The computational requirements of Monte Carlo simulation (MCS) have historically prevented its implementation in portfolio management. Clewlow & Strickland (1998), together with Glasserman (2004), describe in detail the complexity associated with MCS, especially when modeling derivatives or conducting extensive portfolio optimization.

The requirement for computing power can hinder the practicality of MCS for investors and portfolio managers, especially for those who do not have access to significant IT resources.

An additional obstacle in the application of MCS is the need to obtain high-quality comprehensive data to create accurate models of financial markets and instruments. The reliability of MCS results largely depends on the accuracy of the input data, which includes market data, volatility estimates, correlation matrices and other financial indicators. Ensuring the integrity and availability of data can be difficult and expensive, presenting a challenge when implementing MCS.

Advances in technology, especially in cloud computing and big data analytics, have begun to remove some of these obstacles. Cloud computing provides resources that make it more convenient and cost-effective for portfolio managers to conduct complex MCS analysis without investing in expensive equipment.

Machine learning and artificial intelligence (AI) are also changing the field of modeling, including the use of MCS. These technologies have the potential to improve modeling

efficiency, improve model accuracy, and even simplify the analysis of MCS results — thereby making this method more accessible to the audience.

Improving MCS models to better account for the associated risks and consequences of market events, thereby increasing the reliability of portfolio risk assessments.

The link between progressions and practical implementations in portfolio management highlights the importance of bridging the gap between complex financial models and their execution. As the financial environment continues to transform due to the increasing complexity of the market and the emergence of new technologies, there is an urgent demand for models that can accurately adapt to these changes.Monte Carlo Simulation (MCS) plays a role in this progress by providing a reliable tool that can effectively model various financial scenarios and their outcomes.

Recent advances in computational finance have removed obstacles to using complex models such as MCS to manage a portfolio. The development of cloud computing, big data analysis and machine learning methods has created opportunities for complex simulations with increased efficiency (Hilpisch, 2015). These technological developments simplify the processing of data sets for MCS and accelerate the modeling process, allowing portfolio managers to more easily integrate MCS into their decision-making processes.

3. Methodology

In this chapter the details of the research methodology, approach and design will be discussed by outlining the study's subjects, timeframe and settings. There instruments and methods used for data collection will be described and explained. The chapter also addresses the reliability and validity of these data collection tools by explaining their development, collection process and testing procedures. Furthermore, it provides an overview of the steps taken to conduct the research, and describes how data was gathered from the external sources.

After the provision of data collection description information on the collected data preliminary analysis and findings will be provided. Selecting a research methodology or a combination thereof is essential as it acts as a guiding structure encompassing principles to facilitate research within a specific model.

The study delves into the analysis of the investment portfolio of Joint Stock Company "Unified Accumulative Pension Fund" (further - “UAPF" or “Pension Fund”) examining data for a ten year span from January 1, 2015 to January 1, 2024.

Founded on August 22, 2013 as a successor to the State Accumulative Pension Fund, UAPF plays a significant role in Kazakhstan's pension system. It is overseen by the Government of the Republic of Kazakhstans under the Committee for State Property and Privatization within the Ministry of Finance. The collaboration between administration and financial management is evident in how UAPFs pension assets are handled by the National Bank of Kazakhstan and the Council for Pension Assets Management.

The main focus of this research centres around the investment assets managed by the pension fund encompassing bonds, stocks, deposits and various financial instruments across markets.

A quantitative research methodology is employed to systematically evaluate the funds investment data. This approach is selected for its ability to offer measurements and analyse data to identify trends and correlations within the dataset.

3.1 Data collection

Data collection chapter delves into the methods and procedures employed to gather data concerning the examination of the pension funds investment portfolio. The funds for the portfolio are established through a blend of pension contributions, mandatory occupational pension contributions and voluntary pension contributions. Oversight of this securities portfolio is carried out by the National Bank of the Republic of Kazakhstan. The data

collected on the pension funds portfolio offers a foundation for evaluating the impacts of the portfolio composition on the overarching investment strategy of the Pension fund.

The data collection phase began with sourcing information from the pension funds website ensuring both reliability and public accessibility to details concerning its investment activities. This approach guaranteed access to data showcasing the structure of the investment portfolio. The website is renowned for its transparency and accuracy in disclosing information. The Data collected for the research was collected for a ten year period. The composition of the portfolio was extracted from the pension fund's official website through yearly reports spanning from January 1, 2015 to 2024. This specific timeframe was chosen strategically to gain an understanding of how the portfolio evolved revealing any shifts in asset allocation, key investment strategies and alterations in the overall composition throughout the past decade.

Upon extracting data from reports it was organised into tables, a crucial step that preserved data integrity and enhanced subsequent analytical processes efficiency. Challenges mainly arose due to handling a volume of data.

The meticulous process of organising and structuring the data for each year demanded a level of accuracy to ensure coverage and precise presentation of details. It is important to note that in order to safeguard the confidentiality of information and adhere to research standards no specific measures were needed to protect the data as it is open and accessible to all citizens of the Republic of Kazakhstan. The dataset comprises a consolidated spanning from January 1, 2015 to 2024 outlining aspects such as types of financial instruments, ratings, currencies, maturity dates, amounts, nominal and current values, portfolio percentages, issuers details and countries of origin. This diverse range of data enables an analysis of the pension funds investment strategies and decision making processes during that time frame.

An extensive data cleansing effort was carried out which involved identifying the header row and renaming columns for improved clarity. The dataset's long term span offers insights into the decision making involved in asset allocation and risk management within the pension funds portfolio. An extensive breakdown of the portfolio was conducted by categorising financial instruments into stocks, bonds, Eurobonds, derivatives and alternative investments. This breakdown is vital for evaluating the funds risk tolerance and investment variety. Furthermore a detailed classification by countries of issuers and regions was performed to understand the funds distribution and its market impact. Additionally, the dataset was further segmented to differentiate between types like corporate entities and government securities. This differentiation helped to identify diversification strategies of the fund and preferences, within industries.

3.2 Data analysis

This chapter dives into an examination of the content and composition of the Pension fund's investment portfolio from 2015 to 2024. It carefully outlines the paths taken across investment landscapes shedding light on how the fund manages risks, seeks optimal returns and navigates the complexities of global markets. By dissecting the makeup of the portfolio this narrative aims to uncover the expertise behind the funds choices and thinking strategies.

Serving as a cornerstone in the investment approach, bonds have not generated much income but also highlighted the fund's cautious approach to risk management. The peak in bond investments in 2019 may suggest an adjustment in anticipation of market changes or as a response to economic uncertainties. Playing roles in managing liquidity Eurobonds have provided flexibility and access to markets. The shift towards deposits in 2024 indicates a strategy to boost liquidity amidst evolving market conditions.

While representing a portion of the investment mix Equities and Forward Agreements contribute growth potential to the portfolio. The decision to include these instruments shows an acceptance of risk aiming to broaden returns and guard against inflation.

The fund's exploration of instruments, like Sukuk Al Murabaha and Principal Protected Notes indicates a willingness to expand beyond investment avenues. This aspect highlights a nuanced strategy for entering new markets and asset classes.

The portfolio showcases a range of investments with a noticeable focus on the Kazakhstani market. This bias could be influenced by advantages and a careful evaluation of market stability versus potential risks. However the narrative expands to encompass established markets like the USA, UK and Germany as emerging markets such as Brazil and China. This deliberate diversification signifies an approach to capitalising on economic trends for portfolio growth while managing geopolitical and market uncertainties effectively.

The fund's investment scope covers securities and countries ranging from holdings in Kazakhstan to international positions in Luxembourg. This varied mix not only showcases an investment approach but also indicates a deep understanding of global financial tools and markets.

The fund's investment approach combines international investments in asset classes to show a commitment to a diversified growth strategy while also focusing on managing risks effectively.

The prevalence of bonds in the portfolio reflects the fund's outlook with investments in deposits and eurobonds for liquidity and global market exposure. With an emphasis on Kazakhstan accounting for overall 87.8% of investments alongside international placements it demonstrates a thoughtful capital allocation strategy.

The funds investment mix indicates a preference for developing markets Kazakhstan suggesting a willingness to take on country specific risks for potentially greater returns. At

the time having exposure to markets acts as a stabilising factor against volatility enhancing the overall strategic asset allocation of the fund.

Looking at the implications and strategic insights drawn from this analysis reveals a portfolio strategy heavily focused on fixed income securities, those issued domestically in Kazakhstan. This preference could be due to local market support mandates, tax benefits or perceived risks.

Over time there has been a change in the selection of securities and countries from which issuers originate indicating an approach to market changes and a desire for diversified advantages. The decision to heavily invest in short term assets around 2015 also implies that the fund was strategically prepared to take advantage of or protect against market forecasts at that time.

Furthermore, the research takes a dive into the investment journey of a pension fund spanning from 2015 to 2024. In the study shifts, portfolio makeup and the fund's navigated geographical diversity year by year were analysed. The focus was on unravelling how the fund managed risks, optimised returns and navigated through the changing global market landscape with skill.

The analytical approach relied on using expiration dates of portfolio securities as a guide to understand when investments were made and the rationale behind the funds maturity driven decisions. This unique method provided insights into the funds investment pace and strategy over time in lieu of annual comparison data.

2015 - establishing a Solid Foundation - marked a thought out investment path with a strong emphasis on domestic fixed income assets to prioritise stability and liquidity. Beginning investments in Eurobonds and expanding into markets such as the USA reflected a budding strategy to diversify, blending a focus on affairs with aspirations for investments.

The period from 2016 to 2017 years marked Adapting to Market Changes. In 2016 there was a shift towards favouring deposits over bonds showcasing flexibility in managing liquidity during market conditions. By 2017 there was a shift towards prioritising income generation with increased investments in bonds and Eurobonds indicating an engagement in markets.

2018 - 2019 years were marked by a consolidation around bonds peaking in 2019. This consolidation hinted at considerations influenced by market trends or a careful approach to risks. During this period there was exploration of markets emphasising a preference for local investments and signalling a cautious approach to global diversification.

The consistent emphasis on bonds and the strategic introduction of Principal Protected Notes in 2021 showcased a plan tailored to navigate the nature of market dynamics. During that time there was an effort to expand globally with a focus on the USA. This strategic shift continued from 2022 to 2024 with a move towards deposits of bonds to adapt to market changes.

Between 2022 and 2024 there was a new approach to diversification. Starting in 2022 and then shifting focus to Kazakhstan by 2024 to respond effectively to different market dynamics.

The fund's consistent commitment to Kazakhstan over the decade highlighted its preference for market knowledge and stability. Additionally exploring both developed and emerging markets showed a risk management strategy aimed at seizing growth opportunities

Insights gained strategically throughout the decade indicated an approach tailored towards maximising growth opportunities while mitigating risks effectively.

After examining each year the fund's strategic essence shines through a strong belief in fixed income securities as the foundation for stability and reliable returns. Also, a thought out approach to managing liquidity, seen in the shift towards more liquid assets to align with market fluctuations. Additionally, a flexible geographic diversification plan, carefully

balancing a focus on investments with international ventures to safeguard against global market uncertainties.

The investment choices reflect a story of risk management, adept liquidity handling and a pursuit of growth both locally and globally. Apart from showcasing the funds resilience within the landscape this narrative applauds its understanding of market trends risk assessment and seizing investment opportunities – capturing ten years of shrewd financial management and strategic vision execution.

Let's take a look at the makeup of the average investment portfolio of the Pension Fund for the past decade. The majority of the portfolio 44% is invested in State Securities from Kazakhstan. This significant focus reflects a choice for stability over return. Lower risk typically associated with government bonds. About 10.55% of the portfolio is allocated to Foreign State Securities showing a move towards diversification across markets to benefit from global government bond stability while managing geopolitical risks. Domestic corporate bonds make up 6.83% of the portfolio while foreign corporate bonds represent 0.8%. This distribution indicates an approach to engaging with corporate debt markets. Investments in second tier banks in Kazakhstan including bonds and deposits make up around 13.4% of the portfolio showcasing a balanced strategy for potentially higher returns while prioritizing security. Allocations to governmental bonds are at 9.96% contrasting with just 0.66% dedicated to international quasi governmental bonds. This difference highlights a preference for governmental instruments over international ones.

It's important to compare how well the Pension fund’s investments have been doing compared to the inflation rates over the past ten years. In 2015 the Pension fund’s returns started at 6.31% lower than the inflation rate of 6.72% showing a real loss in value right from the beginning. Falling short of its goal to protect or even increase what its beneficiaries can buy. Although there was some improvement in 2016 when returns exceeded inflation this

progress didn't last. In 2017 there was a difference as returns of 8.76% were below an inflation rate of 14.56%. From 2018 to 2021 things were more stable with returns closely matching inflation rates. This stability did not lead to real growth needed for long term pension sustainability. The period from 2022 to 2024 saw a rise in both portfolio returns and inflation rates with inflation higher than returns.

Digging deeper into how the pension fund performed compared to Kazakhstan's low risk government bonds from 2015 to 2024 shows that initially it didn't perform well in a steady economic climate.

In 2016 there was a change as the returns slightly outperformed the benchmark. However this improvement was short lived as the following year saw returns dropping below government bond yields due to market instability affecting the funds investments. This pattern of underperformance persisted until 2023 leading to concerns about the funds investment strategies during a period when safer low risk options were performing better. It was not until 2023 and 2024 that the funds returns matched and slightly exceeded government bond yields hinting at enhancements. Nonetheless a thorough evaluation of the funds risk management and return optimization methods is still necessary.

3.3 Monte Carlo simulation

The process of calculating the expected returns and risks involves an analysis of the pension fund's performance data for each type of asset like bonds, stocks and cash. We delve into evaluations to determine the returns and variability for each asset class over a specific timeframe. This analysis goes beyond numbers, it includes studying market and geopolitical events that impacted these assets. Our goal is not only to quantify data but to gain qualitative insights that can help predict future performance. For example, when analysing bonds we consider factors like interest rate changes, credit risks and specific news. Similarly for stocks we look at market trends, company performances and sector shifts. This comprehensive

approach ensures that our return and risk estimates are based on data well as a contextual understanding to enhance their reliability for Monte Carlo simulations.

Creating the correlation matrix involves more than computations. It requires an in depth exploration of how different asset classes in the pension funds portfolio have interacted historically.

By analysing the relationships between assets we aim to unravel the intricate network of connections that shape the portfolio's diversification approach. This process is guided by a mix of data and subjective evaluation acknowledging that correlation trends can change in response to market fluctuations. For instance in times of market turmoil asset correlations may align closely challenging the notion of diversification advantages. Therefore our correlation matrix is not set in stone.it is a tool that captures both patterns and potential future changes in how assets interact. Crafting this matrix is an endeavour in grasping the dynamics within the portfolio allowing us to forecast how these connections may transform under varying market conditions and impact the portfolio's risk and return characteristics.

In this research we opted to conduct 10,000 Monte Carlo simulation iterations due to a considered decision aimed at capturing the intricate complexity and variability present in financial markets. This thorough method ensures that each simulation run serves as an exploration into the ways the market could develop, reflecting a wide range of economic, geopolitical and financial scenarios. The diversity in these iterations is essential for creating a view of future portfolio performance taking into consideration the unpredictable nature of market dynamics. This extensive simulation effort allows us to navigate uncertainties with a perspective laying a solid empirical foundation for understanding the spectrum of risks and returns that the pension fund may face.

Incorporating data spanning over a decade acts as an anchor for our simulations anchoring our forecasts in real world information. By extending our analysis beyond performance and

projecting into timelines we are effectively bridging the gap between historical data and potential future outcomes. This forward thinking approach is carefully crafted to evaluate not how the fund has fared historically but how it is positioned to perform amidst forthcoming economic and market changes.

This extension, over time is crucial for testing the funds investment approach evaluating how well it can withstand future situations and adapt accordingly. It also enables us to explore changes in strategy and asset allocation within the funds portfolio carefully analysing how these decisions could influence results. By using forward looking models our goal is to reveal insights that can inform the funds strategic planning and decision making procedures guaranteeing that its investment strategy stays strong, adaptable and in line with its long term goals.

In the Monte Carlo simulation framework determining the weighted returns it is necessary to consider the historical significance of each asset class, in the pension funds portfolio. This crucial step aims to reflect how each asset's performance impacts the returns of the portfolio. To ensure our simulations are realistic we adjust for any changes in asset allocation or rebalancing that have occurred over time. This dynamic adjustment helps capture not past allocation strategies. Also reflects the fund's evolving investment approach and adaptation to market conditions. Each simulation scenario produces a range of weighted returns that encompass market scenarios, allowing for an analysis of how different market conditions may affect the portfolio's performance.

The aggregation phase combines outcomes to provide a view of the portfolio's future performance landscape. This thorough process involves compiling the weighted returns, from 10,000 Monte Carlo runs to create a distribution representing the future values of the portfolio.

This analysis provides insights, including an evaluation of the chances of reaching different levels of returns and the potential risk of facing losses during challenging market conditions. Such, in depth examination is crucial for grasping the risk return dynamics of the portfolio allowing fund managers to anticipate scenarios and evaluate the portfolio's volatility. By compiling and analysing this information we extract details about the portfolio's strength and susceptibility giving us a nuanced understanding of its ability to withstand market fluctuations while seizing growth opportunities. This detailed exploration into the performance potential of the portfolio forms the foundation for making decisions guiding the fund in optimising its asset distribution to strike a balance between managing risks and maximising returns.

After coming up with future scenarios for the pension funds investment portfolio we dive into a thorough assessment of risks. This process involves using risk measures like Value at Risk (VaR) and Conditional Value at Risk (CVaR) to gauge how vulnerable the portfolio is to financial losses within a specified timeframe. VaR gives an estimate of the loss with a certain confidence level providing a snapshot of the worst case scenario under normal market conditions. On the other hand CVaR goes a step further by calculating expected losses that surpass the VaR threshold delving deeper into risks faced by the portfolio.

By employing this approach to evaluating risks we get a view of the portfolio's risk landscape. This assessment not looks at the chances of losses but also considers how severe those losses could be if they occur. Such meticulous risk analysis is crucial for understanding how extreme market downturns could impact the funds assets and ensures that our risk management strategies align well with our investment goals and risk tolerance.

Armed with insights into our portfolio's risk profile we use Monte Carlo simulation techniques to explore alternative asset allocation strategies and test their effectiveness.

During this phase of optimization we focus on adjusting the weights of assets within the simulation model to identify allocation patterns that can improve the portfolio's returns while effectively managing risks.

This ongoing process includes examining diversification strategies ranging from approaches that prioritise preserving capital to more aggressive strategies aiming for higher returns. Each potential allocation is carefully analysed in the simulation environment to understand how it affects the balance, between risk and return in the portfolio with an emphasis on finding setups that decrease volatility and lessen the chances of losses.

Through this optimization process our goal is to discover allocation strategies that not enhance the portfolio's performance potential but also strengthen its ability to withstand market fluctuations. The objective is to strike a balance by utilising diversification benefits. Spreading risk across asset classes and geographic regions. To protect the portfolio from market uncertainties and improve its overall stability and growth trajectory.

The valuable insights obtained from this risk assessment and optimization procedure provide pension fund managers with tactics to adjust their asset allocations guiding the fund toward a more resilient and well rounded portfolio structure that aligns with its long term investment objectives and risk tolerance.In the world of managing pension funds the systematic strategy highlights the importance of utilising analytics and simulation methods to make well informed decisions based on data.

The method goes beyond just testing variability, it involves an examination of how changes in financial assumptions affect the overall strength and performance expectations of the pension funds investments. By adjusting estimated returns and correlation coefficients for each asset class we simulate economic and market scenarios. This thorough testing approach helps us understand how sensitive the portfolio's projected results are to variations in these factors.

During this analysis we will focus on the volatility of asset returns and the interaction between asset classes during challenging situations. This not assesses how well the portfolio strategy holds up against changing market conditions but also pinpoints weaknesses that could impact the funds goals.

Results

The Monte Carlo simulation was carried out using a custom Python script that handled data processing, performance calculations and optimization. Initially historical returns data from an Excel file was preprocessed to ensure accuracy in the simulation. The key focus of the simulation was on optimizing the portfolio by maximizing the Sharpe Ratio. Through this process different weight combinations across assets were explored to determine the favorable Sharpe Ratio. This approach not only improved performance predictions but also provided a framework for assessing investment strategies in various market conditions. The application of Monte Carlo simulation to the Pension Fund's portfolio led to changes in asset allocation moving from domestic investments to a globally diversified and dynamic portfolio strategy. By leveraging data and optimization techniques including filling values and calculating log returns the simulation aimed at enhancing overall portfolio performance.

After running the simulation the portfolio weights have been optimised. The adjustments made to the asset weights led to the following changes: State Securities in Kazakhstan, which originally made up 44% of the portfolio were reduced to 10.49% indicating a shift towards a more diversified risk profile. On the other hand Foreign State Securities and International Financial Organizations saw increases in their weights to 18.60% and 16.75% respectively expanding exposure and leveraging global financial structures for varied growth opportunities. Changes in Quasi Governmental Bonds and reallocations of Corporate Bonds and Bank Deposits further demonstrated a strategy aimed at managing yield and liquidity.

Table 1. Comparison of the average portfolio weights with the optimised portfolio weights after Monte Carlo simulation

	Average weight	Average weight (optimized)	Change
State Securities (foreign)	10.55%	18.60%	-8.05%
International Financial Organisations	2.37%	16.75%	-14.38%
Quasi-governmental Bonds (foreign)	0.81%	14.29%	-13.48%
Quasi-Governmental Bonds (KZ)	6.83%	12.79%	-5.96%
Deposits (foreign)	1.24%	12.66%	-11.42%
State Securities (KZ)	43.95%	10.49%	33.46%
Corporate Bonds (KZ)	6.83%	6.21%	0.62%
Deposits_NB	1.19%	5.27%	-4.08%
Corporate Bonds (foreign)	0.81%	1.04%	-0.23%
Bonds of second-tier Banks (KZ)	9.02%	0.98%	8.04%
Deposits in second-tier banks (KZ)	4.38%	0.93%	3.45%
other immaterial	12.01%	0%	12.01%

Following the optimization process the portfolio's expected return rose to 5.39% with decreased volatility at around 0.87% resulting in a Sharpe Ratio of 6.21. These measures showcase an investment trajectory with potentially higher returns aligning with the Pension fund’s goal of sustaining strong growth without taking on excessive risk exposure. The significant enhancement in the risk return profile highlights the effectiveness of the simulation in improving portfolio performance. Through Monte Carlo optimization there was redistribution of fund allocations to reduce overexposure to assets while increasing diversification and potential upside effectively balancing growth pursuits with investment risk management.

Conclusion

The conducted research has thoroughly explored how effective Monte Carlo simulation is in optimizing asset allocation for the Unified Accumulative Pension Fund (UAPF). The results strongly support the hypothesis one, confirming that Monte Carlo simulations significantly improve the achievement of risk adjusted returns compared to traditional asset allocation methods.

The study's results highlight benefits of using Monte Carlo simulation in financial planning and management. Firstly this approach is crucial in providing reliable portfolio forecasts greatly enhancing the ability to foresee and prepare for future financial scenarios. This predictive capability lowers the chances of facing outcomes thus boosting the resilience of the investment strategy. Additionally the dynamic nature of Monte Carlo simulation greatly enhances risk management capabilities by allowing for real time identification and adjustments to market volatilities thereby strengthening the stability of the portfolio under conditions.

While the study has its strengths it also has some limitations remaining scope for further research. To improve the robustness of the results future studies could consider using a broader range of simulation techniques and exploring a diverse range of economic scenarios. Another notable limitation of the study is its reliance on historical data, which may not fully account for future market uncertainties or changes.

Despite these limitations the study offers evidence showcasing the benefits of using Monte Carlo simulations in portfolio management. These insights can be invaluable for Pension fund management and policymakers to make decisions that ultimately improve financial outcomes for pension holders.

This study not only addresses a gap in the current body of research but also establishes a foundation for future exploration into utilizing advanced computational methods in managing pension funds. By expanding beyond asset management practices the research opens doors to intricate data focused strategies that may enhance financial stability and prosperity for pension fund recipients in the long run.

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Appendix 1

The composition of the UAPF portfolio in billions tenge

Type of financial instrument in the portfolio	01/01/2014	01/01/2015	01/01/2016	01/01/2017	01/01/2018	01/01/2019	01/01/2020	01/01/2021	01/01/2022	01/01/2023	01/01/2024	2024/03
State Securities of the Republic of Kazakhstan	630.31	1,913.90	2,631.84	2,910.82	3,587.63	4,057.98	4,368.01	5,648.40	5,104.82	7,270.16	8289.48	8623.58
State Securities of foreign states	21.71	74.32	50.67	365.01	948.84	1,191.92	1,235.06	1,280.10	2,500.81	2,429.23	2789.47	2973.38
Bonds of international financial organizations	24.78	82.47	84.92	86.63	172.55	170.96	361.70	531.43	407.31	370.94	359.46	360.21
Corporate bonds of issuers of the Republic of Kazakhstan	299.12	1,219.45	2,212.56	84.03	58.30	42.06	28.49	29.80	18.19	16.25	14.01	13.42
Corporate bonds of foreign issuers	9.07	93.86	165.76	137.92	62.74	8.85	9.33	6.89	3.93	5.51	0	0
PPN (structural notes)	8.94	48.47	53.47	31.64	35.00	33.95	30.80	33.34	10.70	9.47	7.23	7.23
Shares and depositary receipts of issuers of the Republic of Kazakhstan	43.43	145.48	113.09	127.46	184.14	224.40	239.36	294.31	304.07	246.54	350.53	370
Shares and depositary receipts of foreign issuers	8.43	8.99	13.55	18.33	23.68	20.42	29.03	30.50	0.00	0.00	0	0
Precious metals (gold)	57.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
Deposits in second-tier banks of the Republic of Kazakhstan	139.98	710.20	363.93	399.91	325.82	277.65	254.91	251.71	251.71	200.39	197.21	198.03
REPO	11.37	53.39	51.32	0.00	11.02	0.00	0.00	26.25	215.74	0.00	26.71	0
Cash	22.22	150.77	76.32	151.84	20.88	126.69	510.67	12.02	3.11	22.69	48.34	41.95
Other assets (accounts receivable , overdue debts,	0.00	0.00	14.03	16.18	28.64	15.23	13.49	0.00	0.00	2.06	0	0

provisions)												
Bonds of quasi-governmental organizations of the Republic of Kazakhstan	0.00	0.00	0.00	900.17	791.68	1,299.90	1,604.96	1,821.67	1,670.05	1,666.98	1619.89	1812.62
Bonds of the second-tier banks of the Republic of Kazakhstan	0.00	0.00	0.00	1,450.20	1,246.49	1,264.78	1,183.29	1,158.49	1,046.62	945.94	848.05	795.58
Deposits шт foreign banks	0.00	0.00	0.00	0.00	277.41	343.16	328.42	282.90	0.00	0.00	0	0
Bonds of foreign issuers of the quasi-public sector	0.00	0.00	0.00	0.00	0.00	232.92	232.50	256.44	0.00	0.00	0	0
Deposits in National Bank of RK	0.00	0.00	0.00	0.00	0.00	154.07	138.00	332.19	127.00	80.34	876.66	604.41
Assets under external management	0.00	0.00	0.00	0.00	0.00	82.80	211.89	816.51	1,382.51	1,355.43	2378.99	2648.6
Swaps	0.00	0.00	0.00	0.00	0.00	0.00	18.40	0.00	0.00	0.00	0	0
Notes of National Bank of RK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	81.65	0.00	0.00	0	0
Total portfolio for the year	1,277.22	4,501.30	5,831.46	6,680.14	7,774.82	9,547.74	10,798.31	12,894.60	13,046.57	14,621.93	17806.03	18449.01
Portfolio profitability		6.31%	10.12%	8.76%	7.50%	7.00%	7.10%	7.70%	7.80%	10.60%	10.70%	10.40%

Appendix 2

The composition portfolio increase in assets of the UAPF in %

Type of financial instrument in the portfolio	**01/01/2014**	**01/01/2015**	**01/01/2016**	**01/01/2017**	**01/01/2018**	**01/01/2019**	**01/01/2020**	**01/01/2021**	**01/01/2022**	**01/01/2023**	**01/01/2024**	**2024/03**
State Securities of the Republic of Kazakhstan	-5.95%	3.44%	10.60%	23.25%	13.11%	8.11%	43.24%	-9.81%	35.40%	13.47%	4.03%	-5.95%
State Securities of foreign states	-1.75%	-2.48%	620.43%	159.95%	25.62%	22.62%	2.82%	70.29%	-8.14%	23.98%	955.18%	-1.75%
Bonds of international financial organizations	-1.14%	-1.95%	2.01%	99.18%	-0.92%	78.07%	35.16%	-10.21%	-7.50%	-1.32%	0.21%	-1.14%

Corporate bonds of issuers of the Republic of Kazakhstan	5.51%	1.68%	-32.55%	-30.62%	-27.86%	-28.92%	3.01%	-19.61%	-3.03%	-15.01%	-4.21%	5.51%
Corporate bonds of foreign issuers	0.71%	10.63%	-16.79%	-54.51%	-5.35%	3.37%	-26.60%	-42.97%	63.46%	0.00%	0.00%	0.71%
PPN (structural notes)	-5.34%	3.13%	-40.82%	10.62%	-3.01%	-6.47%	9.36%	-68.78%	-6.41%	-23.40%	-0.09%	-5.34%
Shares and depositary receipts of issuers of the Republic of Kazakhstan	2.09%	-2.92%	12.71%	44.48%	21.87%	7.69%	16.89%	60.06%	-17.79%	38.11%	5.55%	2.09%
Shares and depositary receipts of foreign issuers	-15.36%	-0.47%	35.20%	29.24%	-13.76%	32.56%	-1.57%	-100.00%	0.00%	0.00%	0.00%	-15.36%
Precious metals (gold)	-100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-100.00%
Deposits in second-tier banks of the Republic of Kazakhstan	-0.23%	-4.92%	9.89%	-18.53%	-14.78%	-8.03%	-2.00%	-0.76%	-20.99%	-2.33%	0.42%	-0.23%
REPO	2193.69%	1992.17%	-100.00%	0.00%	0.00%	0.00%	0.00%	501.15%	-31.43%	0.00%	-100.00%	2193.69%
Cash	443.89%	105.32%	98.95%	-86.25%	0.00%	0.00%	0.00%	0.00%	-98.56%	1076.97%	-13.22%	443.89%
Other assets (accounts receivable , overdue debts, provisions)	83.26%	-65.10%	15.37%	76.86%	0.00%	0.00%	0.00%	0.00%	0.00%	-100.00%	0.00%	83.26%
Bonds of quasi-governmental organizations of the Republic of Kazakhstan	0.00%	0.00%	74.77%	-12.05%	64.20%	23.55%	10.86%	-4.90%	3.04%	3.43%	11.90%	0.00%
Bonds of the second-tier banks of the Republic of Kazakhstan	0.00%	0.00%	-7.80%	-14.05%	1.47%	-5.54%	-2.76%	-10.59%	-9.70%	-10.20%	-6.19%	0.00%
Deposits шт foreign banks	0.00%	0.00%	0.00%	0.00%	23.70%	-22.07%	-36.54%	-38.60%	0.00%	-100.00%	0.00%	0.00%
Bonds of foreign issuers of the quasi-public sector	0.00%	0.00%	0.00%	0.00%	336.23%	0.59%	11.14%	-100.00%	0.00%	0.00%	0.00%	0.00%
Deposits in National Bank of RK	0.00%	0.00%	0.00%	0.00%	0.00%	-35.73%	-7.18%	-45.77%	-54.17%	477.54%	-31.06%	0.00%
Assets under external management	0.00%	0.00%	0.00%	0.00%	0.00%	157.80%	261.45%	69.12%	-6.05%	57.06%	11.33%	0.00%

Swaps	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Notes of National Bank of RK	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-81.73%	-100.00%	0.00%	0.00%	0.00%	0.00%

Appendix 3

Share in the portfolio of the UAPF in %

Type of financial instrument in the portfolio	01/01/2014	01/01/2015	01/01/2016	01/01/2017	01/01/2018	01/01/2019	01/01/2020	01/01/2021	01/01/2022	01/01/2023	01/01/2024	2024/03
State Securities of the Republic of Kazakhstan	49.35%	42.52%	45.13%	43.57%	46.14%	42.50%	40.45%	43.80%	39.13%	49.72%	46.55%	46.74%
State Securities of foreign states	1.70%	1.65%	0.87%	5.46%	12.20%	12.48%	11.44%	9.93%	19.17%	16.61%	15.67%	16.12%
Bonds of international financial organizations	1.94%	1.83%	1.46%	1.30%	2.22%	1.79%	3.35%	4.12%	3.12%	2.54%	2.02%	1.95%
Corporate bonds of issuers of the Republic of Kazakhstan	23.42%	27.09%	37.94%	1.26%	0.75%	0.44%	0.26%	0.23%	0.14%	0.11%	0.08%	0.07%
Corporate bonds of foreign issuers	0.71%	2.09%	2.84%	2.06%	0.81%	0.09%	0.09%	0.05%	0.03%	0.04%	0.00%	0.00%
PPN (structural notes)	0.70%	1.08%	0.92%	0.47%	0.45%	0.36%	0.29%	0.26%	0.08%	0.06%	0.04%	0.04%
Shares and depositary receipts of issuers of the Republic of Kazakhstan	3.40%	3.23%	1.94%	1.91%	2.37%	2.35%	2.22%	2.28%	2.33%	1.69%	1.97%	2.01%
Shares and depositary receipts of foreign issuers	0.66%	0.20%	0.23%	0.27%	0.30%	0.21%	0.27%	0.24%	0.00%	0.00%	0.00%	0.00%
Precious metals (gold)	4.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Deposits in second-tier banks of the Republic of Kazakhstan	10.96%	15.78%	6.24%	5.99%	4.19%	2.91%	2.36%	1.95%	1.93%	1.37%	1.11%	1.07%
REPO	0.89%	1.19%	0.88%	0.00%	0.14%	0.00%	0.00%	0.20%	1.65%	0.00%	0.15%	0.00%

Cash	1.74%	3.35%	1.31%	2.27%	0.27%	1.33%	4.73%	0.09%	0.02%	0.16%	0.27%	0.23%
Other assets (accounts receivable , overdue debts, provisions)	0.00%	0.00%	0.24%	0.24%	0.37%	0.16%	0.12%	0.00%	0.00%	0.01%	0.00%	0.00%
Bonds of quasi-governmental organizations of the Republic of Kazakhstan	0.00%	0.00%	0.00%	13.48%	10.18%	13.61%	14.86%	14.13%	12.80%	11.40%	9.10%	9.83%
Bonds of the second-tier banks of the Republic of Kazakhstan	0.00%	0.00%	0.00%	21.71%	16.03%	13.25%	10.96%	8.98%	8.02%	6.47%	4.76%	4.31%
Deposits шт foreign banks	0.00%	0.00%	0.00%	0.00%	3.57%	3.59%	3.04%	2.19%	0.00%	0.00%	0.00%	0.00%
Bonds of foreign issuers of the quasi-public sector	0.00%	0.00%	0.00%	0.00%	0.00%	2.44%	2.15%	1.99%	0.00%	0.00%	0.00%	0.00%
Deposits in National Bank of RK	0.00%	0.00%	0.00%	0.00%	0.00%	1.61%	1.28%	2.58%	0.97%	0.55%	4.92%	3.28%
Assets under external management	0.00%	0.00%	0.00%	0.00%	0.00%	0.87%	1.96%	6.33%	10.60%	9.27%	13.36%	14.36%
Swaps	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%
Notes of National Bank of RK	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.63%	0.00%	0.00%	0.00%	0.00%