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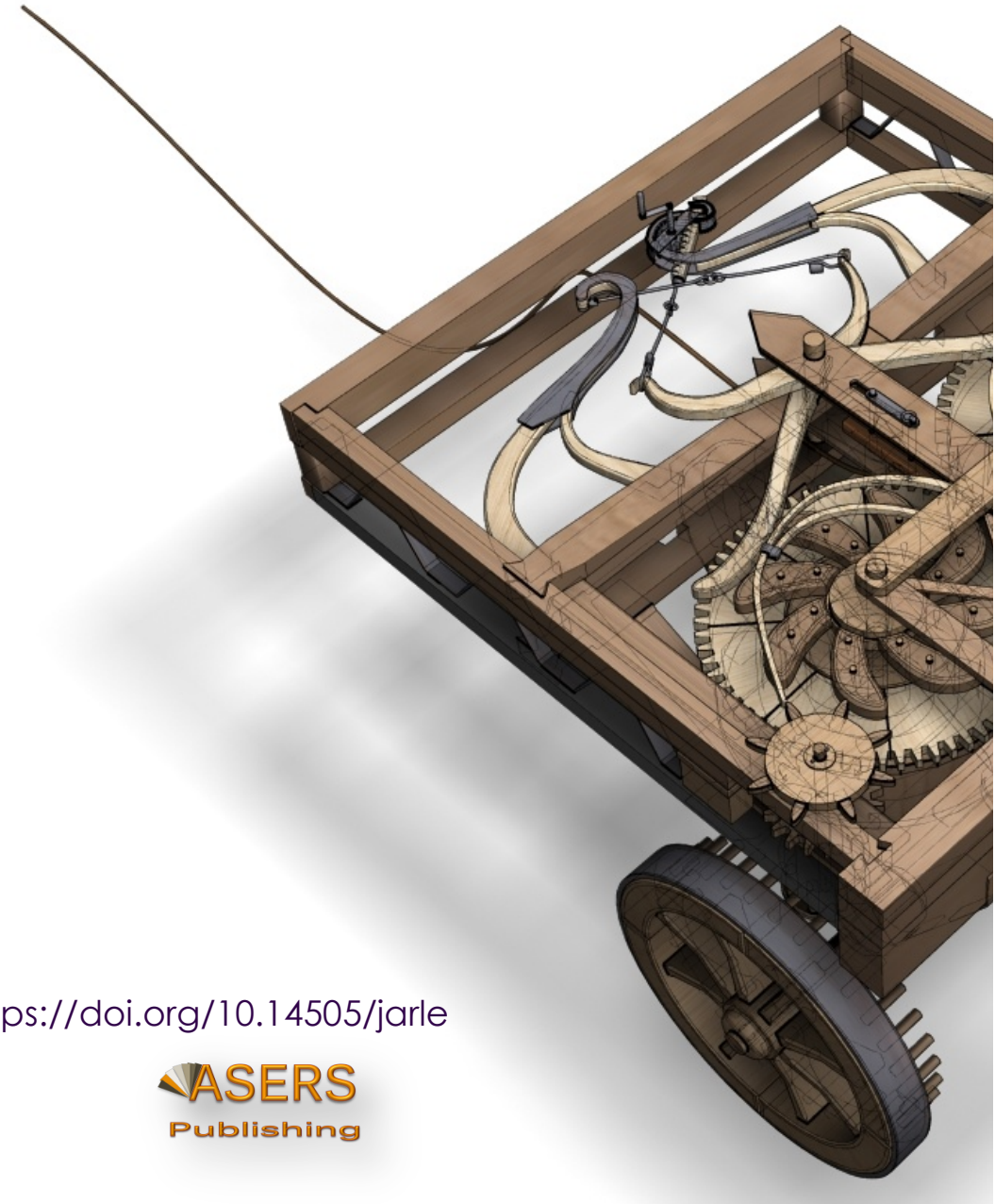

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Journal of Advanced Research in Law and Economics

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Evaluation of Management of the UAPF Pension Assets Based on the Method of Multidimensional Clustering

Aigul Abitzhanovna ZHANTAYEVA
Turar Ryskulov New Economic University, **Kazakhstan**
aigul_0905@mail.ru

Aizhan Sarsenovna ASSILOVA
Al-Farabi Kazakh National University, **Kazakhstan**
aijan@mail.ru

Aigul Malibekovna ATCHABAROVA
Turar Ryskulov New Economic University, **Kazakhstan**
a.atchabarova@mail.ru

Diana Baltabaevna MURATOVA
M.H. Dulati Taraz National University, **Kazakhstan**
Muratova_diana77@mail.ru

Gulmira AMALBEKOVA
M.H. Dulati Taraz National University, **Kazakhstan**
Guleke27@mail.ru

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Abstract:

Against the background of the financial crisis, all the shortcomings in the management of pension assets have become apparent, and not only in Kazakhstan. The authors have calculated the possible options of forming the funding structure of pension assets, which would satisfy the different age generations of investors in Kazakhstan. For the calculation, the methods of the multivariate statistical analysis and the quasi-Sharpe optimization model were used. Based on these results, the authors have proved the need of introducing additional components, which would insure the collateral risks of adequate pension payments.

Keywords: pension assets, multidimensional clustering, securities.

JEL Classification: H75, J35, H55.

Introduction

Kazakh society has set the goal to strengthen the well-being of the country to join the top 30 most developed nations of the world, as a long-term priority, defined by the Strategy (2014) 'Kazakhstan's way - 2050: Common aim, common interests, common future': 'The social conditions of ordinary people should be the most important indicator of our progress towards the major goal'. To achieve this, there is still a long way to go before Kazakhstan will be equal in terms of the quality of life with the most developed countries of the world. Provision of decent pensions for those who is retiring in the middle of this century, is a matter of today, the solution of which depends on the quality of the current pension system in the country as a whole and is determined by how successful it is.

Experience of the accumulative pension system, which has been functioning in the country for almost two decades, has been the subject of a serious analysis from three perspectives:

(1) Have the pension reforms ensured the social objectives – security and a decent level of income of senior citizens?
(2) Have the so-called 'second-order' goals (an increase in national savings, the development of capital markets and the enhancement of flexibility of the labor market) been achieved? (Degtyar 2012).
(3) To what extent will the expected reforms in the pension system (introduction of joint and several liability of employers) affect the management of pension assets?

In Kazakhstan, despite the positive results of the market reforms and positive developments in macroeconomic dynamics, the state of the country's pension system still does not meet modern requirements.

In this regard, one of the main challenges currently facing the management company is the sustainable management of pension fund assets for effective long-term investment, protecting the accumulated funds from inflationary devaluation and ensuring their real growth to the extent possible.

The advanced growth of inflation over profitability, the volatility of individual markets, wherein the pension savings are invested, the underdeveloped corporate securities market and stock market, the lack of market mechanism for the overflow of money from the pension market to the real economy sector not only intensify the problems of this market, but also slow down the development of the national economy as a whole.

The need to increase the efficiency of pension assets management is not only a factor of the growth of people's savings, but also a trigger for the economic growth. All of the above identified the relevance of the research topic.

The purpose of this research is to improve the management of pension assets in order to ensure the qualitative growth of the pension system resources for the diversification of investment of the national economy.

The research objectives are as follows:

- to evaluate the management of pension assets of the Unified Accumulative Pension Fund (UAPF) based on the classification by several parameters and the method of multidimensional clustering;
- to construct the optimal portfolios of investments under the versatile structure of financial instruments and the volatile stock market based on the quasi-Sharpe model;
- to make recommendations towards the development of the effective management of pension assets within the UAPF.

The modern theory for selecting the optimal set of securities for the compilation of an investment portfolio and evaluation of financial assets of the pension fund in the capital market was formed in the works of foreign scientists-economists: H. Markowitz (1959), J. Tobin (1958), William F. Sharpe (1964), John Lintner (1965) and J. Mossin (1965).

Currently, the Markowitz model is mainly used in the first stage of formation of a portfolio of assets in the allocation of investment capital by various types of assets: shares, bonds, real estate, etc.

The impact of the Markowitz portfolio theory was significantly enhanced by the emergence of the works by J. Tobin in the late 1950s and early 1960s, who reviewed the adequacy of the quantitative characteristics of assets and portfolios that constitute the raw data in the Markowitz theory.

In the classical financial theory, the relationship between risk and yield is described by a linear function, which is most clearly demonstrated by the capital asset pricing model (CAPM). The model was proposed by the economists Sharpe and Lintner.

On the basis of one-factor model, William F. Sharpe (1964) proposed a simplified method for selecting the optimal portfolio. This simplification has made the methods of portfolio optimization applicable in practice and the improvement of the statistical evaluation technique of parameters 'alpha' and 'beta' of individual securities and

index of the overall market yields led to the emergence of the first software packages for solving the securities portfolio management tasks. The development of this model was the first successful attempt to demonstrate how it is possible to take into account the risk of the cash flows from the potential investment project and to assess the cost of capital and the expected rate of return required by investors in the event of a decision to invest the project.

In recent decades, in most developed world economies, there is a complication of mechanisms of financial resources redistribution. Consequently, there is a sharp increase in the activity of portfolio investment in the financial markets. The stock market experiences ups and downs under the influence of all sorts of political and economic, internal and external factors. The situation in the stock markets is unstable and very risky for a large number of investors.

The applicability of the existing theories of portfolio investment in the current markets, strengths and weaknesses of the existing strategies of management of the securities portfolio are reflected in the works of Russian researchers: Anshin, V.M. (2000), Aliyev, A.T. and Somik, K.V. (2013), Blank, I.A. (2003), Nedosekin, A.O. (2003), Lukasevich, I.Ya. (2013), Shapkin, A.S. and Shapkin, V.A. (2013).

A comprehensive analysis of financial and real investments, the relationship of yield and risk of financial investments of various kinds and optimization methods of the portfolio are reflected in the works of V.M. Anshin (2000).

The essence, objectives and functions of management of the financial resources of the subject, the methodological basis for the formation of systems for its assurance and resources risk balancing are considered in the works of I.A. Blank (2003).

The main concept of the investment portfolio, the process of management, including the formation and diversification of the portfolio of the models of Markowitz and Sharpe, portfolio management strategies and the evaluation of its efficiency are considered in the works of A.T. Aliyev and K.V. Somik (2013).

A.O. Nedosekin (2003) examines the theoretical background of optimal investment at the level of the model and real stock portfolios, the author's methods of securities rating and bonds scoring and provides the calculated data and examples of optimal investment.

Theoretical concepts of the used methods and models, as well as various aspects of their practical application in the process of managerial decision-making on capital investments in different types of assets are given in the works of I.Ya. Lukasevich (2013).

The essence of economic risk, the factors affecting the level of risk and methods for the quantitative evaluation of economic risk are considered by A.S. Shapkin and V.A. Shapkin (2013).

The problem of management of pension assets in the Republic of Kazakhstan has been sufficiently analyzed by Kazakh scholars-economists: A.B. Alibayev (2010), A.A. Adambekova (2005), B.L. Bekberdiyev (2001), V.Yu. Dodonov (2011). A.B. Alibayev considers the problems of using the assets of accumulative pension funds in infrastructure projects for the development of the national economy. The work of A.A. Adambekova (2005) highlights the Kazakhstan's model of the pension market and its role in the development of the national economy. Analysis of the processes of portfolio investment of pension accumulative funds and prospects of using the APF assets in the financing of the economy of Kazakhstan is held by B.L. Bekberdiyev (2001). Theoretical and methodological approaches to the organization of portfolio management and problems of increasing the efficiency of management of the portfolio of shares in the emerging stock markets are studied by V.Yu. Dodonov (2011).

Despite a certain number of works relating to the matters of management of financial assets, the issues of evaluating the efficiency of investment assets management and formation of the investment strategy for the effective management of assets of accumulative pension funds have been insufficiently developed in the economic literature.

1. Methodology

To make the calculation, we used the structure of the investment portfolio presented on the UAPF official website as the basic data. It was grouped *by issuers,* and the data within the group were presented *by types of securities* and *identifiers, rating, the nominal and current value* and *the share* in the total volume. The amount of data is 714 entries. However, in this representation of information there is quite a large number of classification objects which coincide by the issuer, type of securities, rating, maturity, and only the identifiers are different. Directly, the data in such a form are not applicable for solving the set task because, as a result of classification, those clusters, which cannot uniquely define different model portfolios, are obtained.

Data rearrangement was made with the use of Excel tools (Data ⇨ Group). Types of securities with an indication of the issuer were identified as the objects of classification. One group included similar objects having the same values of rating and maturity. By the group, the average yield was calculated (formula (7)) on the basis of the price lists of the official website of the stock exchange, as well as the group's share in the total current value of assets. The identifiers of financial instruments were associated with a corresponding group at the next lower level in the hierarchy.

Thus, as far as the objects of classification included not a separate security but a group of securities of one type and maturity, but with different identifiers, their number was reduced to 103. The indices of rating, maturity, share in the total current value of the portfolio and the average yield for the group were determined as classification features. Since the rating of the securities included in the UAPF investment portfolio is given in the assessment of different agencies (Moody's, Standard & Poor's and Fitch), they were ranked for the comparability of estimates (see Table 1).

Table 1. Interrelation of rating and the assigned ranks

Moody's	Standard & Poor's	Rank	Rating characteristics
Aaa	AAA	9	The highest quality. Ratings of this level are assigned only in case of the exceptionally strong capacity for payment of financial obligations
Aa1 Aa2 Aa3	AA+ AA AA-	8	Very low expectations of the default risk. A very high capacity for payment of financial obligations. Exposure to adverse conditions is small.
A1 A2 A3	A+ A A-	7	Low expectations of the default risk. The ability to repay financial obligations is high. However, this ability is more affected by the adverse economic conditions than in the case of higher ratings
Baa1 Baa2 Baa3	BBB+ BBB BBB-	6	Low expectations of the default risk at this stage. The ability to repay financial obligations is considered adequate; however, there is a high probability of the effect of adverse economic conditions.
Ba1 Ba2 Ba3	BB+ BB BB-	5	Vulnerability to the default risk, particularly in the event of adverse changes in economic conditions over time. However, business flexibility or financial flexibility supports the ability to service financial obligations
B1 B2 B3	B+ B B-	4	Significant risks of the default. However, there is still a limited margin of safety. At this stage, financial obligations are met, but the ability to continue payment is vulnerable in the event of deterioration in economic conditions.
Caa	CCC+ CCC CCC-	3	Low quality, a high level of speculativity, a high risk of non-fulfillment of obligations by the issuer.
Ca C	CC C	2	The lowest quality of the Central Bank (CB). Very high levels of credit risk. The default in one form or another seems likely
	D	1	The default status. The liquidation process or other formal winding-up procedure has been started

Source: Ranking was conducted by the author based on the rating characteristics.

As shown in Table 1, the same rank was assigned to the rating categories of different agencies that have the same characteristics based on the research (Khorev, Sovik and Leontieva 2014). Each category typically includes three levels of ratings. For public securities, the rank 10 was taken, and for the securities of issuers that have no rating, the rank was 0.

The index of 'maturity' was ranked as follows:

- short-term - 1;
- medium-term - 2;
- long-term - 3.

Thus, the information base was prepared for multidimensional clustering with the purpose to divide the structure of the UAPF investment portfolio into several types of model portfolios. This was made with the use of the software package Statistica 6.0.

Before applying the method of multidimensional classification – the cluster analysis, the interrelation of initial classification features was assessed using the correlation analysis. The Excel-2007 functions and add-ins were used as calculation tools (Data ⇨ Data Analysis ⇨ Correlation).

The correlation matrix is presented in Table 2.

Table 2. Correlation matrix of classification features

	Rating	Maturity	Proportion	Yield
Rating	1			
Maturity	-0.17677	1		
Share	0.317991	0.0296276	1	
Yield	-0.56964	0.057839	-0.315029704	1

Source: Calculated by the authors.

As shown in Table 2, multicollinearity between factors (features of classification) is not observed, which makes it possible for the subsequent application of the method of the cluster analysis with the Euclidean metric (Dubrov, Mkhitaryan and Troshin 2003).

Then, to split the structure of the UAPF investment portfolio into model portfolios of different types, the hierarchical agglomerative methods and the method of 'k-means' in the Statistica 6.0 package were used (Vulkov 2008).

The essence of hierarchical agglomerative clustering consists in the successive merging of smaller clusters into larger, *i.e.* initially, each object (issuer / Central Bank group) is a cluster. In the next steps, the most similar objects are combined, forming a new cluster. There is a number of clustering rules. The Ward method was chosen for the construction of clusters in this work. The advantage of this method is that at every step, there is a combination of those clusters, which lead to a minimum increase in the objective function (within – a group sum of squares), i.e. those clusters are merged that have the lowest variation in their properties.

To determine the overall risk by the quasi-Sharpe model and the residual risk, the Excel-2007 add-ins were used (Data ⇨ Data Analysis and Data ⇨ Solver).

2. Results and Discussion

The result of classification in the context of the hierarchical method is represented graphically in the form of a special figure - dendrogram. Dendrogram is a tree diagram that represents the embedded grouping of objects which varies at different levels of the hierarchy.

Figure 1 shows the dendrogram of objects clustering by four features.

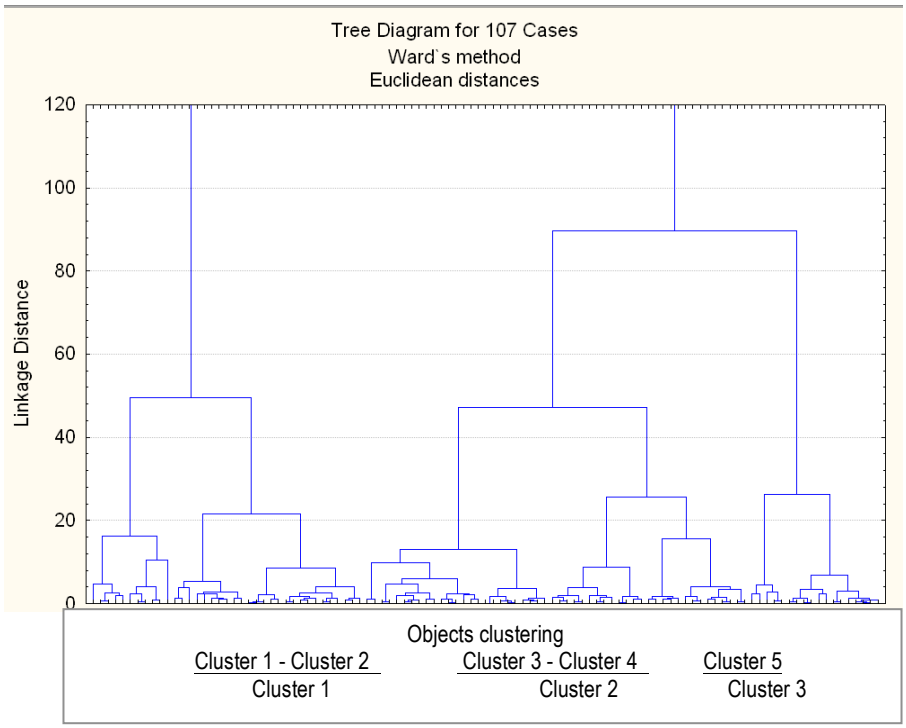

Figure 1. Dendrogram of clustering by four features.

Source: Constructed by the author in the Statistica 6.0 package.

As shown by the dendrogram, five clusters can be identified at the Euclidean distance of up to 30 in the investment portfolio structure.

At the next level of the hierarchy, the first and second clusters are merged at the Euclidean distance of 50 units, the third and fourth clusters - 48 units and the fifth cluster group - 90 units. If at this hierarchy level, we consider the first and second clusters as one cluster, the third and fourth - as another one, and the fifth – as the third cluster, it is possible to form three model portfolios. The next step in the research is to validate the importance of separation and analysis of the structure of each of these clusters. But in the event of a large number of statistical population that takes place in this case, the determination of the clusters composition and the evaluation of the structure classification with the hierarchical agglomerative method are quite time-consuming processes.

Unlike the hierarchical procedures, the method of k-means does not require the calculating or storing of a matrix of distances or similarities between objects, may be used at a large amount of classification objects, includes the procedures of the analysis of variance to assess the significance of clustering, however, requires a preset number of clusters. Therefore, in the clustering of large volumes of objects, we consider it necessary to combine these two methods – a preliminary assessment of possible options for the number of clusters in the dendrogram and the analysis by the method of k-means.

As a result of the classification by the k-means method, with k=3, the following plot of means for each corresponding cluster was received (Figure 2).

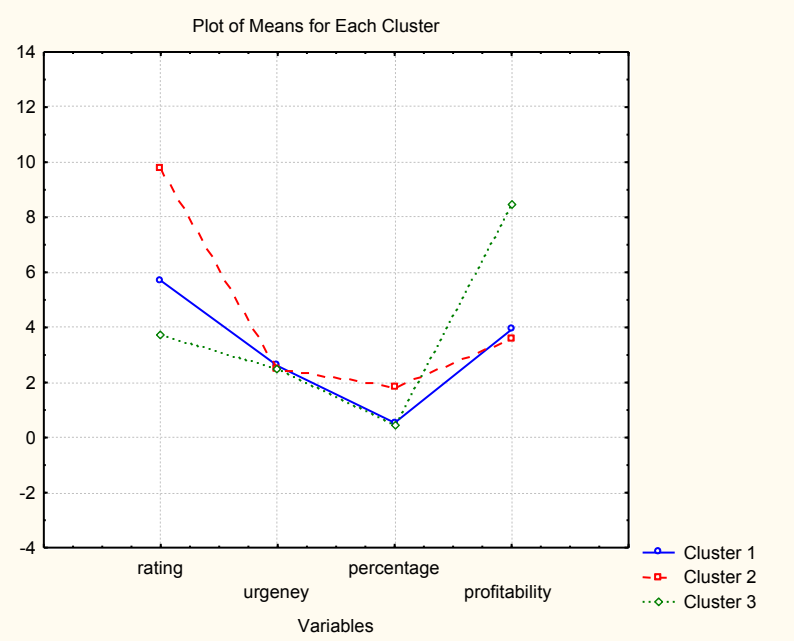

Figure 2. Plot of means at the merging of CB into three clusters by four features

Source: Constructed by the author in the Statistica 6.0 package.

As follows from the plot, all three clusters have the same means in terms of 'maturity' and very close values in terms of 'share'. The results of the analysis of variance are presented in Table 3.

Table 3. Results of the analysis of variance

	Between	df	Within	df	F	signif.
Rating	758.04	2	266.39	104	147.97	0.00
Maturity	2.18	2	50.46	104	2.25	0.11
Share	22.12	2	246.66	104	4.66	0.01
Yield	478.11	2	395.75	104	62.82	0.00

Source: Calculated by the author in the Statistica 6.0 package.

As shown in Table 3, in terms of 'maturity' and 'share' the sum of squared differences (Between) between the clusters is less than the sum of squared differences within the cluster (Within), and for the 'maturity' index the table Fisher's value F=2.25 is less than F_{cr}=3.94. On the basis of the latter, the hypothesis of the equality of means is accepted, which means that in terms of this index, splitting is insignificant. The Fisher's criterion in terms of 'share' shows the difference in clusters by means, but the excess of the sum of squared differences between clusters over the intra-group sum of squares and the proximity of means on the basis of this index allow to conclude that this factor is also not very significant. Similarly, the study of splitting into five clusters according to the same features of classification was conducted, which confirmed the insignificance of the 'maturity' index for clusters differentiation, and the weak influence of the 'share' index. Consequently, the indices of 'maturity' and 'share' should be excluded from the classification into clusters. Thus, of the considered indices of the overall investment portfolio structure for the allocation of model portfolios on the basis of a multi-dimensional classification the following two features can be used: rating and yield. Figure 3 shows the dendrogram of clustering on the basis of two features.

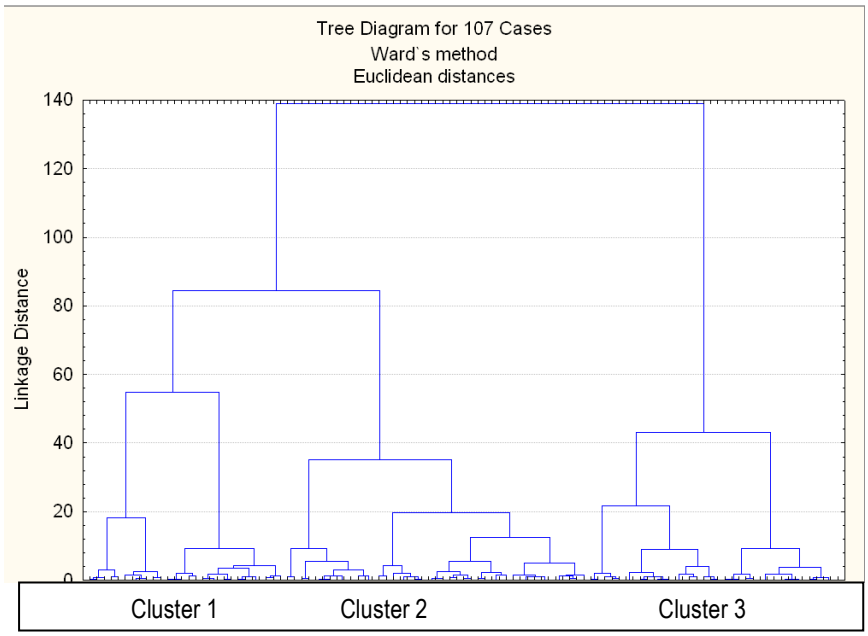

Figure 3. Dendrogram of clustering on the basis of two features

Source: Constructed by the author in the Statistica 6.0 package.

As shown by the dendrogram in Figure 3, three clusters are clearly distinguished in the classification according to two features. Let us test the hypothesis about the allocation of three model portfolios in the structure of UAPF securities by the k-means method.

The plot of clusters and their means, built in the Statistica 6.0 package, is shown in Figure 4.

Figure 4. Plot of means in the separation into three clusters according to two features (рейтинг – rating доходность - yield)

Source: Constructed by the author in the Statistica 6.0 package.

As seen in Figure 4, the clusters are far apart according to the means of features. Moreover, the first cluster has the lowest rating in comparison with the other two, but the highest rate of yield. The third cluster has the highest rating, but a low yield. The significance of these estimates can be determined from the analysis of variance shown in Table 4.

Table 4. Results of the analysis of variance in clustering according to two features

	Between	df	Within	Df	F	signif.
Rating	729.35	2	304.84	104	124.41	0.00
Yield	536.27	2	355.97	104	78.34	0.00

Source: Constructed by the author in the Statistica 6.0 package.

Table 4 shows that the calculated values of the Fisher's criterion for both features are far more than the critical value, which is equal to 3.94, thus, the difference in clusters according to the average values is significant.

Thus, in the structure of the UAPF investment portfolio, based on this classification, three clusters can be distinguished, different in rating and yield of the securities included in their composition.

In the first cluster, 58.06% were the securities with an average rating; 9.68% - with a low rating and highly speculative, and 32.26% - with no rating, *i.e.* the increased risk. By types of securities, the bonds of banks and a small number of large corporations of Kazakhstan were dominant. The number of common and preferred shares was 16%. There were also depository receipts and investments in banks.

The distribution of Central Bank securities in terms of 'maturity' in this cluster is shown in the following diagram (Figure 5).

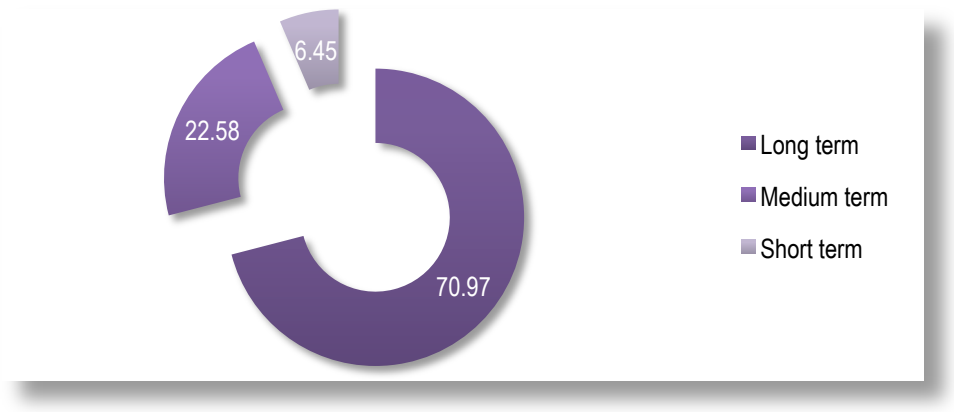

Figure 5. Distribution of CB securities in terms of 'maturity' in the first cluster

Source: Calculated and constructed by the author.

The yield of securities in the first cluster was slightly higher than in others - 8.3% on average with a standard deviation of 1.6%.

The second cluster included the shares and bonds of banks and large Kazakh corporations, the deposits of some banks, as well as a small amount of government securities (MEKAM and foreign issuers). In terms of maturity, the long-term securities are predominant in the cluster - 65.79%; the medium-term securities take 15.79%; and the short-term - 18.42%. The average yield in the cluster was 5.5% with a standard deviation of 1.9%.

The securities are mainly of the average quality and have an officially assigned rating. The distribution of rating of the securities within the cluster into categories according to the classification used by the Moody's agency is presented in Figure 6.

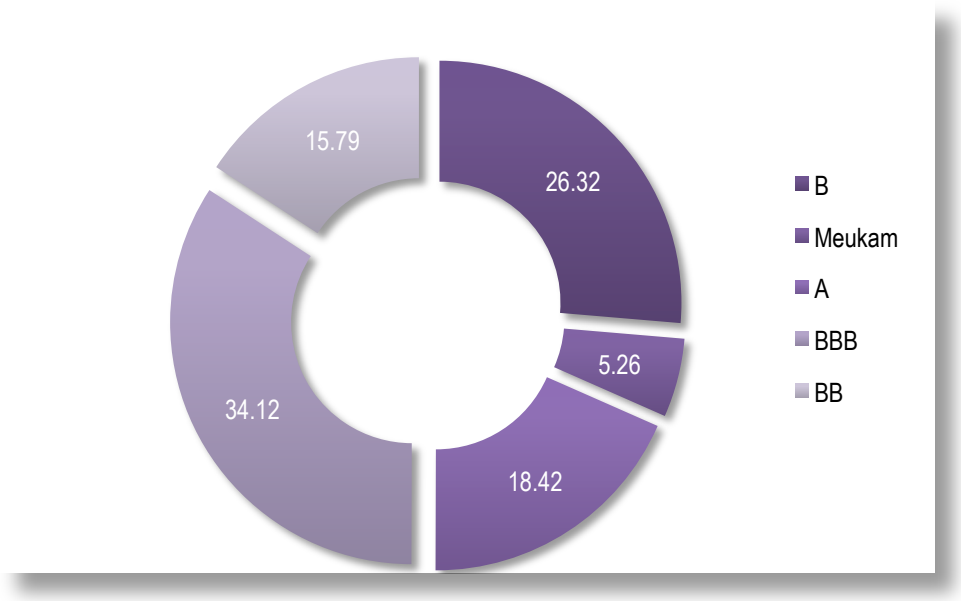

Figure 6. The rating of CB securities included in the second cluster

Source: Calculated and constructed by the author.

The third cluster is 74% composed of government securities with low yields. 3% of the remaining are precious metals, 18% - foreign securities and 5% - 'Samruk-Kazyna' and Kazakhstan Mortgage Company (Management Company Baiterek) having a high rating.

The average yield of the securities included in this cluster, calculated in the Statisica 6.0 package, is equal to 3.1%, with a standard deviation of 1.6%.

The rating, by definition, is inversely proportional to the risk, i.e. it can be concluded that the Central Bank securities, included in the third cluster, have the lowest risk than the securities of issuers of the first and second clusters. Moreover, the yield, on average, is higher in the first cluster. According to the conducted clustering, the UAPF assets can be grouped into three types of the model portfolio:

- moderately aggressive, based on the first cluster, containing the securities from those with the average rating to the unrated and with an average yield of 8.3%;
- moderately conservative, based on the second cluster, consisting of the securities, mainly of the average quality, having the rating assigned by international agencies and the average yield of the portfolio of 5.5%;
- conservative portfolio, in accordance with the third cluster, containing government and highly rated securities and having the average yield of 3.1%.

The conducted splitting of assets that make up the structure of the UAPF investment portfolio in general, into three types of model portfolios is average, but it allows to highlight the investment focus of model portfolios.

However, in the practice of foreign pension funds there are usually five model portfolios (Khachumov 2012). The conducted clustering of the existing UAPF structure into five portfolios showed that, despite the importance of the received splitting by the Fisher's criterion, clusters are fairly similar to each other in some of their features and reflect the same investment profile, which is proved by Figure 7: clusters 1, 2 and 3 are similar in their rating and clusters 4 and 5 – in the yield.

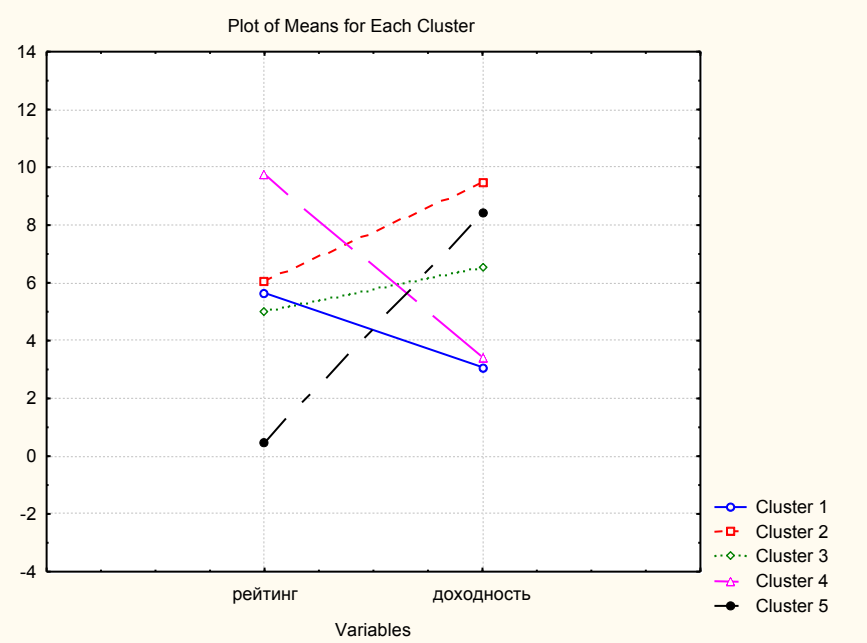

Figure 7. Plot of means in the separation into five clusters according to two features (рейтинг – rating; доходность - yield)

Source: Calculated and constructed by the authors.

This is explained by the fact that at present, the UAPF structure includes a lot of similar assets, perhaps because of the existing legal and regulatory restrictions on the investment of pension contributions.

Currently, the UAPF assets have such a composition that only three types of model portfolios can be created, significantly separated in the yield rate and the risk level. Given the fact that there is an inversely proportional relationship between the risk and the rating, the formula (1) for the calculation of the risk probability may help to assess the risk of the group.

$$T_i = 1 - rank_i / 100 \quad (1)$$

where T_i – risk probability of the i – group of CB;

$rank_i$ – rating rank of the i - group of CB.

One cannot say that the model portfolios formed on the basis of the published UAPF investment structure fully meet the interests of all the depositors of the pension fund. Different investors have different opinions on the optimal combination of the risk and yield. The behavior of any investor largely depends on his or her age. Most young investors (aged 20-30) prefer growth-oriented investments. These investors tend to use speculative stocks and shares of fast-growing mutual fund companies and convertible securities. Middle-aged investors (30-40 years old) are already moving to the investment strategy, which has less a speculative character, although they are still focused on the growth rate securities. The investors aged 40-50 years use the tools focused on the quality of growth, and pay more attention to current income as an important source of revenue. When the investor reaches the pre-retirement age, his or her investment portfolio becomes very conservative.

Among the model portfolios formed by the multivariate analysis method there is no aggressive portfolio as far as the majority of all the portfolios consist of bonds, and there are practically no speculative growing shares. Consequently, the UAPF investors of up to 35 years old currently may be offered with the moderately aggressive portfolio with an average yield of up to 8.3%. This is slightly higher than the expected rate of inflation (5.5-6%). The probability of the risk for this portfolio is quite high – in the range of [0.5-1].

The moderately conservative investor (over 35 – up to 50) may be recommended to use the model portfolio of the second type, with the yield of 5.5 and the risk probability of [0.3-0.5]. The yield is slight higher than the rate of inflation in 2014 (5%) and less than in 2015.

The conservative portfolio is the most reliable and can be recommended to citizens of the pre-retirement age (over 50). However, its yield does not cover inflation; in addition, it contains most of the long-term securities, which obviously does not meet the needs of senior citizens.

It should be emphasized that the main difference between the proposed solution and simple sorting and dividing is that in the use of a multi-dimensional classification each portfolio is specified with the composition of

certain securities, available today in the UAPF structure, and clustering takes into account two main indicators: yield and risk. Analysis of the portfolios by the composition of the included assets revealed the underlying problem of the UAPF: the monotony of type and quality of securities. In addition, the average yield of the portfolio is low, only in the model type it covers the expected inflation. The UAPF structure has a high percentage of bonds, including governmental (81% throughout the base in general). Basically, the long-term securities predominate. Their average share in the portfolio is up to 60%, which is extremely unattractive for the investors of the pre-retirement age.

Therefore, it is advisable to change the structure of assets and to clarify the portfolio boundaries based on the interests of different age groups of investors.

Models of the portfolio selection on the ground of the average yield and risk are based on the classical model of the American scientist Markowitz (1952).

The key provision of the Markowitz theory is the investor's ability to form such a portfolio in which a combination of the expected yield and the risk level would ensure maximum satisfaction of needs and minimize the risk at the desired yield. An addition to the Markowitz portfolio theory is the capital asset pricing model (CAPM), designed by Jack Treynor, William F. Sharpe, John Lintner and Jan Mossin in the 60s independently of each other (Sharpe, Alexander and Bailey 1999).

The CAPM, known in the literature also as the Sharpe's model, is used to select assets from the entire set, and then with the use of the Markowitz model an optimal portfolio is being formed. However, the models of Markowitz and Sharpe were developed during periods of stable growth of the national economy. They work well in foreign markets, which are characterized by a monotonous dynamics of development, but for the emerging markets these models are directly inapplicable.

For the stock market of Kazakhstan, in particular, they can lead to modeling errors and unexpected losses on the portfolio. It is explained, first of all, by the dynamics and characteristics of these markets that are characterized by the instability and impulsiveness of the yield, a strong influence of inside information, the imperfection of the legal framework, the dominant influence of primary industries on the overall dynamics of development.

For unstable stock markets, the model was modified and named as the 'Quasi - Sharpe' model (Jackson and Staunton 2001). The basis of this model is in the relationship of a single security not with the stock index, as in the Sharpe's model, but with the yield of the entire single portfolio consisting of these assets.

Key assumptions of the quasi-Sharpe model are as follows:

(1) The yield of a security is calculated as the expectation of yields (this assumption is also common for the Sharpe's model).
(2) The benchmark single portfolio is a portfolio consisting of all the considered securities in the same proportion. In the Sharpe's model, the benchmark portfolio is the market portfolio, which can be described by the stock index. For the Kazakh market, it is the KASE index, for the Russian stock market – the RTS index (RTSI), for the US stock market - S & P500.
(3) The yield of a security is directly proportional to the yield of a single portfolio. The same assumption exists in the Sharpe model for the market portfolio.
(4) The risk of a security is calculated as the level of change in the yield of a security depending on changes in the yield of a single portfolio. The calculation for the Sharpe's model is similar, only it depends on the market portfolio.
(5) The average yield of a single portfolio rather than of government bonds is taken as the risk-free rate, in contrast to the Sharpe's model.

The interrelation of the security yield, the yield of the single portfolio and the risk of the security in the 'Quasi - Sharpe' model is described by a linear regression function. The formula of the security yield is as follows:

$$R_i = \overline{R}_i + \beta_i (R_{sp} - \overline{R}_{sp}) \quad (2)$$

where: R_i – yield of the *i* security;

$\overline{R_i}$ – average yield of the *i* security;

β_i – regression coefficient in the yield equation;

R_{sp} – yield of the single portfolio;

$\overline{R_{sp}}$ – average yield of the single portfolio.

The regression coefficient β_i shows the modification in the yield level of the security when there is a change in the yield of the single portfolio into a unit of its measurement. The higher the value of the beta coefficient, the greater the yield of the security changes at the fluctuation of the yield of the single portfolio. This coefficient, as in the Sharpe's model, is called the risk. But the overall risk in the quasi-Sharpe model consists of β risk of the yield reduction, when there is a drop in the yield of the single portfolio and the residual risk (σ_{ri}), calculated as the standard deviation of the security yield from the regression line. The residual risk is also defined as the risk falling below the regression line.

Taking into account the determination of the yield of the *i* security by the formula (2) and the overall risk, the yield of the investment portfolio in the quasi-Sharpe model and the risk is calculated according to the following formulas:

$$\mathrm{R_p} = \sum_{i=1}^{N} (\overline{R}_i * W_i) + (R_{sp} - \overline{R}_{sp}) * \sum_{i=1}^{N} (\beta_i * W_i) \tag{3}$$

where: R_p - yield of the investment portfolio

W_i - proportion (share of the *i* security in the portfolio) $W_i \geq 0$;

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

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

where: σ_p - risk of the investment portfolio

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

σ_{ri} - residual risk (standard deviation of the *i* security from the regression line).

Taking the portfolio yield (4) as the objective function and fixing it to the maximum, by introducing the restrictions on the risk - σ_{reg}, one can summarize the search for the optimal portfolio based on the quasi-Sharpe model as follows:

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

$$\sqrt{\sum_{i=1}^{N} (\beta_i * W_i)^2 * \sigma_{sp}^2 + \sum_{i=1}^{N} (\sigma_{ri}^2 * W_i^2)} \leq \sigma_{reg} \tag{5}$$

$$W_i \geq 0$$

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

Then, the reverse problem of forming the optimal portfolio will consist in the task to minimize the overall risk of the portfolio at a fixed level of yield (R_{reg}):

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

$$\sum_{i=1}^{N} (\overline{R}_i * W_i) + (R_{sp} - \overline{R}_{sp}) * \sum_{i=1}^{N} (\beta_i * W_i) \geq R_{reg} \tag{6}$$

$$W_i \geq 0$$

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

Consider the application of the quasi-Sharpe model for the formation of the optimal aggressive portfolio of shares included in the list of the most liquid shares for the year, posted on the official website of the Kazakhstan Stock Exchange (kase.kz),

- KazTransOil (KZTO);
- Kazakhtelecom (KZTR);
- KazKommertsBank (KKGB);
- KAZAKHMYS PLC (GB_KZMS);
- Halyk Savings Bank of Kazakhstan (HSBK);
- 'Kcell' JSC (KCEL).

These shares are also included in the UAPF structure as of January 1, 2015.

The Excel-2007 functions and add-ins were used as calculation tools (Statistical Bulletin 2015). First, calculate the monthly yield of the Central Bank on the basis of data, using the following formula:

$$\mathrm{R_i} = \frac{P_i - P_{i-1}}{P_{i-1}} \quad (7)$$

For each type of shares, calculate the average value of the yield for the whole selected period using the function of the average value.

Based on the definition of a single portfolio as a unity, composed of the shares taken in equal proportions, the formula of the yield of the single portfolio for the *t* period will be equal to the average yield of the *i* securities included in the portfolio (8):

$$R_{sp}^{t} = \frac{\sum_{i=1}^{N} R_i^t}{N} \quad (8)$$

where: R_{sp}^{t} – yield of the single portfolio for the *t* period;

R_i^t – yield of the *i* securities for the *t* period;

N – number of securities comprising the portfolio.

On the basis of the yield of the single portfolio for each month, determine the average yield of the single portfolio for the year:

$$\overline{R_{sp}} = \frac{\sum_{t=1}^{T} R_{sp}^{t}}{T} \quad (9)$$

where: $\overline{R_{sp}}$ – average yield for the entire *T* period

R_{sp}^{t} – sum of all *t* periods

The results of calculations of the yield of the Central Bank and the single portfolio, as well as their respective averages are presented in Table 5.

Table 5. Calculation of the yield of securities and the single portfolio

KZTO	KZTK	KKGB	RDGZ	KCEL	GB_KZMS	HSBK	Yield of the single portfolio by t_i periods
-0.008	0.003	0.015	-0.006	0.006	-0.133	0.035	-0.012
0.094	0.005	0.025	0.379	0.065	-0.020	0.043	0.084
0.040	0.002	-0.073	-0.257	0.010	-0.152	0.143	-0.041
0.238	-0.117	0.157	0.416	0.014	-0.022	0.081	0.110
0.127	0.026	0.060	0.174	0.072	0.406	0.074	0.134
-0.036	0.002	0.062	-0.191	-0.099	0.068	-0.091	-0.041
-0.025	0.005	0.238	0.147	0.004	-0.086	0.076	0.051

KZTO	KZTK	KKGB	RDGZ	KCEL	GB_KZMS	HSBK	Yield of the single portfolio by t_i periods
-0.004	0.001	0.009	-0.004	0.081	0.050	-0.024	0.016
-0.055	0.013	-0.086	-0.209	-0.003	0.180	0.168	0.001
0.037	0.003	0.679	0.372	0.003	0.120	0.060	0.182
-0.013	0.075	0.197	0.147	0.000	-0.035	0.001	0.053
0.036	**0.002**	**0.117**	**0.088**	**0.014**	**0.034**	**0.052**	**0.049**

Source: Calculated by the authors according to stock prices on the website www.kase.kz

The last line of Table 5 shows the calculated average yields by types of securities, and the cell at the intersection of the last row and column – the average yield of the single portfolio (0.049).

The degree of dependence (change sensitivity) of the yield of shares on changes in the single portfolio yield is shown by the beta (), which is calculated for each *i* security as follows:

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

To determine the overall risk by the quasi-Sharpe model, it is also necessary to calculate the residual risk, which is the yield spread with respect to the regression line and measured by the following value:

$$\sigma_{ri} = \frac{\sum_{t=1}^{T}(R_i^t - \overline{R} - \beta_i * (R_{sp}^t - \overline{R}_{sp}))^2}{T} \quad (11)$$

For the formation of the investment portfolio of these securities, it is necessary to calculate the risk of the single portfolio itself:

$$\sigma_{sp} = \sqrt{\frac{\sum_{t=1}^{T}(R_{sp}^t - \overline{R}_{sp})^2}{T}} \quad (12)$$

Table 6 shows the received results.

Table 6. Collective results of the yield and risk of the Central Bank

Name	β - coefficient	Average yield (%)	Residual risk (%)
KZTO	0.8746	3.58	0.46
KZTK	0.0450	0.17	0.19
KKGB	2.6892	11.67	2.00
RDGZ	3.7420	8.81	1.27
KCEL	0.3547	1.39	0.20
GB_KZMS	1.7377	3.41	1.89
HSBK	0.1669	5.15	0.47

Source: Calculated by the author based on data from the Kazakhstan Stock Exchange.

As long as all the parameters of the quasi-Sharpe model are calculated, we can use it to find the optimal portfolio, solving the direct task: to maximize the yield of the investment portfolio with limited risks. The limitation on the risk will be at least 5%.

The results show that the maximum yield rate of the generated aggressive optimal portfolio (consisting of liquid shares) is 8% while the risk will not exceed 5%, and the portfolio structure formed of the shares included in the UAPF is as follows: 57% are common shares of the Halyk Bank, 32% - KazKommertsBank and 11% -

KazMunayGas Exploration Production. The shares of KazKommertsBank and KazMunayGas Exploration Production have the greatest value of yield, but they also have the greatest values of the risk coefficients.

By analogy, the optimal portfolio was formed on the set of bonds included in the UAPF structure and the representative list of indices of KASE B * series as of September 23, 2014.

The original single portfolio with equal shares includes the following government and corporate bonds (Table 7).

Table 7. The structure of the single portfolio of bonds

Issuer	Product code	The weighted average yield, % p.a.
The Ministry of Finance of the Republic of Kazakhstan (government securities)	MEKAM	2.9
The Ministry of Finance of the Republic of Kazakhstan (government securities)	MEUJKAM	4.7
'KaspiBank' JSC	CSBNb11	8.40
'OGCC KazStroyService' JSC	KASSb2	6.99
'National Company 'KazMunayGas' JSC	KMGZb4	8.28
'Kazakhstan Mortgage Company' JSC	KZIKb24	8.15
'Mangistau Electricity Distribution Network Company' JSC	MREKb7	5.96
'Samruk-Energy' JSC	SNRGb1	5.68
'Central-Asian Power-Energy Company' JSC	CTECb1	10.95

Source: Calculated by the author based on data from www.kase.kz/ru/index_bonds

On the basis of the data in Table 7, the calculated average yield of the single portfolio during the period T = 12 m is equal to 5%.

As a result, based on the quasi-Sharpe model, we received the following structure of the optimal portfolio with the yield of 7.75% and the limitation on the risk of no more than 3%:

CSBNb11 – 30%
KZIKb24 – 30%
MREKb7 – 30%
CTECb1 – 10%

At present, according to the UAPF structure, up to 16% of assets are invested in banks, and the pension assets are usually invested for the long term, more than five years. Consider the dynamics of interest rates on deposits for legal entities for the past year, from September 2014 to September 2015 according to the National Bank of the Republic of Kazakhstan (Vidyanova 2014) (Figure 8).

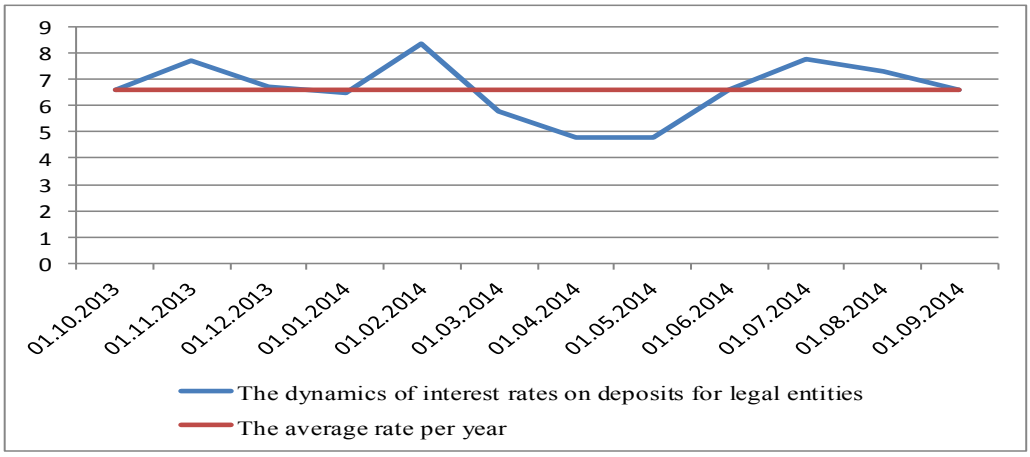

Figure 8. The dynamics of interest rates on deposits on average for the second-tier banks

Source: Constructed by the author based on data from the National Bank of Kazakhstan.

As follows from Figure 8, the deposit rate on average per year for the second-tier banks of Kazakhstan was 6.3% with the fluctuation (standard deviation) of 1.1. One can say that the rate did not exceed 8%, but was higher than 4%. Consequently, the yield on the deposit investment as well as the yield of the aggressive portfolio of shares may not exceed 8%.

Thus, on the basis of the UAPF structure, the formed aggressive portfolio of the most liquid shares, according to the Kazakhstan Stock Exchange, has the same level of yield as the portfolio formed by the cluster analysis, with the allowable risk in the optimization model of more than 5%.

The optimal portfolio formed from bonds has the rate of yield of lower than 7.75%, while the level of allowable risk does not exceed 3%.

Investments in banks also cannot exceed 8% of yield, the risks of investing in this case are difficult to assess, and the issue of relations between the UAPF and banks are insufficiently elaborated.

The limited yield of the investment portfolio is due to the poor quality of its securities, the underdevelopment of the stock market, the sluggish activity of the fund itself and the homogeneity of its structure, which requires an explicit review and diversification of assets investment in order to encourage investors to invest voluntarily in the pension fund.

In our opinion, the financial strategy should ensure the efficient allocation of pension assets on the basis of the investors' interests and, according to their age preferences, form portfolios with different investment focus in their relation to income and risk. The investor is now deprived of the right of choice, which is one of the negative aspects of centralized management of pension assets.

In this connection, we consider it necessary to increase the yield of the cumulative part of the pension and to expand the market of financial instruments for the selection of investment options, based on the age interests of the UAPF investors.

For the people of pre-retirement and retirement age, adhering to a conservative portfolio, it is essential that the portfolio should contain not the long-term government securities, as in the UAPF, but the medium-term and short-term securities, and the yield of these government securities should be increased for the yield of the portfolio to be 'inflation plus' (Vidyanova 2014).

The expansion of the structure of funding of the UAPF pension assets with regard to the interests of investors to some extent compensates for the violation of the constitutional right of citizens to choose how to implement the accumulation of their pension, and, at best, will keep their savings.

Conclusion

The research presents the possible options of forming the funding structures of pension assets. For the calculation, the methods of the multivariate statistical analysis and the quasi-Sharpe optimization model were used. They showed that the yield of pension assets within the current funding structure could be more than 8% with the limitation on the level of risk of no more than 5%.

The model calculations showed that within the existing structure of the UAPF financial instruments as of January 1, 2015, it is possible to build a portfolio with a higher yield, but it will violate the restrictions on the eligible financial instruments established by the regulator.

In this connection, we believe that the UAPF financial strategy should ensure the efficient allocation of pension assets based on the interests of investors. For this purpose, it is necessary to develop the limitations on allocation in financial instruments with regard to the interests of investors and to make information on allocation accessible and transparent.

However, given that the joint component of pension for future retirees is being reduced, we believe that the current pension system, even with an increase in yield of the cumulative part, formed by contributions from employees, could neither fully compensate for the decrease in the size of pension in general nor ensure its growth. In this connection, to reduce the risks of pension assets management, there is need for an additional component of the pension system, formed by introducing a new party into its structure - the employer.

The proven low yield of the pension assets funding is the rationale for the modernization of the accumulative pension system. The introduction of a relatively accumulative component into the pension system is timely and helps insure against the decrease in pension payments in connection with the gradual reduction and closure of the joint component.

The research gives recommendations on the UAPF financial strategy, which should ensure the efficient allocation of pension assets based on the interests of investors. To do this, it is necessary to expand the segment of equity instruments, including shares of companies associated with promising infrastructure projects included in the program of industrial-innovative development of the Republic of Kazakhstan for 2015-2019. On the other hand, it will contribute to the development of domestic production. It is also necessary to increase the share of medium-term and short-term securities, however, the yield should be 8% and higher so that the yield of the whole portfolio could meet the slogan of the National Bank of the Republic of Kazakhstan 'Inflation plus'.

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