VILNIUS UNIVERSITY

MANTAS VALUKONIS

CENTRAL BANK FOREIGN EXCHANGE RESERVES MANAGEMENT MODEL

Summary of Doctoral Dissertation

Social sciences, Economics (04S)

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VILNIAUS UNIVERSITETAS

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SUMMARY OF DOCTORAL DISSERTATION

INTRODUCTION

Relevance of the subject. Central banks play an important role in finance market maintaing stability of prices, economics and finance system. Foreign exchange reserves management is one of the CB functions and its realization is significant to both the bank and the state. The part of the CB profit is transfered to the budget; the profit from reserves management are used for CB‘s maintenance. Foreign exchange reserves management results depend not only on proper reserves‘ management strategy, but also are related to changes in financial markets. The demand to develop the new concepts of foreign exchange reserves management is due to rise of foreign exchange reserves volume, decrease of low risk government securities yield and rise of foreign exchange reserves maintenance cost. Low interest rate environment in finance markets determine CB duty to look for new investment instruments. Higher return in low interest rate environment is an important issue not only for CB, but also to the other investment portfolio managers. Because of the specific investment criteria of CB, which make CB portfolio management exceptional, this paper focuses exactly on investment portfolio management of CB. Investing foreign exchange reserves in low-risk government securities is not the optimal decision, because yield of these financial instruments is low or even negative. In order to get higher return, banks have to invest foreign exchange reserves in more risky financial instruments. Hence reserves management concentrates on higher yield rather than liquidity resulting in demand of reserve management policy changes. As a result of foreign exchange reserves investment policy changes, reserve management methods based on liquidity and yield balance should be applied. Due to importance of higher yield, higher risk level is taken, even the demand of adequite reserves liquidity level still exists.

From the begining of the first J. Treynor‘s and W. Sharpe‘s capital asset pricing model (CAPM) and H. Markovitz‘s modern portfolio theory, investment management models have been constantly altering. Due to the changes of capital market structure and features many models have become hardly applicable. Black-Litterman model is described as one of the most important CB models in finance theory however it‘s application to CB has not been fully analysed. Lack of theory, which would describe how CB have to perform asset allocation and form strategic investment portfolio

including higher risk level instruments still exists in literature. Investing in these securities results in higher CB investment portfolio risk. In consequence, new risk evaluation methods to assess and manage portfolio risk reliably are needed.

Exploration level of the scientific problem. The demand to apply a reliable methodology for better risk management and yield forecasts is essential while managing foreign exchange reserves. Summarising scientific literature on methods of foreign exchange reserves investment portfolio management, the main research areas were explicited as following: changes of foreign exchange management policy, investment portfolio formation applying mathematical methods, foreign exchange reserves risk, investment portfolio risk management methods.

Foreign exchange reserves management was analysed by J. Nugee (2004), Z. Zhang, F. Chaua, L. Xie (2012), M. Williams (2005), S. Roger (1993), A. Scalia, B. Sabel (2011), G. Baksay, F. Karvalits, Z. Kuti (2012), B. Wijnholds, A. Kapteyn (2001), S. Claessens, J. Kreuser (2006), U. J. Walther (2012), G. Pineau, E. Dorrucci, F. Comelli, A. Lagerblom (2006), C. Abdelnour (2007), J. Philman (2010), D. Zhang ir C. Zhou (2013), B. H. Putnam (2004), M. Obstfeld, J. C. Shambaugh, A. M. Taylor (2008). The scientists have summarised foreign exchange reserves management criteria and their importance in CB.

Changes of the reserves management policy and subsequent reserves management problemes were analysed by G. Pineau et ct. (2006) , U. J. Walther (2012), U. Bindseil (2009), J. Philman (2010), E. Lavigne (2003), M. Williams (2005), F. Salman bei A. Salih (1999), J. Nugee (2004), L. Goldberg, C. E. Hull, S. Stein (2013), D. Rodrik (2006), S. Roger (1993), S. Edwards (1986), J. M. Landell-Mils (1989), R. McCauley, J. F. Rigaudy (2011), A. Morahan, C. Mulder (2013), C. Borio, G. Galati, A. Heath (2008), I. Clacher, R. Faff, D. Hillier, S. Mohamed (2004). These scientists focused on aspects of reserves management policy changes, but not considered the adoption of asset allocation and risk evaluation methods. Moreover, CB foreign exchange reserves investment portfolio formation under changed condions was not analysed.

According to the literature, investment portfolio management and formation usually are performed using CAPM model and mean - variance model created by H. Markowitz who won Nobel Prize in 1990 for this reason. Such kind of models were used in researches by M. C. Steinbach (2001), Y. Simaan (1993), B. H. Putnam (2004), R.

Michaud (1989), F. Black, R. Litterman (1992), S. Mei, J. Li (2008), J. Li, H. Huang, X. Xiao (2012), J. Fernandes (2012), C. Leon, D. Vela (2011), F. Black, R. Litterman (1991), W. Drobetz (2001). Many variations of CAPM and Markovitz models as well as other mathematical - statistical models are described in literature. Such models were summarized by R. Michaud (1998), S. Mei ir J. Li (2008), J. Fernandes (2012). In order to eliminate drawbacks of CAPM and Markovitz‘s model, A. Reveiz, C. Leon (2010), W. Lee (2000), T. M. Idzorek (2005), J. Fernandes (2012), C. Mankert (2006), F. Black, R. Litterman (1992) proposed and described Black-Litterman model. The theorical conception of this model was developed by W. Lee (2000), S. Satchell, A. Scowcroft (2000). Practical application of the model was analyzed by A. Bevan, K. Winkelmann (1998), G. He, R. Litterman (1999), U. Herold (2003), T. M. Idzorek (2005), R. Jones, T. Lim, P.J. Zangari (2007). Black-Litterman model was applied to hedge funds by M. Kooli, M. Selam (2010), L. Martellini, V. Ziemann (2007). However, this model was not related to CB activity.

Foreign exchange reserves risk sorts ant their management strategies were described by M. Fridson, C. McLeod – Salmon (2011), W. Elshof (2012), U. J. Walther (2012), F. W. Sharpe, J. G. Alexander ir V. J. Bailey (1999), T. Manchev (2009), E. Walker (2007), Y. Romanyuk (2012). Global portfolio hedging using derivatives was analysed by S. Krull (1992), F. Black (1990), J. F. Rigaudy (2000) and S. Claessens, J. Kreuser (2006). L. S. Hoon (2011) and E. Stalstedt (2006) focused on global portfolio hedging strategies. Currency risk hedging in CB investment portfolio was analysed by R.J.Caballero (2005).

Numerous scholars considered relevant risk management methods. Modified duration method (MD) was analysed by S. Noorali, C. Santos (2005), M. Fridson, C. McLeod – Salmon (2011), A. Scalia, B. Sahel (2011), B. H. Putman (2004). VaR method was analysed by M. Dwyer bei J. Nugee (2004), V. Sakalauskas (2006), M. A. Lajeune (2009). CVaR was researched by R. T. Rockafellar, S. P. Uryasev (2000), S. Claessens, J. Kreuser (2004), C. Acerbi, D. Tasche (2001), P. Artzner et al (1999), G. Flug (2000), R. T. Rockafeller and S. Uryasev (2002). Even separate risk management methods were analysed in details, combined activity of MD and CVaR methods has not been researched.

Change of foreign exchange reserves management policy due to demand of higher return, determines the need to adapt CB investment portfolio formation and risk management to new investment landmark. Only few researchers (S. J. Fisher ir M. C. Lie, 2004) have analysed CB investment portfolio formation and management. In addition to this, the researches were restricted to government bonds portfolio excluding higher risk level investment instruments.

Having considered the discussed problem issues of the topic the problem of the research has been formulated– *how to manage CB investment portfolio, which consists of different risk level investment instruments?* Two approaches to solving the problem of the research are as following: 1) Asset allocation between different risk level financial instruments – the created CB foreign exchange reserves investment portfolio formation model, which enables foreign exchange reserves distribution among different risk level investment instruments; 2) investment portfolio risk management – by creating risk management methodology, which allows to evaluate and manage debt securities portfolio risk by deviding it in to interest rate risk and credit risk.

The object of the research – Management of central bank foreign exchange reserves.

The aim of the research – according to the principles of foreign exchange reserves management to create and test CB foreign exchange reserves investment portfolio formation and management model, which includes decisions of investment portfolio risk management and asset allocation among different risk level financial instruments.

The main objectives of the research are:

1. To analyze theorical speciality of CB foreign exchange reserves management;
2. To summarize the approaches of foreign exchange reserves asset allocation in academic researches;
3. To supply CB investment portfolio risk management principles combining the empirical and theorical research results of CB investment portfolio risk management and assessment;
4. To create foreign exchange reserves management model according to analyzed methods of CB investment portfolio risk management and asseet allocation.

5. To test the created CB foreign exchange reserves management model by forming investment portfolio using real market data and evaluating it‘s return and risk.

Methods of the research: Comparative and systematic scientific literature analysis as well as filling and summation methods were used analysing CB foreign exchange reserves importance in CB activity as well as foreign exchange reserves management criteria and goals.

In order to evaluate foreign exchange reserves risk management conceptual approaches, scientific literature synthesis, brunching and comparative analysis methods were used. The same methods were used for distinguishing main CB investment portfolio formation and management problems in scientific literature. Deduction, synthesis and comparative analysis methods were applied due to creation the foreign exchange reserves management model.

The created foreign exchange reserves model was tested by using statistical, mathematical and econometrical methods. Factors affecting stocks and bonds market were sorted by correlation and regresion analysis. CB investment portfolio was formed by mathematical modelling and optimisation. The return and risk of the created foreign exchange reserves investment portfolio were evaluated using graphic methods and descriptive statistics.

Linear regression was performed by *SPSS statistics*. *Microsoft Excel* programme was used for portfolio modelling and applying statistical and graphical results.

The limitations of the research: The author aims for model, which would be conceptionally applied for CB managing foreign exchange reserves effectively. The methods, used for model formation are based on presumptions and market factors future expectations, consequently the accuracy of foreign exchange reserves management model results depends on correct future expectations identification and expectations' deviation from real finance market situation. Finance market trend and changes of interest rate environment as well as monetary policy decisions may influence to the accuracy of the model results.

The structure of the research: The thesis consists of an introduction, three main parts, conclusions, list of references and appendices.

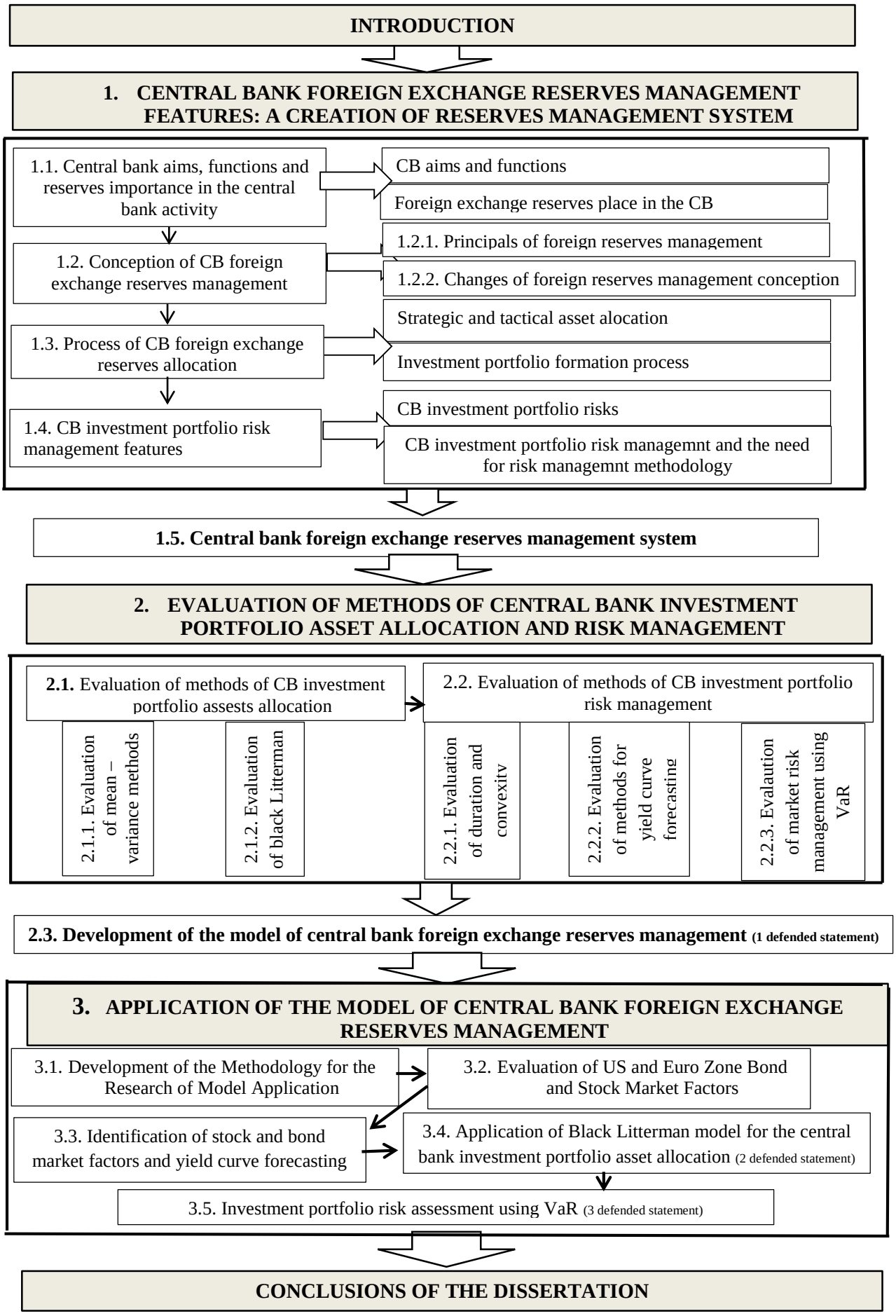

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Figure 1. Logical scheme of the dissertation

The first part of the thesis deals with concept of foreign exchange reserves management focusing on changes of foreign exchange reserves policy. In addition to this, the main problems of CB investment portfolio formation and risk management are considered. The developed theorical foreign exchange reserves management system is presented in this part of the thesis.

The second part of the research concentrates on CB investment portfolio risk management and asset allocation methods by respect of scientific literature. Methods suitable for CB investment portfolio formation and risk management were selected by evaluation of advantages and disadvantages of the methods theorically and practically. The foreign exchange reserves management model developed on basis of selected methods.

The third part of the thesis covers testing the model with real market data. Investment portfolio return and risk were evaluated.

The folowing results reveal **the scientific novelty of the research and its theoretical value:**

Foreign exchange reserves management and investment portfolio formation are analysed by numerous scholars, however nobody has researched yet any model or theory focusing on how CB would perform asset allocation while investing foreign exchange reserves. The author has developed the CB foreign exchange reserves management model and proposed the step-by-step application of the model, which enables central bank to form foreign exchange reserves investment portfolio.

The first part of the research focuses on foreign exchange reserves management importance in the CB activity and its relation to the objectives, instruments and functions of CB. Moreover, the original scheme of changes of foreign exchange reserves management policy highlighting the main tendencies related to foreign exchange reserve managemnt is presented. In addition to this, the main CB investment portfolio formation and risk management problems are pointed out according to academic literature. Besides, logical asset allocation process generelised scheme was made. The author developed theorical foreign exchange reserves management system, associating the criteria of CB objectives, reserves holding goals and reserves mangement goals relation as well as foreign exchange reserves allocation and foreign excahnge reserves investment portfolio results assessment.

The second part of the research investigates asset allocation and risk managemnt methods, suitable for CB foreign reserves management. The author‘s developed foreign exchange reserves management model is based on chosen methods and formulated insights of combining asset allocation among stock and bonds and portfolio risk management. Central bank‘s portfolio formation is performed using Black Litterman model and yield curve forecasting methods which allows to determine expected yield of the assets and use it in the active allocation process. Central bank reserves management model also includes the VaR model which allows to exclude interest and credit risk constituents from the total debt securities portfolio risk

The practical meaning of the research. Author‘s proposed foreign exchange reserves management model allows: 1) to incorporate market expectations to CB portfolio formation 2) to get higher portfolio return by performing asset allocation; 3) to evaluate and manage debt securities portfolio risk reliably under unfavourable market conditions.

The original foreign exchange reserves management model was tested empirically under market conditions. In respect that, the proposed foreign exchange reserves model allows to invest foreign exchange reserves by reaching higher return and evaluate investment portfolio risk reliably, it is suggested to apply this model in practice for CB foreign exchange reserves management.

Defended statements:

1. CB foreign exchange reserves management have to be based on related and suitable factors concept, including market factors assessment, identification of market factors expectations and parameters of yield curve forecast.
2. The created CB foreign exchange reserves management model, based on Black-Litterman methodology, allows to invest foreign exchange reserves in different risk level investment instruments more effectively.
3. Debt securities portfolio risk management model integrating VaR, MD and interest rate risk hedging methodology allows to devide and evaluate interest rate and credit risk reliably.

1. FEATURES OF CENTRAL BANK FOREIGN EXCHANGE RESERVES MANAGEMENT: DEVELOPMENT OF A SYSTEM OF RESERVES MANAGEMENT

This part of the thesis explores the objectives and functions of central banks and the role of foreign exchange reserves in the activity of central banks. The criteria for the management of foreign exchange reserves are discussed, and their importance is outlined. Also, the conclusions of scholarly works on the composition of a portfolio and its risk management are generalized. The process as well as the distinctive elements of the composition of a portfolio of foreign exchange reserves is investigated.

Having explored the relevant scientific literature, it was established that foreign exchange reserves are resources aimed at implementing the monetary policy and supporting the national currency. On the grounds of the ideas developed by V. Cosris, B. Capraru (2008), B. Bernanke (2002), J. C. Trichet (2005), F. S. Mishkin (2004), S. Heffernan (2005), X. Freixas, J. C. Rochet (2008), the author developed a scheme reflecting the relationship between the activity of central banks and the management of exchange reserves.

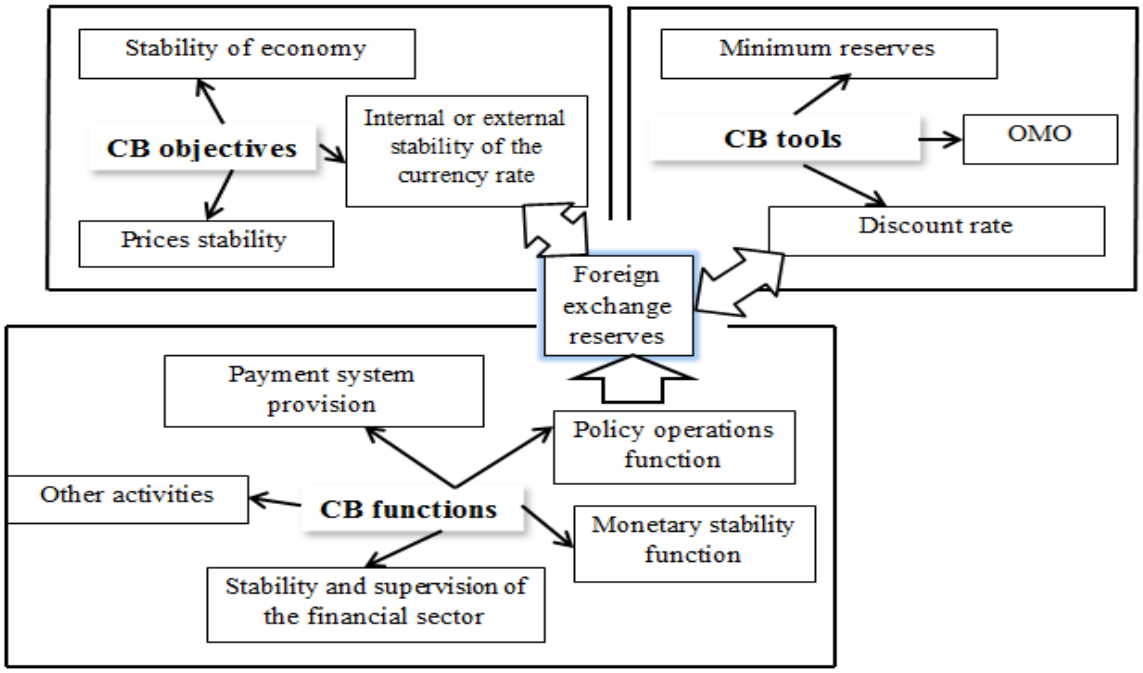

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Figure 2. The importance of the management of foreign exchange reserves in the activity of the central bank

Foreign exchange reserves are closely connected with the priority objectives and the employed tools of the central bank (see Picture 2). While pursuing each of its objectives, the central bank employs corresponding means of monetary policy. Foreign reserves are inseparable from the capacity of ensuring internal and external stability of the currency since central banks employ foreign exchange reserves for interventions into the currency market while pursuing this objective. Hence, the importance of the efficient management of exchange reserves may be briefly defined as one of the core functions performed by central banks because the efficient usage of the tools of monetary policy within the capacity of the central bank leads to the pursuance of the main objective of the central bank and the appropriate implementation of its monetary policy.

The successful management of foreign exchange reserves also contributes to ensuring the independence of the central bank, and the financial aspect is one of the key criteria in the achievement of its independence. By gaining profit from the management of foreign reserves, the central bank financially supports itself and also transfers some funds into the budget of the country. Thus even though scientific literature does not directly relate the issue of the exchange reserve management with the implementation of the objectives of central banks, the management of reserves is still perceived as one of the functions of the central bank which is ultimately important for the activity of the central bank as well as for the national budget.

From the theoretical point of view, the criterion of the return is the third most important criterion pertaining to the management of foreign exchange reserves, however, while dealing with the developments of foreign exchange reserves, G. Pineau et al. (2006), Ulrik J. Walther (2012), U. Bindseil (2009), J. Pihlman (2010), E. Lavigne (2003) established that the priority has shifted from the importance of liquidity to the strife for higher returns. This shift was determined by a number of reasons, first of all, by the rapid growth of foreign reserves and, secondly, by the low yields of the low risk securities.

Having explored scientific literature, the main shifts pertaining to the principles of foreign exchange reserve management are depicted in Figure 3:

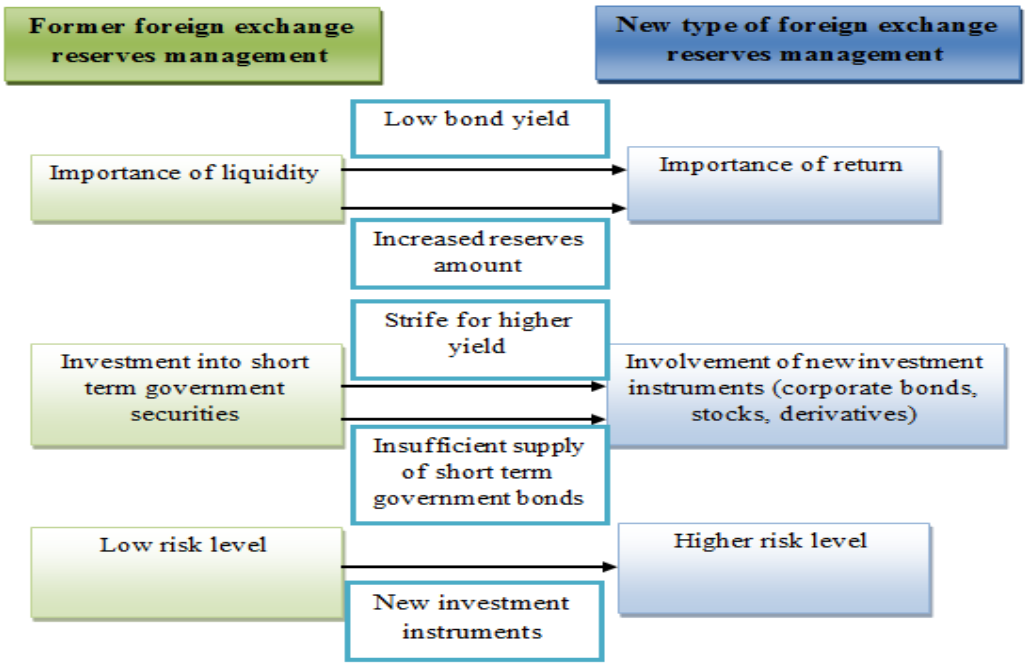

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Figure 3. Alterations in the foreign exchange reserve management

The most commonly highlighted alterations in the management of foreign exchange reserves which are singled out in scholarly literature are the increase of the importance of return, inclusion of new types of investment instruments into the portfolio and the increase of the level of risks. The need for higher return is determined by the low yield of bonds and the increasing extent of reserves. When transiting from liquidity to higher return, a need for new investment instruments arises. When higher return investment instruments are included into a portfolio, the undertaken risk increases as well. Alterations of the foreign exchange reserve management policy result in issues pertaining to risk assessment and portfolio composition. When new types of investment instruments are included into a portfolio, the previously used model of portfolio formation and the corresponding methods of risk management are rendered unsuitable.

Scholars usually explore the management of foreign exchange reserves by focusing on the optimal amount of these reserves rather than on their management. The composition of the central bank foreign exchange reserves portfolio requires outlining a complex set of objectives without restricting oneself to the risk-and-return criterion which is employed in the optimal portfolio theory or in the CAPM.

When constructing the investment portfolio of central banks, there is no theory which could define the correct asset allocation or the composition of the strategic index.

When researching the process of portfolio asset allocation, G. P. Brinson, L. R. Hood, G. L. Beebower (1986), G. P, Brinson, B. D. Singer, G. L.Beebower (1991) and D. Blake, B. Lehmann and A. Timmerman (1999) established that the asset allocation decisions determine approximately 90 per cent of the portfolio return.

Generalization of the allocation process of the investment portfolio performed by the dissertation author resulted in the following logical scheme of portfolio allocation process (Figure 4)

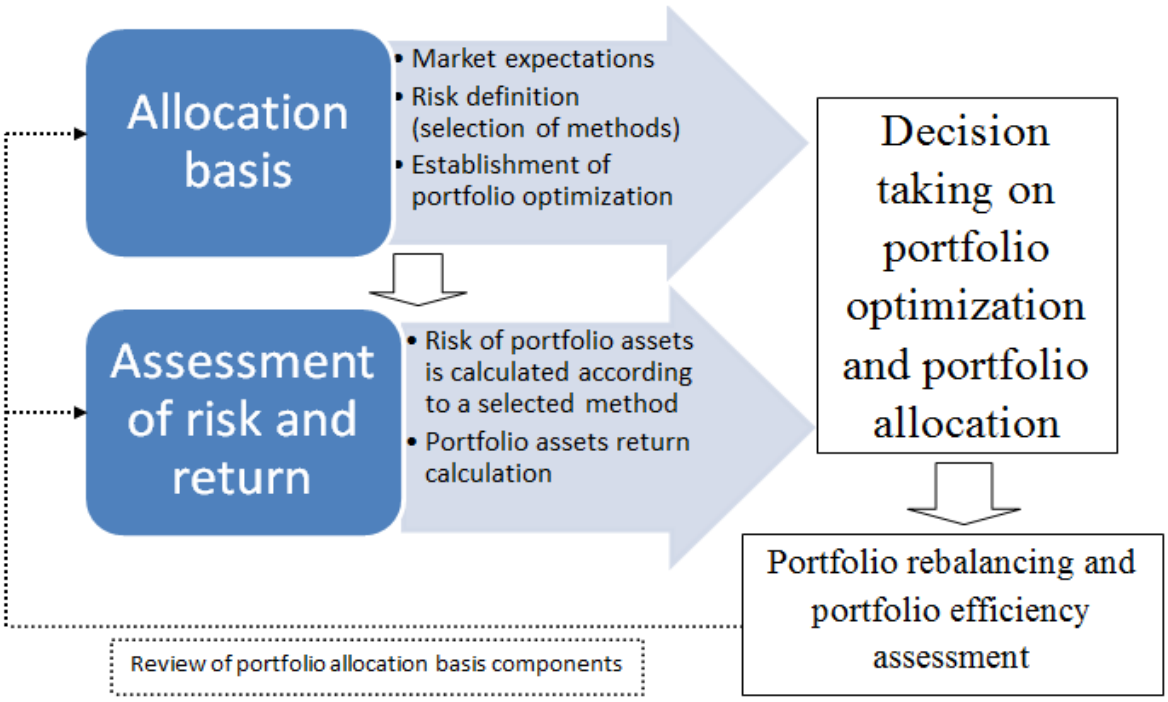

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Figure 4. Logical scheme of portfolio allocation

The traditional attitude to portfolio allocation restricts itself within forecasts of the return on assets and the decisions regarding asset distribution stemming from that forecast. However, this type of attitude determines the increase of the share of more risk-bearing assets in the portfolio since there is no consideration of the volatility difference between the presence of more or less risky securities in the portfolio. It is likely that stocks will have higher expected return; hence, if the allocation of a portfolio is performed only in terms of return, it is likely that a major part of the portfolio will be invested into higher risk assets. That is why, from the point of view of the dissertation author, asset allocation should be implemented not on the grounds of sheer return but rather on giving risk the central position. Decisions on the portfolio allocation should be

directed not towards asset allocation but rather towards risk allocation, according to which decisions should be taken concerning the extent of investment into specific types of assets.

There is no doubt that the central bank foreign exchange reserves risk management finds benefits in the methods and ways used at commercial banks and wealth management companies managing investment portfolios; however, not all management tools and methods may be applicable due to the fact that central banks are exceptional investors.

In general, the investigated researches claim that the bond portfolio risk management in the scientific literature is mostly explored by highlighting market risks. Having analyzed the conducted researches and the opinions of their authors, it was observed that the risk of debt securities in a portfolio is assessed and managed by employing a wide variety of methods; however, the exploration of the devide of the general risk into credit and market risk components is not sufficient. The explored methods allow measuring the general risk of the portfolio; yet, a methodology is required which would allow to devide the market and credit risk constituents. What is more, when central banks invest into new investment instruments, the previously employed methods cannot serve as an efficient tool of assessing the portfolio risk anymore. Scholarly writings extensively explore how single measurement units may be employed in risk management; however, a complex methodology uniting several measurement units is required.

Having explored the role of the management of foreign exchange reserves in the activity of central banks and the peculiarities of the composition of the foreign exchange reserve portfolio and risk management, the following aspects of foreign exchange reserve were established: the mutual dependence between the objective of the central bank, objective of holding reserves and the criteria of reserve management; the process of foreign reserves allocation; and the risk management of the investment portfolio of foreign exchange reserves. These three constituent parts provide a foundation for the foreign exchange reserve management system on which all the other aspects of the reserve management system are based.

It was established that the management of foreign exchange reserves by the central bank starts with the outlining of the objective of the central bank. Even though

foreign reserves are not attributed to the devices of monetary policy, they may still be employed as a tool for pursuing the objectives of the central bank or implementing its monetary policy. Another extremely important aspect of reserve management is the objective of the holding of the reserves by the central bank. Depending on this objective, the balancing of the reserve management criteria (safety, liquidity, return) is established. The selection of these criteria and their importance is as the foundation on which all the management of foreign exchange reserves is being built as these criteria of management determine the further investment decisions.

The main issue of the foreign exchange reserves management arises in the process of asset allocation. It has been found out that no model has been created yet which could allow central banks to conduct asset allocation and construct the foreign exchange reserve investment portfolio. It was established that the traditional methods of portfolio optimization – Markowitz and CAPM methods – are unsuitable to central banks due to the exceptional criteria of investment of each particular central bank.

Another problem issue of the foreign exchange reserve management is risk management. It was established that with the changing foreign exchange reserve policy and the central banks shifting to riskier investments, necessity arises to alter the risk management system by including novel methods of risk management into it. Academic papers have investigated quite extensively distinct methods of risk management; however, the cumulative functioning of the methods in a system has not been researched yet.

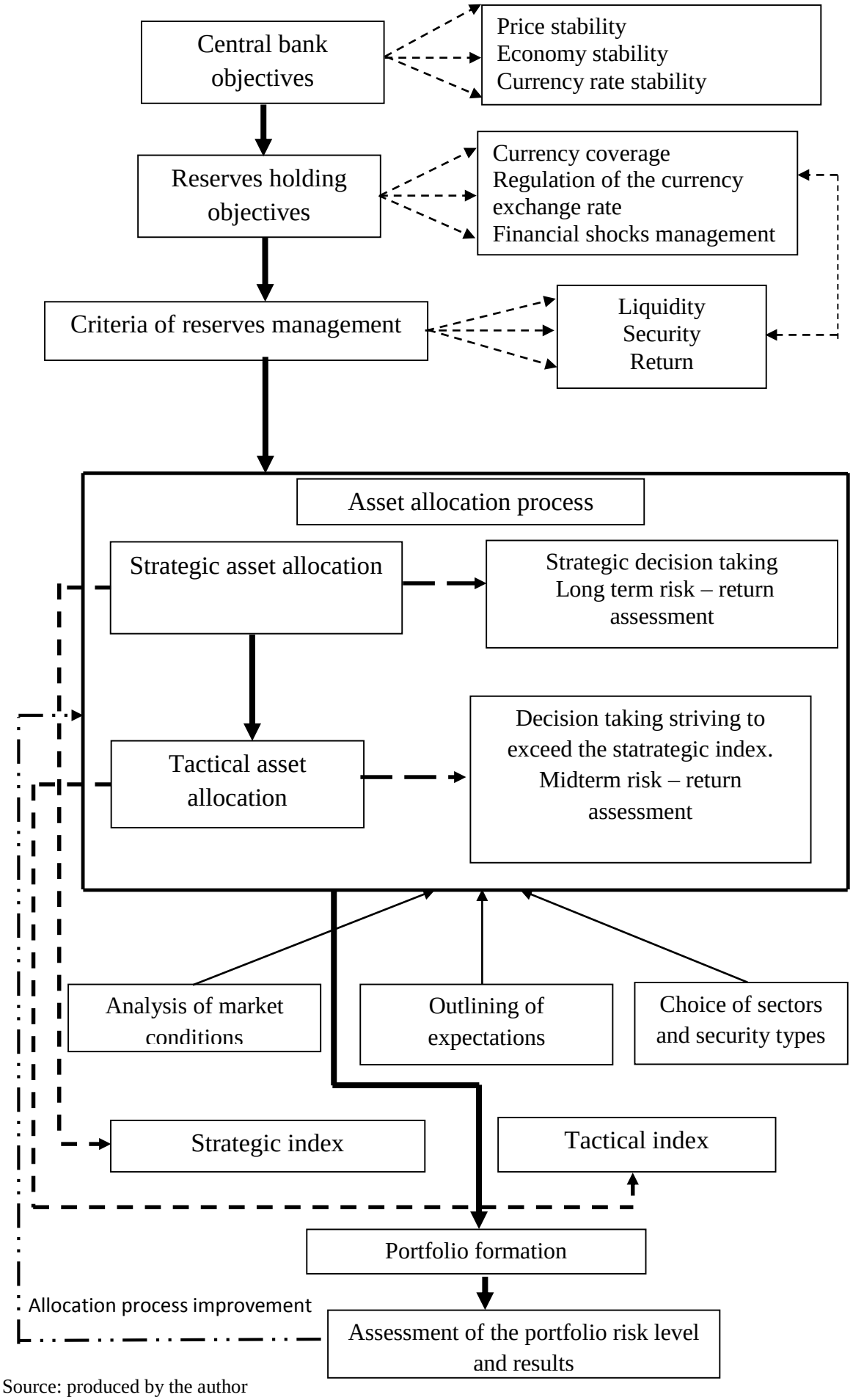

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Figure 5. Foreign exchange reserves management system

2. EVALUATION OF CENTRAL BANK INVESTMENT PORTFOLIO ASSET ALLOCATION AND RISK MANAGEMENT METHODS

There is a wide variety of methods of portfolio construction and portfolio risk assessment; however, not all of these models are acceptable to central banks. This part of the thesis deals with the investment portfolio asset allocation methods and the methods of risk assessment and management. It also assesses the viability of the application of the Black Litterman model in the process of foreign exchange reserve allocation. After exploring the methods which are applicable in the process of asset allocation and risk management, a model of the management of foreign exchange reserves is developed. This model also involves reserve allocation and risk assessment.

Evaluation of asset allocation and risk management methods. The process of optimization of the investment portfolio of central banks featuring the establishment of the optimal combination of currencies was investigated by H. R. Heller and M. Knight (1978), M. Dooley (1986), M. Dooley et al. (1989), J.S. Lizondo and D. Mathieson (1978). These authors established that the application of this method imposes several limitations on the portfolios of central banks.

The results of the research by T. M. Idzorek (2005) showed that the Black Litterman model allows composing a better-diversified portfolio than the one produced by adhering to the theory of the optimal portfolio as developed by Markowitz. The key point of this model is that the expected return depends on two components: market information and the attitude of the analyst. While further constructing the portfolio, according to the Black Litterman model, investors present insights into the future of the market which are expressed in terms of the likely return and a level of reliability. The insights are interlined with the profitability of a balanced market, and this union delivers the expected return of the Black Litterman model. Then, the Black Litterman model return is optimized by employing mean - variance methodology and the investment portfolio is derived only from these securities which are considered to be profitable in the future by the investors.

One of the key strengths of the Black Litterman model is that this model provides an opportunity to involve the expectations of the investors into the process of the portfolio asset allocation due to specific market factors imposing the most prominent impact on the value of financial instruments.

It was observed that the prices of long term bonds are much more sensitive to the fluctuations of the interest rate than the short term bonds. By using financial duration, it is possible to provide quantitative evaluation of this relationship. After the change of the interest rate, the proportional change of the price of a bond may be related with the changes in its yield and conditions of repayment by using the following formula:

$$\frac{\Delta P}{P} = -D\ x\ \left[\frac{\Delta(1+y)}{1+y}\right] \quad (1)$$

From this formula it may be derived that the variability of the price of a bond is proportional to the average duration of the bond. When managing the risk of the interest rate in practice, the method of modified duration is applied, and the calculation is as follows:

$$MD = \frac{D}{1+y} \quad (2)$$

By extending this formula, the shift of the bond price may be described as the multiplication of modified duration and the yield to maturity:

$$\frac{\Delta P}{P} = -MD\ x\ \Delta y \quad (3)$$

The increase of the MD in the decisions on the portfolio management allows increasing the yield of the portfolio as its volatility increases. However, the risk of the portfolio increases simultaneously as its volatility rises. There is no answer as to the optimal size of the MD as it depends on the risks undertaken by each central bank and its choices regarding return.

Having explored the risk management of the bond portfolio by employing the duration and curve convexity models, a generalized table of methods and risk factors is presented:

Table 1. **Generalization of risk factors**

Risk factor	**Risk factor measurement**	**Market change which effects market factor**
Market risk	Modified duration	Alteration of the interest rate – parallel changes in the interest rate curve
Interest rate curve risk	Convexity/Key rate duration	Alteration of the shape and slope of the interest rate curve
Impact of market volatility	Convexity: • Assets with negative convexity (callable bonds) are negatively affected by the market volatility • Assets with positive convexity are positively affected by the market volatility	Market volatility: • Historical, based on the factual prices or yield of the past. • Presumed, based on the implied volatility.

Source: produced by the author

The table singles out three main risks of the debt securities portfolio: the market risk, the interest rate curve risk and the risk related with market volatility. Credit risks are not singled out as the major part of the central bank portfolio is invested into the highest credit rating government bonds. Hence, it is assumed that these securities bear only minor credit risks, and the yield of these securities may be attributed to the risk free rate. The three types of risks may be managed by the modified duration and the curve convexity methods.

Having analyzed the methods of risk management outlined by theoreticians, one may agree with the opinion that the modified duration method by itself is not sufficient for risk management when foreign exchange reserves are invested not only in bonds. In this case, complex risk assessment is required thus additionally employing the VaR method.

It was established that the most appropriate VaR method for the management of foreign exchange reserves by a central bank is the variation – covariation method as central banks do not invest into options. The application of the historical modeling and Monte Carlo simulation methods would only increase the complexity of the portfolio risk management without achieving any more prominent precision of assessment.

From the practical point of view, the assessment of the portfolio risks gives a specific quantitative value. However, the calculation of only the risk value of a portfolio without considering additional information is not sufficient because it only provides a static view of the portfolio. In order to obtain a more precise assessment of the portfolio and to be able to make decisions regarding asset allocation, it is necessary to assess market factor variables. Table 1 shows that the risk factors which are singled out are affected by interest rates or the shifts in the interest rate curve; that is why, full-scale assessment requires the capability of forecasting the interest rate curve.

In order to obtain the valid value of the interest rate risk, it is not sufficient to assess the changes in the interest rate; the potential shifts and the shape of the curve must also be assessed. It was established that indefiniteness affects the bond interest rate curve via two channels: via the attitude of investors to risks (risk aversion) which is reflected in the risk premium and the nonlinear relationship between the yield and the price of a bond.

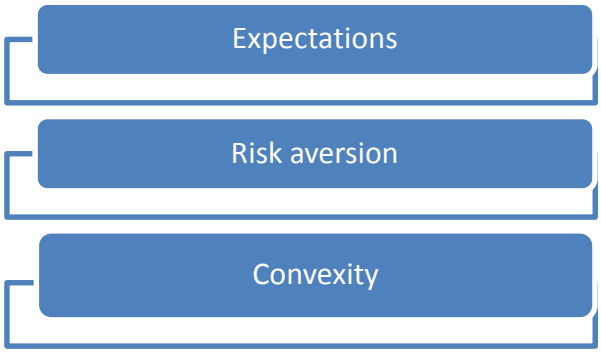

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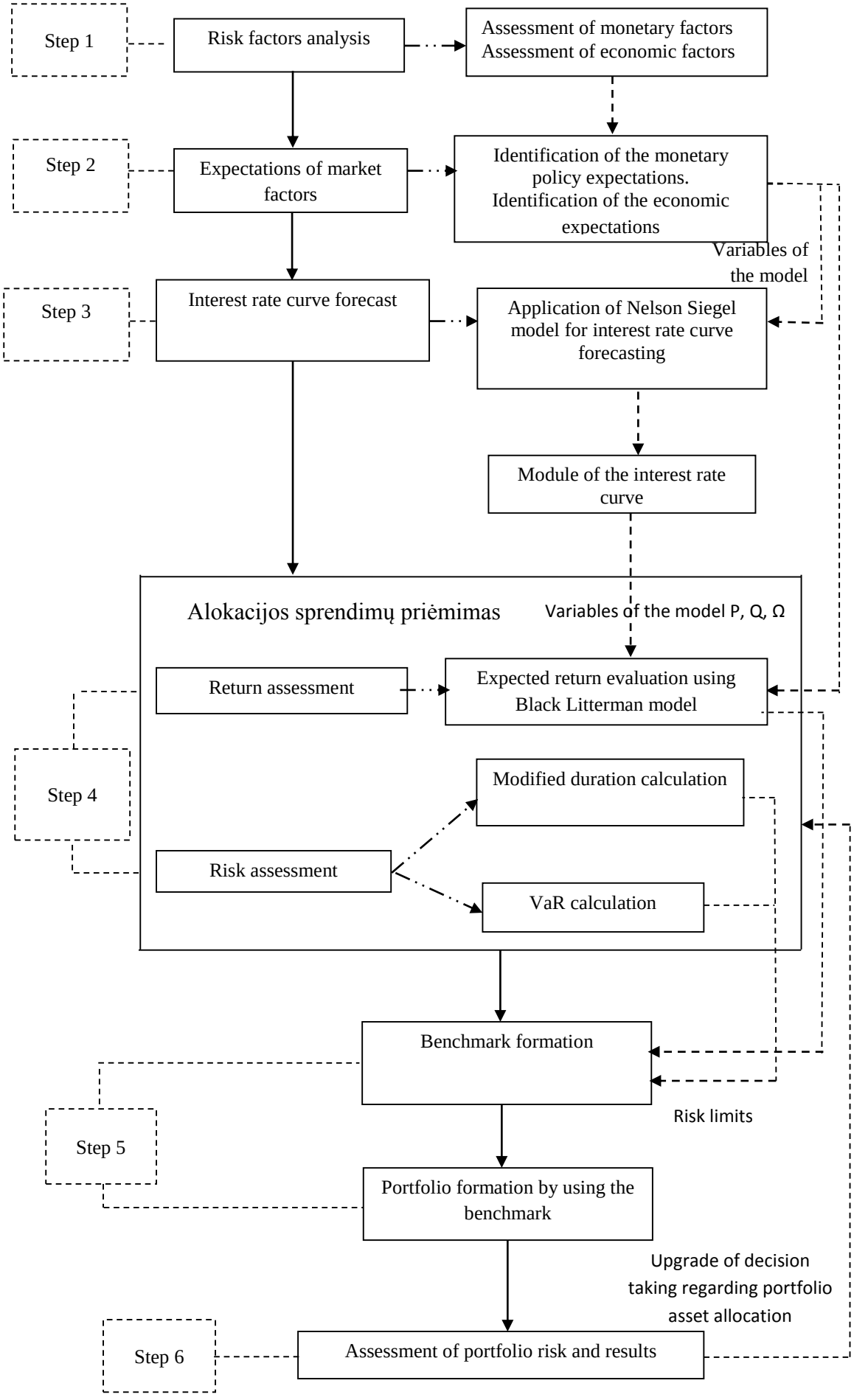
Figure 6. Factors affecting the shape of the interest rate curve

In the practice of the developers of the central bank and monetary policy, the Nelson – Siegel model is most commonly applied (BIS, 2005, ECB, 2008). F. J. Fabozzi, L. Martellini and P. Priaulet (2005) as well as F. X. Diebold and C. Li (2006) compared the forecasts obtained with the Nelson – Siegel model with the forecasts obtained by using other models and established that this model gave the best results, especially whenever long term forecasting was involved. In academic works, the Nelson – Siegel model (R. Theoret et al. (2006), F. X. Diebold and C. Li (2006)) is highly valued because of its easy applicability and forecasting opportunities. The broad applicability of this model in central banks and the possibility of forecasting the interest rates over a longer term single this model out from other yield curve forecasting models thus showing its suitability for the foreign exchange reserves management model which is being developed.

Development of a foreign exchange reserves management model. Having explored the peculiarities of the management of foreign exchange reserves by central banks as well as risk management and portfolio asset allocation models, a model of central bank foreign exchange reserve management was developed. After investigating the theoretical and practical aspects of the methods together with their strengths and weaknesses, the dissertation author singled out for the development of his model the modified duration, Nelson – Siegel and VaR methods. The Black Litterman model was selected for the asset allocation of the investment portfolio.



Source: made by the author

Figure 7. Foreign exchange reserves management model

Market variables are assessed in Step 1 of the model. For the assessment, the bond and stock portfolio-affecting factors are selected. Specific variables are singled out after performing a research assessing the factors affecting stock and bond markets.

Step 2 identifies the expectations of the market factors. For the model of reserve management, the Nelson – Siegel and Black Litterman models were selected; both of them feature future expectations of market factors.

Step 3 forecasts the interest rate curve by employing the selected Nelson – Siegel method. The expectations of market factors identified during Step 2 are employed as variables of the Nelson – Siegel method affecting the interest rate curve. After performing this step, the interest rate curve module is obtained; it allows assessing the developments of the interest rate curve in the future.

Step 4 calculates investment instruments risk and return. For the assessment of the expected return and the optimization of the portfolio, the Black Litterman model is employed. The variables used in this model (return expectations, likelihood of expectations) are obtained by combining the information gained during Steps 2 and 3. The market risk is measured using VaR method. The method of modified financial duration is used as a tool of portfolio management. The obtained VaR and MD results serve as limits when performing Step 5.

On the grounds of the results of the expected return and risk limitations obtained from the Black Litterman model, during Step 5, a benchmark is produced which defines the allocation of assets (i.e. which part of the portfolio should be invested in a financial instrument of a specific risk level).

Step 6 involves the assessment of the created investment portfolio. On the grounds of the portfolio assessment results, the process of asset allocation is improved further. The methodology of the investment portfolio risk assessment developed by the author of the present thesis and used at step 6 is outlined below.

When performing the assessment of the portfolio, the risk of a debt security portfolio is assessed independently for each investment tool. The assessment employs the classical VaR methodology and the Cornish-Fisher expansion-modified VaR. Portfolio risk is assessed as a sum of separate VaR portfolio positions.

$$VaR_i = P_i \cdot \sigma_i \cdot C \cdot \sqrt{T \cdot (1 + r_a)} \qquad (4)$$

Here:

P_i i-th value of the investment instrument.

σ_i i-th standard deviation of the price of the investment instrument calculated according to the formula:

$$\sigma_i = \sqrt{\frac{n\sum Y_i^2(t) - \left(\sum Y_i(t)\right)^2}{n(n-1)}} \quad (5)$$

$Y_i(t)$ i-th instrument logarithmic change of the price.

n – number of observations.

$$Y_i(t) = \begin{cases} \ln\left(\frac{X_i(t)}{X_i(t-1)}\right) \\ \ln\left(\frac{1}{X_i(t-1)}\right), \quad jei\ X_i(t) = 0 \\ \ln\left(X_i(t)\right), \quad jei\ X_i(t-1) = 0 \end{cases} \quad (6)$$

C – constant (quintile):

$$\mathrm{C} = \begin{cases} \mathrm{Z}, \text{when JB} \leq \mathrm{x}^2_{0.01;2} \\ \mathrm{Z}, \text{when } \mathrm{Z_{kf}} < 0 \\ \left|\mathrm{Z} + \frac{1}{6}(\mathrm{Z}^2-1)\mathrm{S} + \frac{1}{24}(\mathrm{Z}^3-3\mathrm{Z})\mathrm{K} - \frac{1}{36}(2\mathrm{Z}^3-5\mathrm{Z})\mathrm{S}^2\right| \end{cases} \quad (7)$$

Z – numerical term of normal distribution at the chosen confidence level.

JB – Jarque Bera, statistical test checking whether timelines are distributed according to the normal distribution pattern.

$$\mathrm{JB} = \frac{\mathrm{n}}{6}\left(\mathrm{S}^2 + \frac{1}{4}(\mathrm{K}-3)^2\right) \quad (8)$$

S – asymmetry coefficient (skewness).

$$\mathrm{S} = \frac{\mu_3}{\sigma^3} \quad (9)$$

K – *kurtosis*, the coefficient assessing the sharpness or flatness of the line distribution.

$$\mathrm{K} = \frac{\mu_4}{\sigma^4} \quad (10)$$

μ_i – i-th moment about the mean.

σ – standard deviation.

$$\mathrm{Z_{kf}} = \frac{1}{6}(\mathrm{Z}^2-1)\mathrm{S} + \frac{1}{24}(\mathrm{Z}^3-3\mathrm{Z})\mathrm{K} - \frac{1}{36}(2\mathrm{Z}^3-5\mathrm{Z})\mathrm{S}^2 \quad (11)$$

T – time horizon.

r_a– autocorrelation coefficient. Autocorrelation lag for the model is selected in accordance to which best matches the time series autocorrelation. The autocorrelation lag in this research is selected as 1.

Portfolio hedging requires a number of contracts which shall be calculated by considering the base risk according to the below presented formula:

$$\text{Number of contracts} = \frac{position\ NAV * Md}{Basis\ risk} \quad (12)$$

position NAV – value of the bond position in the market;

Md – modified duration of a bond;

Base risk – a coefficient showing the dependence between a spot and future prices (used risk_bid data from the *Bloomberg* system)

After calculating the number of contracts necessary for the particular position, the hedge portfolio is formed. In other words, the interest rate risk is converted into the future contracts and by assessing this risk, the possible loss is assessed from the open position of future contracts. The possible loss is calculated according to the following formula:

$$GN = AP * BR * 100 \quad (13)$$

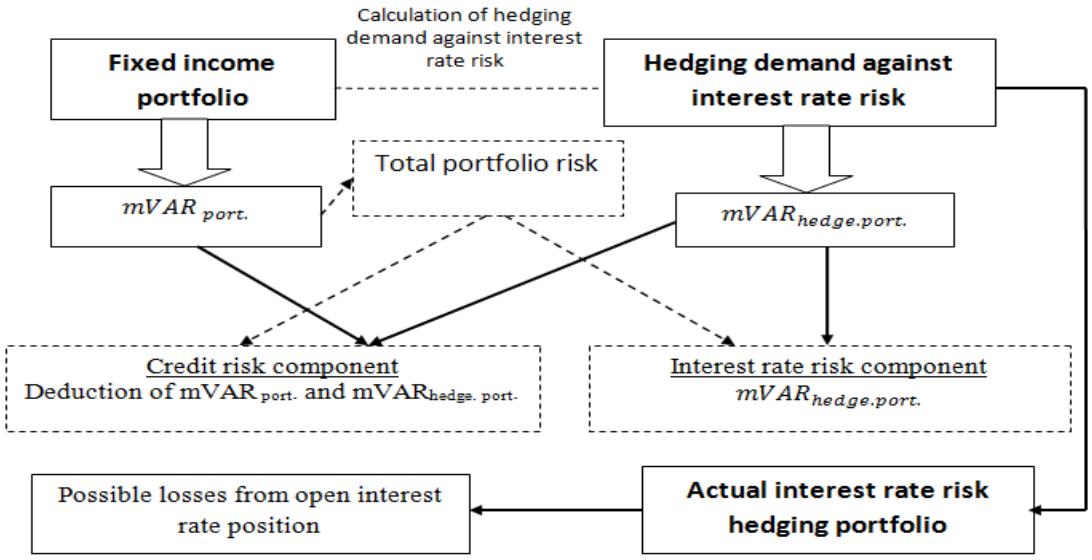
GN – possible loss;

AP – open position of the interest rate;

BR – base risk.

The likely loss of the open interest rate position is calculated under specific levels of change of the interest rate. A value is obtained what loss may be experienced from the portfolio if the interest rate changes to some extent. In the model, the possible loss is calculated considering the interest rate changes by 100 basis point.

Debt securities portfolio and hedge portfolio VaR values are calculated for the risk assessment. The fixed income portfolio risk methodology and the separation of risk components are shown in Figure 8.



Source: produced by the author

Figure 8. Debt security portfolio risk assessment model

For the verification of the developed risk assessment and management model and the assessment of its reliability, back testing is employed. When employing this method, the result for each day is compared with the corresponding expected result of the VaR model. If the factual result (R) exceeds the expected result of the VaR model during the specified period of time, deviation is reported (N):

$$N = (R_i - VaR_i) > 0 \qquad (14)$$

When assessing the instruments whose positions may be only one way (only long or short) which are also referred to as one-way instruments, deviations are registered only in cases of negative shifts. When two-way instruments are considered – these are the instruments whose positions may alter in two directions (both long and short), deviations are registered in case of both positive and negative shifts of results. The time and the extent of the deviation are registered ($R_i - VaR_i$). The assessment of the model is performed by calculating the relative value of deviations during the observed period:

$$Sant = \frac{\sum N}{D \cdot m} \qquad (15)$$

Sant – relative number of deviations during the period.

N – number of observed deviations during the explored period.

D – analyzed cases during the explored period.

m – number of possible changes in an instrument (1 for one-way instruments; 2 – for two-way instruments).

As confidence level of the risk valuation model is 99 %.; therefore, it is assessed whether the number of deviations does not exceed 1 %. If percentage of deviations exceeds 1 %. for three months successively, then, VaR premium is applied to the risk valuation model. In order to determine the risk premium, these amounts of risks are calculated to the received result of the risk valuation model:

The average risk premium is calculated as the medium deviation from the calculated VaR:

$$VRP = \frac{\sum ND}{\sum N} \qquad (16)$$

VRP – average risk premium.

ND – extent of the observed deviations during the researched period when negative results of back testing were observed.

N – the number of observed deviations during the researched period when negative back testing results were observed.

The maximum risk premium is calculated as the maximum deviation from the calculated VaR:

$$MRP = MAX\ (ND) \qquad (17)$$

MRP – maximum risk premium.

ND – value of deviations in researched period excluding the maximum value.

After establishing the risk premium, it is added up to the VaR value of the portfolio of the following month.

3. APPLICATION OF THE CENTRAL BANK FOREIGN EXCHANGE RESERVES MANAGEMENT MODEL FOR THE INVESTMENT PORTFOLIO FORMATION

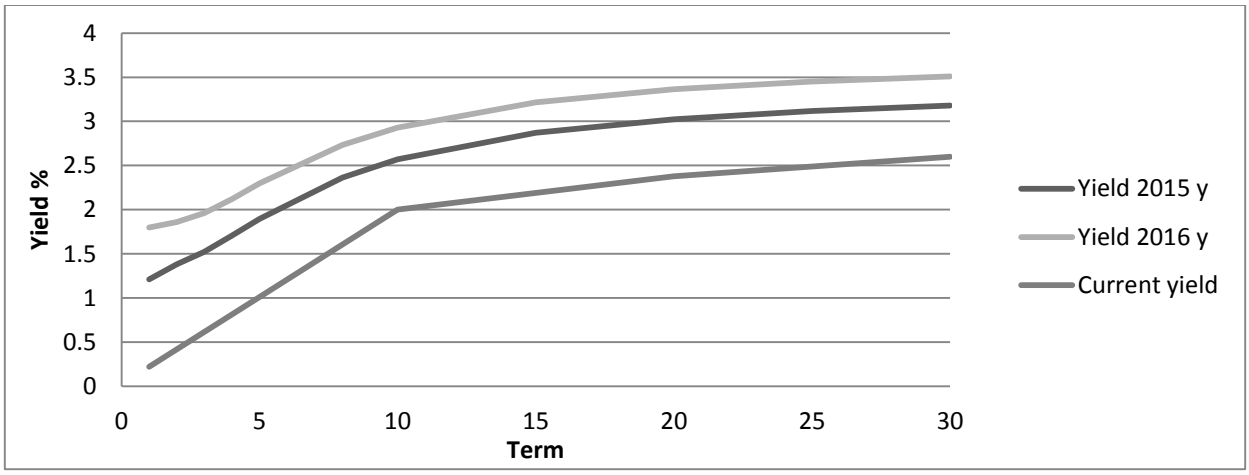
This part of the thesis is aimed at testing the developed model. Model is tested using market data, creating the investment portfolio and assessing investment portfolio return and risk The model is assessed following the six-step sequence presented in Part Two. Risk assessment is conducted by employing the debt securities portfolio risk assessment model developed by the author. The results of the tactical and investment portfolios are researched for the period of January 1, 2015 until December 31, 2015.

Assessment of the factors affecting the USA and Eurozone bonds and stock markets. To generalize on the dynamics of the USA yields and the stock market during the discussed period, evidently, during specific stages of quantitative easing (QE), the yields of all bond terms except for 1-year term, was increasing. The general decline of the yields of long-term securities (10, 20 or 30 years) during the period of quantitative easing was determined by the fall of the yields after the termination of specific stages of quantitative easing. What is more, when the Federal Reserve System started to decrease the extent of quantitative easing, the yields were still rising for some time; however, they shrank afterwards. The impact of quantitative easing in the USA market is positive, and the stock market was rising during the entire period of QE. Furthermore, statistically reliable relationship was established between the researched USA macroeconomic factors and the yields and the stock market. Only 1 year USA government bond yield was not statistically related with the PMI and inflation expectations and 5 years USA government bond yield was not related with the expectations of inflation.

For the assessment of the yields and the macroeconomic factors of the Eurozone, the determination coefficients of all the regression equations are extremely high (above 0.9), which means that the derived regression model adequately describes the relationship between the variables and bond yield and stock index. Analysis of 1 year government bonds did not deliver statistically reliable relationship with the inflation and the amount of money. The absence of a statistical relationship may be explained if the discussed period is considered. This is a period of the base interest rate decrease; yet,

base interest rates strongly impact short term yields. That is why other factors impacting the yields may not be reflected in the context of the decrease of the base interest rate. When the regression analysis of 5 and 10-year bond yields was conducted, statistically reliable relationship with the yields was established for all the researched variables. Analysis of the longest researched period (20 years) did not exhibit statistically reliable relationship with the IP Index. This result may be explained by the length of the period as the IP Index reflects the expectations of the nearest future; yet, the 20-year-long period is excessively long as there is sufficient time for compensating poorer expectations. Statistically reliable relationship was also observed between the DAX Index and the macroeconomic variables. Only one factor (inflation expectations *p* value) slightly exceeded the level of 0.05.

USA and Eurozone yield curve forecast on the grounds of market factor expectations. Considering the identified USA and Eurozone factor expectations and using the Nelson Siegel model, average yield curves of the USA and the Eurozone were produced.

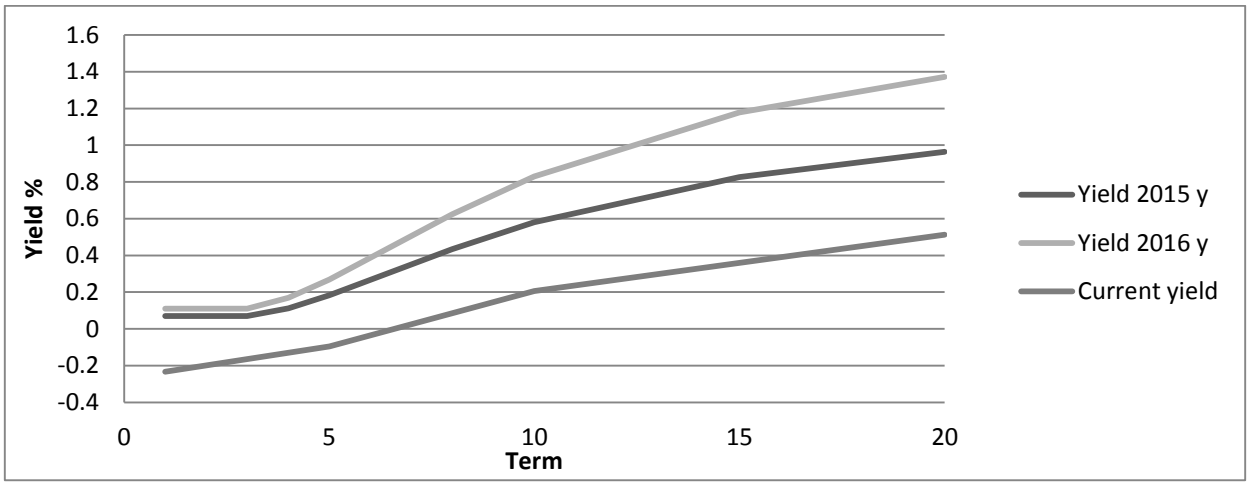


Source: produced by the author based on the data of *Bloomberg*

Figure 9. USA yield curve forecast based on the Nelson Siegel model

The yield curve of 2015 is above the current curve; this shows that the yield of 2015 in comparison with the current yield should be increasing. Also, a flattenering is being forecast for the curve in 2015 as well as in 2016; hence, the difference between the short term and long term yield will be decreasing.

A forecast on the Eurozone yield curve is shown in Figure 10.



Source: produced by the author based on the data of *Bloomberg*

Figure 10. Eurozone yield curve forecast based on the Nelson Siegel model

The obtained results highlight the increase of the Euro interest rate. It was also observed that the shapes of the yield curves for 2015 and 2016 differ as the curve for 2016 is steeper. This rise of the curve demonstrates that the yield of the longer term increases more rapidly than the short term yield.

Thus the different shapes of yield curves in the USA and the Eurozone were modeled. The Eurozone curve is denoted by its steepness; hence the difference between the short term and the long term yields is expected to be growing. Meanwhile, in the USA, to the contrary, due to the forecast of the flattener curve, the yield difference between the short term and the long term will be decreasing. In this case, central banks investing foreign reserves should consider longer term securities of the Eurozone at the same time shortening the investment period of its US investments.

Allocation of the investment portfolio of a central bank. Having established the balance points, market expectations for the period of the next two years (2015 and 2016) were outlined to be used in the Black Litterman model:

1. USA 1 year gov. bond yield will be higher by 283 basis points than the Eurozone 1 year gov. bond yield.
2. USA 5 year gov bond yield will be higher by 374 basis points than the Eurozone 5 year go. bond yield.
3. USA 10 year gov. bonds yield will be higher by 409 basis points than the Eurozone 10 year go. bonds yield.

4. USA investment rating corporate bond yield will be higher by 356 basis points than the Eurozone investment rating corporate bond yield.
5. EU stock market will have 2.74 percentage points higher return than the USA stock market.

For the modeling of the portfolio, the historical yields were calculated for the period from 2010 to 2014. Diversification restrictions were produced on the grounds of the central bank investment criteria by applying the limitation on diversification so that no investment into some kind of assets could exceed 15 %. The optimization of the portfolio was performed in order to maximize the Sharpe ratio for the portfolio. After performing the modeling of the asset allocation, the following results of the Black Litterman model were obtained:

Table 2. **Portfolio optimization by applying the Black Litterman model**

Security	Limitations on diversification	BL portfolio weights with limitations	Portfolio return	Portfolio variation	Sharpe ratio of the portfolio
EZ 1 year VVP	≥15 %	0,00%	0,0305	0,0499	0,1366
EZ 5yrs. VVP	≥15 %	0,00%			
EZ 10yrs. VVP	≥15 %	13,48%			
EZ Investment rating businesses SVP	≥15 %	13,40%			
Stoxx 600	≥15 %	7,82%			
USA 1 year VVP	≥15 %	15,00%			
USA 5yrs. VVP	≥15 %	15,00%			
USA 10yrs. VVP	≥15 %	15,00%			
S&P 500 index	≥15 %	5,30%			
USA Investment rating businesses SVP	≥15 %	15,00%			

Source: produced by the author based on the data of *Bloomberg*

As the next step, according to the obtained results of the Black Litterman model strategic asset allocation, the tactical asset allocation was also performed. The tactical asset allocation is composed from the Eurozone and the US bonds and the stock market indexes. For the portfolio, Merrill Lynch indexes reflecting the bond market and some of the main indexes of the stock market – Stoxx 600 for the Eurozone and S&P 500 for the USA were selected.

Table 3. **Tactical asset allocation**

Index	Portfolio weights	Return, 2015.
BofA Merrill Lynch 1-10 Year Euro Government Index	13.48%	1.15%
BofA Merrill Lynch Euro Corporate Index	13.40%	-0.55%
Stoxx 600	7.82%	6.93%
BofA Merrill Lynch 1-10 Year US Treasury Index	45.00%	1.10%
S&P 500 index	5.30%	-0.70%
BofA Merrill Lynch US Corp Master	15.00%	-0.94%

Source: produced by the author based on the data of *Bloomberg*

The table presents the tactical portfolio risk and return results during the period of 2015.

Table 4. **Return and risk results for the tactical asset allocation, 2015.**

	Tactical portfolio	Benchmark portfolio
Return	0.94%	0.83%
Standard deviation	2.85%	3.14%
VaR of the period	6.63%	7.30%
Sharpe ratio	0.1652	0.1149

Source: produced by the author based on the data of *Bloomberg*

The weights of the benchmark portfolio were selected according to the criteria on the composition of the investment portfolio applied in central banks. The data shows that the suggested tactical portfolio based on the model of the foreign reserves management during the discussed period of 2015 was 11 basic points more profitable than the benchmark portfolio. When evaluating the risk of portfolios, the risk level of the produced tactical portfolio is lower than that of the benchmark portfolio. Due to the higher return of the tactical portfolio, the Sharpe ratio of this portfolio was higher, which shows that the tactical portfolio is more efficient. The **results** of the asset allocation based on the central bank foreign exchange reserves management model **demonstrate the applicability and usefulness of the model for the central bank foreign exchange reserves management.**

Considering the results of the tactical asset allocation, the investment portfolio for a central bank was constructed. Here, securities denominated in Euro and US Dollars were included. Portfolio currency risk is not hedged. Exchange rate changes are not included into portfolio performance assessment, because portfolio manager if it is necessary can hedge currency risk. Hedging decisions depends on central bank total open currency position, which is calculated not only from investment portfolio position, but from the whole balance position. The portfolio was structured by investing into specific corporate and government bonds. For the investments into the Eurozone, four countries

were selected: Germany was picked as the leading country possessing the highest AAA credit rating; Lithuania and Slovenia were selected as countries given a slightly lower credit rating which is still exclusively high, A-; Italy was selected as the Eurozone country with the lowest investment rating BBB-. For the investments into the stock market, exchange traded funds representing the USA and the Eurozone were selected.

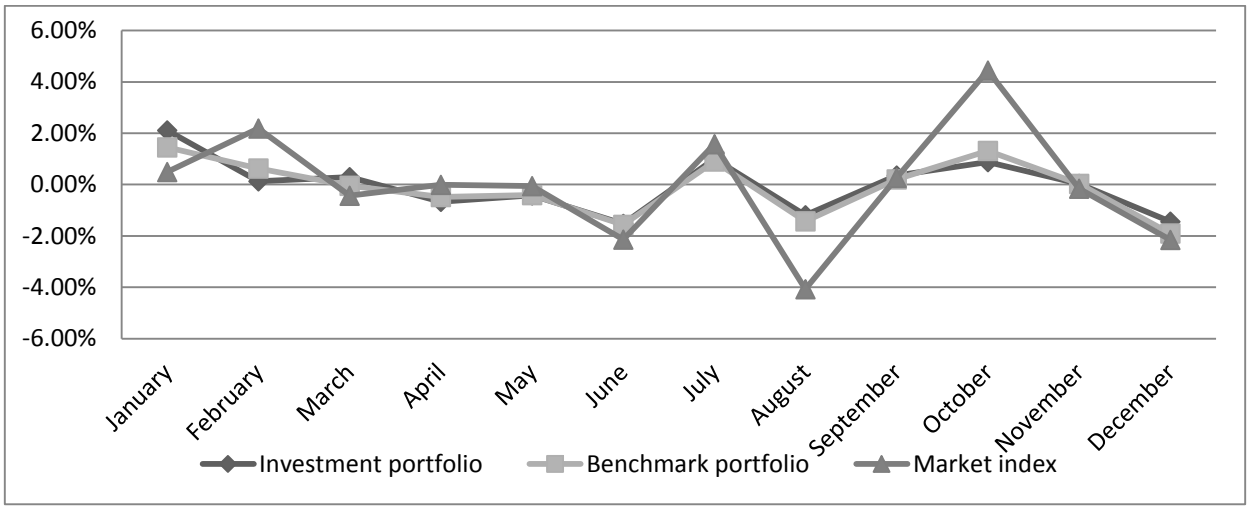
Table 5. **Investment portfolio structure and return in 2015.**

Asset allocation	Securities	Yield/Return	Part of the portfolio
Eurozone governments bonds 5 – 10 yrs.	Germany 7-10yrs.	0,32%	3,37%
	Lithuania 7-10yrs.	4,61%	3,37%
	Slovenia 7-10yrs.	3,48%	3,37%
	Italy 7-10yrs.	0,87%	3,37%
	Total:	9,27%	13,48%
Eurozone Investment Rating Corporate Bonds	Deutche Telekom 7yrs.	-2,49%	13,40%
Eurozone stocks	iShares MSCI Eurozone ETF	6,46%	7,82%
Total Eurozone		**13,24%**	**34,70%**
USA Treasury Bonds	USA 1-3yrs.	0,04%	15,00%
USA Treasury Bonds	USA 3-5yrs.	2,31%	15,00%
USA Treasury Bonds	USA 7-10yrs.	-1,69%	15,00%
USA Treasury Bonds	Total:	0,66%	45,00%
USA Investment Rating corporate bonds	Home Depot 3yrs.	0,15%	15,00%
USA stocks	SPDR S&P 500 ETF	-0,76%	5,30%
Total USA		**0,04%**	**65,30%**
Black Litterman portfolio return		**0,56%**	
Benchmark portfolio return		**0,36%**	
Market return		**0,51%**	

Source: produced by the author based on the data of *Bloomberg*

The table evidently shows that the segment of the investments into the Eurozone within the portfolio was more profitable than the investment into US. This result was determined by the higher return of the European stocks and the superior return of the bond market. The return of the investment portfolio during the discussed period of 2015 was 0.56% which was 20 basic points higher than the return of the benchmark portfolio.

A larger segment of the investment portfolio was invested into the US market; however, the return on this investment was smaller than the return on the Eurozone investment. The best return was obtained from the Eurozone stocks and the bonds of the Government of Lithuania. From the US assets, the best return was provided by medium length government bonds.



Source: produced by the author based on the data of *Bloomberg*

Figure 11. Investment portfolio, benchmark portfolio and market return dynamics in 2015

Only during 3 months (February, April and October) out of the researched 12-month period, the return on the investment portfolio was lower than that on the benchmark portfolio. This allowed the investment portfolio to ensure higher returns than the benchmark portfolio, which by default shows that the investment portfolio derived according to the developed foreign exchange reserves management model allowed earning higher return. However, only the assessment of the return is not sufficient for the efficiency evaluation. That is why Table 6 presents data on the risk and returns of the investment portfolio and the benchmark portfolio.

Table 6. **Data on the risk and returns of the investment portfolio in 2015**

	Investment portfolio	Benchmark portfolio	Market index
Return	0.56%	0.36%	0,51 %
Standard deviation	2.73%	2.71%	7,68 %
VaR of the period	5.56%	5.62%	17,68 %
Modified duration	5,44	4,78	n/a
Sharpe ratio	0.0345	-0.0409	0,0025

Source: produced by the author based on the data of *Bloomberg*

According to the proposed model of the management of foreign exchange reserves, the composed investment portfolio of foreign exchange reserves was more efficient than the benchmark portfolio and market index. The investment portfolio earned more return per risk unit. Hence it may be stated that the suggested model of management of foreign exchange reserves allows the central bank to invest foreign exchange reserves more profitably under the same levels of undertaken risks. The proposed **model allows efficient distribution of foreign exchange reserves between bonds and stocks and results in superior return without facing extra risks**.

Results of the risk assessment model. During the discussed period, the deviations of the back testing of the risk assessment model exceeded the allowed limit of 1 % 8 times. These results were conditioned by various turmoils of financial markets (the Greece debt crisis and its likely bankruptcy, the sudden fall of the stock market of China, the expectations of the increase of the base interest rate of the Federal Reserve System) determining extreme colatility in financial markets. The fact that deviations of the model were encountered is not a negative phenomenon as the methodology of risk assessment is developed in such a way that under extreme volatility in the market the model should still be applicable under the encountered conditions. In January and February 2015, the results of back testing exceeded the maximum limit two months in a row. That is why in March 2015, the calculations of the VaR model were applied the additional value of the deviation observed in February 2015. By analogy, when calculating the VaR in March 2015, the principle of conservatism was adhered to, and the VaR was increased by adding the above outlined value. The excess beyond the maximum limit was also observed in April and May 2015; that is why the calculation of the VaR of July featured the addition of the medium deviation of May. Even despite the application of the addition, the percentage of the back testing breaches in June still exceeded the maximum allowed value. That is why due to the extreme conditions in the market, to the VaR of July 2015, the maximum supplementary value was also added which equaled the maximum deviation of June 2015. This addition allowed to evaluate portfolio risk more precisely in July 2015. When back testing was performed in July, no risk assessment model deviations were observed from the factual results of the market.

The outlined results also demonstrate that the risk assessment model gave positive results, and during the other periods, deviations were either not encountered or they did not exceed the maximum limit of 1 %. **These results lead to a conclusion that the model properly and reliably allows assessing the risks of the debt securities portfolio.** Besides, the derived methodology approves the application of the model for unfavorable market conditions. When performing back testing under unfavorable market conditions, the conservatism principle is employed, and corrections of the VaR model may be performed by adding the corresponding supplementary value. In this way, the model is applicable under exceptional conditions when volatility increases in the market.

CONCLUSIONS

1. According to theorical approach of scientific literatere, foreign exchange reserves are linked with CB objective to maintain the internal and external stability of currency exchange rate, discount rate implementation and CB operational function. Foreign exchange reserves are appreciated as the source of CB income and government revenue.

According to analysis of scientific literature, it was identified the changes of foreign exchange reserves management principles, prioritizing return rather than liquidity. This change was determined by increased reserves amount and low bonds yield. The priority of high return determined the choice of stocks and corporate bonds as CB investment instrument. When higher return investment instruments are included into a portfolio, the undertaken risk increases as well.

2. According to systemized scientific researches of CB‘s investment portfolio formation and management, classical Markowitz and CAPM portfolio management models are not suitable for CB due to specific CB reserves management criteria. It is assumed, that theorical aspects of Black-Litterman model satisfies the CB reserves investment portfolio formation requirements and specifications considering that Black-Litterman model is able to reach diversified asset allocation.

It is instituted, that the main foreign exchange reserves management problem upsprings in allocation process. According to scientific literature portfolio allocation logical scheme was created summarizing the investment portfolio allocation process. The scheme demonstrates, that asset allocation should be performed on grounds of risk and secondary matter - return. Portfolio asset allocation decisions should focus not on the asset allocation, but on risk allocation, which acts as determinant for investment in different asset classes.

3. By summarizing risk management conceptions, it is stated that various single risk assessment methods are analysed in scientific literature, even CB investment portfolio risk has to be evaluated integrating several risk evaluation methods. Modified duration and VaR methods assort with CB foreign exchange reserves portfolio risk management, but still lack of scientific researches how these methods would operate in complex portfolio risk management system.

Debt securities portfolio risk management is analysed focusing only on a market risk, however, debt securities total portfolio risk distribution to credit risk and market risk are not considered among scientists adequately. The discussed methods are able to evaluate the total portfolio risk level, but the methodology distinguishing market risk and credit risk is in demand.

4. Having analysed foreign exchange reserves management role in CB activity and foreign exchange reserves investment portfolio formation and risk management specialities, the *CB foreign exchange reserves management system* was created. The created system combines four main foreign exchange reverves management sides: reliance of CB objectives, objectives of reserves holding and reserves management criterion; foreign exchange reserves allocation proccess; foreign exchange reserves investment portfolio risk management; investment portfolio formation and results evaluation. The first three sides are foundation of foreign exchange reserves management.

5. Having analysed theorical and practical sides of CB investment portfolio risk management, methods suitable for foreign exchange reserves management were designated:

- Modified duration method was chosen after evaluation of bonds prices and yield relation.
- By analising 12 interest rate curve forecasting methods, it was instituted, that the majority of models were designed for short-term interest rate curve forecast. Having analysed the theorical and practical aspects of Nelson-Siegel model proclaimed the best results in comparison with other interest rate forecasting models. In consequence, this method was chosen for the central bank foreign exchange reserves model.
- According to analysis of VaR methods, the variance-covariance method is the most suitable in view of CB portfolio structure. On the basis of this method, foreign exchange reserves risk management model was constructed in compelment with Cornish-Fisher extension. This model is integrated in the whole foreign exchange reserves management model and is able to exclude market and credit risk constituents.

6. Having analyzed theorical and practical possibilities to integrate Black-Litterman model in CB foreign exchange reserves management, implementation possibilities were set. Inputs of Black-Litterman model was distinguished as following 1) yield curve module 2) monetary policy expectations: amount of money supply; 3) economics factors expectations: economic expectations (GDP, PMI, IP), inflation expectations, unemployment.

7. The six-step *foreign exchange reserve management model* has been developed. In **Step One**, risk factors, which influence bond and stock markets, are evaluated. Particular variables are determined according to research of bonds and stock market factors. In **Step Two**, the market factor expectations are identified. These expectations are further used in Nelson-Siegel and Black-Litterman model. **Step Three** is about interest rate curve forecasting using Nelson-Siegel method. Modulus of interest rate curve it is derived, which enables to predict yield curve changes in the future. **Step Four** is about calculation of expected return of portfolio assets on the grounds of *Step Two and Three* information using Black-Litterman model. The result of this step is portfolio allocation structure. In **Step Five** benchmark, which describes asset allocation is composed according to the results of *Step Four* and risk limits. The created portfolio testing is performed on **Step Six** as well as evaluation of portfolio return and risk. Backtesting method is used in order to evaluate if portfolio results exceed VaR value. According to the calculted portfolio results, asset alocation is improved.

8. According to analysis of factors influencing USA and Eurozone government bonds yield and stock prices, the results are as following:

- The yield of USA goverment bonds (except 1 year term) was constantly growing during the separate quantitive easing periods. Yield of long-term bonds (10 years, 20 years, 30 years) overall yield decrease during quantitative easing period was determined by the decrease of yield after the finish of separate quantitave easing periods. What is more, when the Federal Reserve System started to decrease the extent of quantitative easing, the yields were still rising for some time; however, they shrank afterwards. The impact of quantitative easing in the USA market is positive, and the stock market was rising during the entire period of QE. Furthermore, statistically reliable relationship was established between the researched USA macroeconomic factors and the yields and the stock market. Only

1 year USA government bond yield was not statistically related with the PMI and inflation expectations and 5 years USA government bond yield was not related with the expectations of inflation.

- Yield of the eurozone bonds was declining during interest rate cutting period. The analysis of stock market dynamics suggested that stock market had started to grow constantly only at 2011. Very high determination coefficients of the regresion equation was calculated evaluating bonds yield and macroeconomic factors relation. Analysis of 1 year government bonds did not deliver statistically reliable relationship with the inflation and the amount of money. Analysis of the longest researched period (20 years) did not exhibit statistically reliable relationship with the IP Index. Statistically reliable relationship was not also observed between the DAX Index inflation expectations.

9. After the research of developed foreign exchange reserves management model application, it was stated:

- The tactic and investment portfolio, which are formed according to the created model, return results are higher than benchmark portfolio results in 11 and 20 basis point respectively. Portfolios constructed according to developed reserves management model are more effective, because they have higher return to risk unit. The test of foreign exchange reserves management model has confirmed that this model based on Black-Litterman methodology allows distribute reserves among bonds and stocks more effectively.
- Risk assessment model backtesting deviations exceeded the limit of 1 % eight times. These results were conditioned by various financial markets turmoils, however, because of higher financial market volatility additional VaR values were used, which allowed to evaluate portfolio risk more precisely. The risk assessment model gave positive results, and during the other periods, deviations were either not encountered or they did not exceed the maximum limit of 1 % According to backtesting results, it was come to a conclusion, that risk evaluation model properly and reliably allows to assess debt securities portfolio risk and distribute it into credit and market risk components. Besides, the derived methodology approves the application of the model for unfavorable market conditions.

DAKTARO DISERTACIJOS SANTRAUKA

Temos aktualumas. Centriniai bankai finansų rinkoje užima ypatingą vietą, užtikrindami kainų, šalies ekonomikos ir finansų sistemos stabilumą. Užsienio rezervų valdymas yra viena iš centriniams bankams deleguotų funkcijų, kurių įgyvendinimas reikšmingas ir bankui, ir valstybei. Pelnas, gaunamas iš rezervų, skiriamas centrinio banko išlaikymui, taip pat pelno dalis pervedama į šalies biudžetą. Užsienio rezervų valdymo rezultatus lemia ne tik tinkamas rezervų valdymo strategijos pasirinkimas bei jos įgyvendinimas, bet ir pokyčiai finansų rinkose. Išaugus užsienio rezervų apimčiai, mažėjant žemos rizikos vyriausybės vertybinių popierių pajamingumui ir didėjant rezervų laikymo kaštams, iškyla poreikis plėtoti naujas užsienio rezervų valdymo koncepcijas. Dėl finansų rinkose vyraujančios žemų palūkanų aplinkos centriniai bankai yra priversti ieškoti naujų investicinių priemonių. Didesnės grąžos problema, esant žemų palūkanų normų aplinkai, aktuali ne tik centriniams bankams, bet ir kitiems investicinių portfelių valdytojams, tačiau specifiniai centrinių bankų investavimo kriterijai daro šių institucijų investicinio portfelio valdymą išskirtinį, todėl šiame darbe analizuojamas būtent centrinių bankų investicinio portfelio valdymas. Investuoti užsienio rezervus į žemos rizikos vyriausybės vertybinius popierius nebepakanka, kadangi šių priemonių pajamingumas yra žemas ar netgi neigiamas. Siekdami didesnės grąžos centriniai bankai yra priversti užsienio rezervus nukreipti į rizikingesnes finansines priemones. Tokiu būdu valdant rezervus nuo likvidumo svarbos pereinama prie didesnio pelningumo siekio, o tada reikia keisti rezervų valdymo sistemą. Pakitus užsienio rezervų investavimo politikai, reikia taikyti likvidumo ir pelningumo derinimu pagrįstus rezervų valdymo metodus, kadangi išaugus pelningumo svarbai didėja prisiimamas rizikos lygis, tačiau poreikis išlaikyti reikiamą rezervų likvidumo lygį išlieka.

Investicijų valdymo modeliai nuo pirmųjų J. Treynor ir W. Sharpe ilgalaikio turto įkainojimo modelio (CAPM) bei H. Markowitz optimalaus portfelio modelio buvo nuolat tobulinami. Tačiau, pakitus kapitalo rinkų struktūrai ir savybėms, daugelis modelių tapo sunkiai pritaikomi. Dabartinėje finansų teorijoje, kaip vienas iš centriniams bankams reikšmingų modelių, yra minimas Black Litterman modelis, tačiau jo pritaikymas centriniams bankams iki galo neišnagrinėtas. Mokslinėje literatūroje nėra

bendros teorijos, kuri apibrėžtų, kaip centriniai bankai turėtų vykdyti aktyvų alokacijos procesą ir sudaryti strateginį investicijų portfelį į jį įtraukiant rizikingesnius finansinius instrumentus. Investuojant į šiuos instrumentus auga centrinio banko investicinio portfelio rizika, o iš to kyla poreikis naujiems rizikos vertinimo metodams, kurie leistų patikimai įvertinti ir valdyti portfelio riziką.

Mokslinė problema ir jos ištyrimo lygis. Valdant centrinio banko užsienio rezervus, iškyla poreikis taikyti patikimus metodus rizikai valdyti ir pelningumui prognozuoti. Pagrindžiant užsienio rezervų investicinio portfelio sudarymo ir valdymo metodus, mokslinėje literatūroje pateikiama nemaža tyrimų, kuriuos sisteminant išryškėja šios pagrindinės tyrimų kryptys: užsienio rezervų valdymo politikos pasikeitimas, investicinio portfelio sudarymas taikant matematinius metodus, rizika, atsirandanti užsienio rezervų valdymo procese, ir investicinio portfelio rizikos valdymo metodai.

Mokslinėje literatūroje užsienio rezervų valdymo problematiką nagrinėja J. Nugee (2004), Z. Zhang, F. Chaua ir L. Xie (2012), M. Williams (2005), S. Roger (1993), A. Scalia ir B. Sahel (2011), G. Baksay, F. Karvalits ir Z. Kuti (2012), B. Wijnholds ir A. Kapteyn (2001), S. Claessens ir J. Kreuser (2006), U. J. Walther (2012), G. Pineau, E. Dorrucci, F. Comelli ir A. Lagerblom (2006), C. Abdelnour (2007), J. Philman ir H. Hoom (2010), D. Zhang ir C. Zhou (2013), B. H. Putnam (2004), M. Obstfeld, J. C. Shambaugh ir A. M. Taylor (2008). Šie mokslininkai apibendrina užsienio rezervų valdymo kriterijus ir jų vaidmenį centrinio banko veikloje.

Rezervų valdymo politikos pasikeitimą ir iš to kylančias rezervų valdymo problemas analizuoja G. Pineau ir kt. (2006), U. J. Walther (2012), U. Bindseil ir kt. (2009), J. Philman ir H. Hoom (2010), E. Lavigne (2003), M. Williams (2005), F. Salman ir A. Salih (1999), J. Nugee (2004), L. Goldberg, C. E. Hull ir S. Stein (2013), D. Rodrik (2006), S. Roger (1993), S. Edwards ir L. Ahamed (1986), J. M. Landell-Mils (1989), R. McCauley, J. F. Rigaudy (2011), A. Morahan ir C. Mulder (2013), C. Borio, G. Galati ir A. Heath (2008), I. Clacher, R. Faff, D. Hillier ir S. Mohamed (2004). Šie mokslininkai išskiria pagrindinius rezervų valdymo politikos pasikeitimo aspektus, tačiau savo darbuose nenagrinėja, kaip prie pasikeitusių sąlygų pritaikyti naudojamus turto alokacijos ir rizikos vertinimo metodus bei sudaryti centrinių bankų užsienio rezervų investicinį portfelį.

Mokslinėje literatūroje investicinio portfelio sudarymas ir valdymas dažniausiai modeliuojamas naudojant CAPM modelį ir vidurkio – variacijos modelį, už kurį Harry Markowitz 1990 m. gavo Nobelio premiją. Tokius modelius moksliniuose tyrimuose naudoja ir Marc C. Steinbach (2001), Yusif Simaan (1993), B. H. Putnam (2004), R. Michaud (1989), F. Black ir R. Litterman (1992), S. Mei ir J. Li (2008), J. Li, H. Huang ir X. Xiao (2012), J. Fernandes ir kt. (2012), C. Leon ir D. Vela (2011), F. Black ir R. Litterman (1991), W. Drobetz (2001). Mokslinėje literatūroje pateikiama nemažai CAPM ir H. Markowitz modelių modifikacijų bei kitų matematinių statistinių modelių, kuriuos apibendrino R. Michaud (1998), S. Mei ir J. Li (2008), J. Fernandes (2012). Siekdami portfelio sudarymo procese eliminuoti CAPM ir H. Markowitz modelių trūkumus, A. Reveiz ir C. Leon (2010), W. Lee (2000), T. M. Idzorek (2005), J. Fernandes (2012), C. Mankert (2006), F. Black ir R. Litterman (1992) pasiūlė naudoti ir savo darbais pagrindė Black Litterman modelį. Šio modelio teorinę koncepciją plėtojo W. Lee (2000), S. Satchell ir A. Scowcroft (2000). Praktinį modelio pritaikymą nagrinėjo A. Bevan ir K. Winkelmann (1998), G. He ir R. Litterman (1999), U. Herold (2003), T. M. Idzorek (2005), R. Jones, T. Lim ir P. J. Zangari (2007). Black Litterman modelį apribotų rizikos fondų (angl. *hedge fund*) veikloje pritaikė M. Kooli ir M. Selam (2010), L. Martellini ir V. Ziemann (2007), tačiau šio modelio veikimas centriniuose bankuose nebuvo tirtas.

Užsienio rezervų valdymo rizikos rūšis ir valdymo būdus mokslinėje literatūroje analizuoja M. Fridson ir C. McLeod-Salmon (2011), W. Elshof ir R. H. A. Van Beers (2012), U. J. Walther (2012), F. W. Sharpe ir kt. (1999), T. Manchev (2009), E. Walker (2007), Y. Romanyuk (2012). Globalaus portfelio apdraudimą naudojant išvestines finansines priemones apibendrina S. Krull ir A. Rai (1992), F. Black (1990), J. F. Rigaudy (2000) ir S. Claessens, J. Kreuser (2006), o galimas apsidraudimo strategijas analizuoja L. S. Hoon (2011) ir E. Stalstedt (2006). Centrinių bankų investicinių portfelių apdraudimą nuo valiutinės rizikos analizuoja R. J. Caballero ir S. Panageas (2005).

Akademinėje literatūroje taip pat nagrinėti aktualūs rizikos valdymo metodai. Modifikuotos finansinės trukmės metodą (MFT) analizuoja S. Noorali ir C. Santos (2005), M. Fridson ir C. McLeod-Salmon (2011), A. Scalia ir B. Sahel (2011), B. H. Putman (2004). VAR metodiką nagrinėja M. Dwyer ir J. Nugee (2004), V. Sakalauskas

ir D. Krikščiūnienė (2006), M. A. Lajeune (2009). CVAR nagrinėja R. T. Rockafellar ir S. P. Uryasev (2000), S. Claessens ir J. Kreuser (2004), C. Acerbi ir D. Tasche (2001), P. Artzner ir kt. (1999), G. Flug (2000), R. T. Rockafeller ir S. Uryasev (2002). Nors atskiri rizikos valdymo matai ir jų veikimas mokslinėje literatūroje išnagrinėti gana plačiai, nėra tirta, kaip MFT ir CVAR metodai veiktų kartu.

Užsienio rezervų valdymo politikos pasikeitimas, orientuotas į didesnio pelningumo siekį, nulemia tai, jog centrinio banko investicinio portfelio sudarymo ir rizikos valdymo metodai turi būti pritaikyti prie naujų investavimo gairių. Centrinių bankų investicinių portfelių sudarymas ir valdymas mokslinėje literatūroje yra labai mažai nagrinėtas, o jeigu ši problema ir tirta (Fisher ir Lie 2004), tai tyrimai apsiriboja vyriausybės obligacijų portfeliu į jį neįtraukiant rizikingesnių instrumentų.

Apibendrinus aptartus probleminius analizuojamos temos aspektus suformuluota mokslinė problema – *kaip efektyviai valdyti centrinio banko investicinį portfelį į jį įtraukiant skirtingo rizikingumo aktyvus?* Šiame darbe mokslinė problema sprendžiama dviem aspektais: 1) *aktyvų alokacija tarp skirtingos rizikos finansinių instrumentų* – darbe pateikiamas centrinio banko užsienio rezervų investicinio portfelio sudarymo modelis, leidžiantis paskirstyti užsienio rezervus tarp skirtingo rizikingumo aktyvų; 2) *investicinio portfelio rizikos valdymas* – sudaroma rizikos valdymo metodika, leidžianti įvertinti ir valdyti skolos VP portfelio riziką išskaidant ją į palūkanų normos ir kredito rizikų dedamąsias.

Disertacijos objektas – centrinių bankų užsienio rezervų valdymas.

Darbo tikslas – išanalizavus užsienio rezervų valdymo principus bei modelius, sukurti ir patikrinti centrinių bankų užsienio rezervų investicinio portfelio sudarymo ir valdymo modelį, apimantį investicinio portfelio rizikos valdymo bei skirtingo rizikingumo aktyvų alokacijos sprendimus.

Tikslui pasiekti keliami šie **uždaviniai**:

1. Išnagrinėti teorinius centrinių bankų užsienio rezervų valdymo ypatumus ir identifikuoti užsienio rezervų valdymo tikslus bei kriterijus.
2. Susisteminti užsienio rezervų aktyvų alokacijos proceso tyrimų mokslinėje literatūroje požiūrį.

3. Klasifikuojant centrinio banko investicinio portfelio rizikos valdymo ir vertinimo mokslinių bei empirinių studijų rezultatus, pateikti centrinio banko investicinio portfelio rizikos valdymo principus.

4. Išanalizavus centrinio banko investicinio portfelio rizikos valdymo bei aktyvų alokacijos metodus, sudaryti užsienio rezervų valdymo modelį.

5. Sudarytą centrinių bankų užsienio rezervų valdymo modelį patikrinti turimų duomenų pagrindu sudarant investicinį portfelį ir įvertinant jo pelningumą bei riziką.

Tyrimo metodai. Analizuojant centrinių bankų užsienio rezervų vietą centrinio banko veikloje ir užsienio rezervų valdymo tikslus bei kriterijus darbe taikomi šie metodai: lyginamoji ir sisteminė mokslinės literatūros šaltinių analizė, sisteminimas ir apibendrinimas.

Išskiriant pagrindines centrinių bankų investicinio portfelio sudarymo ir valdymo tyrimų mokslinėje literatūroje problemas bei vertinant užsienio rezervų valdymo rizikos konceptualius požiūrius naudoti mokslinės literatūros sintezės, grupavimo ir lyginamosios analizės metodai. Kuriant užsienio rezervų valdymo modelį taikyti dedukcijos, sintezės ir lyginamosios analizės metodai.

Tikrinant sudarytą užsienio rezervų valdymo modelį naudoti matematinis, statistinis ir ekonometrinis metodai. Akcijų ir obligacijų rinkoms įtaką darantys veiksniai atrinkti remiantis koreliacine ir regresine analize. Centrinio banko investicinis portfelis suformuotas taikant matematinį modeliavimą ir optimizavimą. Vertinant pagal užsienio rezervų valdymo modelį sudaryto investicinio portfelio pelningumo ir rizikos rezultatus naudota aprašomoji statistika, grafiniai metodai.

Tyrimo apribojimai. Disertantas siekia sudaryti modelį, kuris pagal savo koncepciją būtų tinkamas centriniams bankams siekiant efektyviai valdyti užsienio rezervus. Modelio kūrimui pasirinkti metodai remiasi prielaidomis ir rinkos veiksnių ateities lūkesčiais, todėl užsienio rezervų valdymo modelio rezultatų tikslumas priklauso nuo teisingo ateities lūkesčių identifikavimo bei šių lūkesčių nuokrypio nuo realios finansų rinkos situacijos. Modelio rezultatų tikslumui įtakos gali turėti finansų rinkų krypties bei palūkanų normų aplinkos pasikeitimas, o taip pat monetarinės politikos sprendimai.

Darbo struktūra. Darbą sudaro įvadas, trys pagrindinės dalys, išvados ir pasiūlymai, literatūros sąrašas ir priedai.

Pirmoje darbo dalyje nagrinėjama užsienio rezervų valdymo koncepcija, akcentuojant rezervų valdymo politikos pasikeitimą. Taip pat šioje dalyje nagrinėjamos mokslinėje literatūroje pateikiamos pagrindinės centrinių bankų investicinio portfelio sudarymo ir rizikos valdymo problemos. Šioje dalyje autorius pateikia teorinę užsienio rezervų valdymo sistemą.

Antroje darbo dalyje analizuojami mokslinėje literatūroje siūlomi centrinio banko investicinio portfelio rizikos valdymo bei aktyvų alokacijos metodai. Išnagrinėjus teorinius ir praktinius metodų aspektus, įvertinus jų privalumus ir trūkumus, taip pat pritaikymą užsienio rezervams valdyti išskiriami metodai, tinkantys centrinio banko investiciniam portfeliui sudaryti ir rizikai valdyti. Atrinktų metodų pagrindu sudarytas užsienio rezervų valdymo modelis.

Trečioje darbo dalyje modelis patikrintas naudojant realius rinkos duomenis. Portfeliui sudaryti pasirinkti JAV ir euro zonos šalių vyriausybių bei investicinio reitingo įmonių skolos VP. Į portfelį taip pat įtraukti JAV ir euro zonos rinkų biržoje prekiaujami investiciniai fondai. Įvertinta pagal modelį sudaryto investicinio portfelio grąža ir rizika.

Darbo mokslinį **naujumą** atskleidžia šie gauti rezultatai:

Užsienio rezervų valdymas ir investicinio portfelio sudarymas analizuojami įvairių autorių, tačiau mokslinėje literatūroje nėra teorijos ar modelio, kaip centriniams bankams investuojant užsienio rezervus atlikti aktyvų alokaciją. Autorius sukūrė centriniams bankams tinkantį užsienio rezervų valdymo modelį ir pasiūlė modelio pritaikymo žingsnius, pagal kuriuos centrinis bankas gali suformuoti užsienio rezervų investicinį portfelį.

Pirmoje darbo dalyje atskleista užsienio rezervų valdymo vieta CB veikloje ir jų ryšys su CB tikslais, priemonėmis bei funkcijomis. Sudaryta užsienio rezervų valdymo politikos pasikeitimo schema, išryškinanti pagrindines užsienio rezervų valdymo tendencijas. Išskirtos pagrindinės centrinių bankų investicinio portfelio sudarymo ir rizikos valdymo tyrimų mokslinėje literatūroje problemos. Sudaryta apibendrinta aktyvų alokacijos proceso loginė schema. Autorius sukūrė teorinę užsienio rezervų valdymo sistemą, kurioje atsiskleidžia centrinio banko tikslo, rezervų laikymo tikslo ir rezervų valdymo kriterijų priklausomybė; užsienio rezervų alokacijos procesas, užsienio rezervų investicinio portfelio rezultatų įvertinimas.

Antroje darbo dalyje atrinkti aktyvų alokacijos ir rizikos valdymo metodai, tinkantys centrinių bankų užsienio rezervams valdyti. Iš atrinktų metodų ir remiantis teorinėje darbo dalyje suformuotomis užsienio rezervų valdymo modelio sukūrimą pagrindžiančiomis įžvalgomis sudarytas užsienio rezervų valdymo modelis, sujungiantis aktyvų alokacijos tarp obligacijų ir akcijų sprendimus bei rizikos valdymą. Į centrinių bankų investicinių portfelių sudarymą integruotas Black Litterman metodas ir pajamingumo kreivės prognozavimo metodika, kuri leidžia nustatyti laukiamą aktyvų pajamingumą ir jį taikyti aktyvų alokacijos procese. Taip pat modelyje integruota VaR rizikos valdymo metodika, leidžianti iš bendros skolos VP portfelio rizikos išskirti palūkanų normos ir kredito rizikos dedamąsias.

Darbo praktinė reikšmė. Sudarytas užsienio rezervų valdymo modelis, leidžiantis: 1) centrinio banko investicinio portfelio valdytojui įtraukti į portfelio sudarymo procesą rinkos lūkesčius; 2) atliekant aktyvų alokaciją pasiekti aukštesnę portfelio grąžą; 3) patikimai įvertinti ir valdyti skolos VP portfelio riziką esant nepalankioms rinkos sąlygoms.

Sukurtas užsienio rezervų valdymo modelis patikrintas empiriškai realiomis rinkos sąlygomis. Atsižvelgus į tai, kad autoriaus pasiūlytas užsienio rezervų valdymo modelis leidžia efektyviau investuoti užsienio rezervus pasiekiant didesnę grąžą bei patikimai ir tinkamai įvertinti investicinio portfelio riziką, siūloma šį modelį taikyti praktikoje centriniams bankams valdant užsienio rezervus.

Ginamieji disertacijos teiginiai:

1. Centrinių bankų užsienio rezervų valdymas turi būti grindžiamas susijusių ir suderintų veiksnių koncepcija, apimančia rinkos veiksnių vertinimą, rinkos veiksnių lūkesčių identifikavimą ir palūkanų normos kreivės prognozavimo parametrų nustatymą.
2. Pasiūlytas centrinių bankų užsienio rezervų valdymo modelis, paremtas Black Litterman metodika, leidžia efektyviau investuoti užsienio rezervus į skirtingo rizikingumo investicinius instrumentus.
3. Skolos VP portfelio rizikos valdymo modelis, integruojantis VaR, MFT ir palūkanų normų rizikos apdraudimo metodiką, leidžia patikimai išskirti bei įvertinti palūkanų normos ir kredito rizikos dedamąsias.

IŠVADOS

1. Išanalizavus centrinių bankų užsienio rezervų tyrimo teorines prieigas, identifikuotas instrumentinio požiūrio vyravimas, užsienio rezervus siejant su CB siekiamu vidinio ir išorinio valiutos kurso stabilumo tikslu, diskonto normos priemonės įgyvendinimu ir CB politikos operacijų funkcija. Užsienio rezervai vertintini kaip centrinio banko pajamų ir valstybės biudžeto įplaukų šaltinis.

Integruojant mokslinės literatūros analizės pagrindu atskleistus užsienio rezervų laikymo tikslų ir užsienio rezervų valdymo principų elementus, identifikuotas užsienio rezervų valdymo principų svarbos pasikeitimas, pereinant nuo likvidumo prie pelningumo principo. Šį pasikeitimą nulėmė išaugusi rezervų apimtis ir žemas obligacijų pajamingumas. Pelningumo prioritetas sąlygojo akcijų ir įmonių obligacijų kaip CB investicinių priemonių pasirinkimą, o į portfelį įtraukiant aukštesnio pelningumo investicinius instrumentus išaugo prisiimama rizika.

2. Susisteminus centrinių bankų investicinio portfelio sudarymo ir valdymo tyrimus išryškėjo, kad klasikiniai (Markowitz, CAPM) portfelio sudarymo modeliai dėl specifinių centrinių bankų rezervų valdymo kriterijų taikymo nėra tinkami centriniams bankams. Atsižvelgiant į tai, kad Black Litterman modelis leidžia pasiekti diversifikuotą turto alokaciją, darbe suformuota prielaida, jog Black Litterman modelio teorinės prieigos atitinka centrinių bankų rezervų investicinio portfelio sudarymui taikytino modelio ypatumus.

Nustatyta, kad pagrindinė užsienio rezervų valdymo problema iškyla alokacijos procese. Apibendrinus mokslo darbuose pateikiamą investicinio portfelio alokacijos procesą, parengta portfelio alokacijos loginė schema, kuri nurodo, kad aktyvų alokacija turėtų būti vykdoma remiantis ne tik pelningumu, bet pagrindinį vaidmenį suteikiant rizikai. Portfelio alokacijos sprendimai turėtų orientuotis ne į aktyvų alokaciją, o į rizikos alokaciją, pagal kurią turėtų būti priimami sprendimai, kiek investuoti į atskiras aktyvų rūšis.

3. Susisteminus rizikos valdymo koncepcijas, nustatyta, kad mokslo darbuose plačiai nagrinėjami įvairūs pavieniai rizikos vertinimo matai, nors centrinių bankų investicinio portfelio riziką reikia vertinti kompleksiškai, integruojant keletą rizikos vertinimo matų. CB užsienio rezervų portfelio rizikai valdyti išskirti modifikuotos

finansinės trukmės ir VaR metodai, tačiau kol kas mokslo darbuose nėra analizuota, kaip šie metodai veiktų bendroje portfelio rizikos valdymo sistemoje.

Skolos VP portfelio rizikos valdymas mokslinėje literatūroje nagrinėjamas akcentuojant tik rinkos riziką, tačiau nepakankamai analizuojamas skolos VP portfelio bendros rizikos išskaidymas į kredito ir rinkos rizikų dedamąsias. Nagrinėjami metodai leidžia išmatuoti bendrą portfelio rizikos lygį, tačiau reikalinga metodika, kuri leistų atskirti rinkos ir kredito rizikos dedamąsias.

4. Išnagrinėjus užsienio rezervų valdymo vaidmenį centrinių bankų veikloje ir užsienio rezervų investicinio portfelio sudarymo ir rizikos valdymo ypatybes, sukurta centrinio banko užsienio rezervų valdymo sistema, sujungianti keturis pagrindinius užsienio rezervų valdymo aspektus: centrinio banko tikslo, rezervų laikymo tikslo ir rezervų valdymo kriterijų priklausomybę; užsienio rezervų alokacijos procesą; užsienio rezervų investicinio portfelio rizikos valdymą; investicinio portfelio sudarymą ir rezultatų vertinimą. Pirmos trys sistemos dedamosios yra užsienio rezervų valdymo sistemos pamatas, į kurį remiasi visi rezervų valdymo sistemos aspektai.

5. Išnagrinėjus centrinio banko investicinio portfelio rizikos valdymo metodų teorinius ir praktinius aspektus išskirti užsienio rezervų valdymo modeliui sudaryti tinkami metodai:

- Įvertinus skolos VP kainos ir palūkanų normos priklausomybės matus, pasirinktas MFT metodas.
- Išnagrinėjus 12 palūkanų normų kreivės prognozavimo metodų nustatyta, kad dauguma modelių skirta trumpo laikotarpio palūkanų normų kreivei prognozuoti. Išnagrinėjus teorinius ir praktinius Nelson Siegel palūkanų normų kreivės prognozavimo modelio aspektus nustatyta, kad šis modelis, palyginti su kitais, parodė geriausius rezultatus, todėl jis pasirinktas modeliui kurti.
- Išnagrinėjus VaR metodiką nustatyta, kad variacijos-kovariacijos metodas yra tinkamiausias pagal centrinio banko portfelio sudėtį. Šio metodo pagrindu, papildžius Cornish-Fisher plėtote, sudarytas užsienio rezervų rizikos valdymo modelis, leidžiantis išskirti kredito ir palūkanų normos rizikos dedamąsias.

6. Išnagrinėjus Black Litterman modelio teorinius ir praktinius aspektus, numatyta šį modelį integruoti į centrinio banko užsienio rezervų valdymą. Išskirti Black

Litterman modelio įėjimo kintamieji: 1) palūkanų normos kreivės modulis; 2) pinigų politikos lūkesčiai: pinigų kiekio apimtis; 3) ekonominių veiksnių lūkesčiai: ekonomikos lūkesčiai (BVP, PMI, IP), infliacijos lūkesčiai, nedarbas.

7. Sukurtas 6 žingsnių užsienio rezervų valdymo modelis. **Pirmame** žingsnyje įvertinami rinkos veiksniai. Vertinimui pasirenkami obligacijų ir akcijų portfelį veikiantys kintamieji. Konkretūs kintamieji išskiriami atlikus akcijų ir obligacijų rinkas veikiančių veiksnių tyrimą. **Antrame** žingsnyje identifikuojami rinkos veiksnių lūkesčiai, kurie toliau naudojami Nelson Siegel ir Black Litterman modelyje. **Trečiame** žingsnyje remiantis Nelson Siegel metodu prognozuojama palūkanų normos kreivė. Gaunamas palūkanų normos kreivės modulis, kuris leidžia prognozuoti palūkanų normos kreivės kitimą ateityje. **Ketvirtame** žingsnyje pagal *antro ir trečio žingsnio* informaciją naudojant Black Litterman modelį skaičiuojamas portfelio aktyvų laukiamas pelningumas ir gaunama portfelio alokacijos struktūra. **Penktame** žingsnyje pagal gautus *ketvirto* žingsnio rezultatus ir rizikos apribojimus sudaromas lyginamasis indeksas, kuris apibūdina aktyvų alokaciją (kokia portfelio dalis investuojama į obligacijas ir kokia į akcijas). **Šeštame** žingsnyje atliekamas sudaryto portfelio testavimas. Įvertinamas portfelio pelningumas ir rizika. Testuoti naudojamas atgalinio testavimo metodas, vertinant, ar portfelis per laikotarpį neviršijo nustatytos VaR reikšmės. Pagal gautus portfelio vertinimo rezultatus toliau yra tobulinamas aktyvų alokacijos procesas.

8. Atlikus JAV ir euro zonos vyriausybės obligacijų pajamingumui ir akcijų pelningumui įtaką darančių veiksnių analizę gauti šie rezultatai:

- Atskirais kiekybinio skatinimo etapais JAV VP, išskyrus 1 m., pajamingumas didėjo. Ilgo laikotarpio VP (10 m., 20 m., 30 m.) bendrą pajamingumo sumažėjimą per kiekybinio skatinimo laikotarpį nulėmė tai, jog pasibaigus atskiriems kiekybinio skatinimo etapams pajamingumas krisdavo, be to, Federalinei rezervų sistemai pradėjus mažinti kiekybinio skatinimo apimtį pajamingumas kurį laiką dar kilo, tačiau vėliau susitraukė. Kiekybinio skatinimo įtaka JAV akcijų rinkai yra teigiama, akcijų rinka stebint per visą kiekybinio skatinimo laikotarpį kilo. Taip pat nustatytas statistiškai patikimas ryšys tarp JAV PMI, infliacijos, infliacijos lūkesčių, nedarbo ir pinigų kiekio bei JAV vyriausybės VP pajamingumo ir akcijų rinkos, ir tik 1 m. pajamingumas neturėjo

statistiškai patikimo ryšio su PMI ir infliacijos lūkesčiais, o 5 m. pajamingumas su infliacijos lūkesčiais.

- Bazinių palūkanų mažinimo laikotarpiu euro zonos obligacijų pajamingumas mažėjo. Analizuojant akcijų rinkos dinamiką pastebėta, kad tik nuo 2011 m. galima įžvelgti pastovią akcijų rinkos augimo tendenciją. Įvertinus obligacijų pajamingumo ir makroekonominių veiksnių ryšį gauti labai aukšti visų sudarytų regresinių lygčių determinacijos koeficientai. Statistiškai patikimo ryšio nepavyko gauti tarp: 1 m. pajamingumo ir infliacijos bei pinigų kiekio; 20 m. pajamingumo ir IP indekso; akcijų indekso ir infliacijos lūkesčių.

9. Atlikus sudaryto užsienio rezervų valdymo modelio pritaikymo tyrimą, nustatyta:

- Pagal siūlomą modelį sudarytų taktinio ir investicinio portfelių grąžos rezultatai viršija palyginamųjų portfelių rezultatus atitinkamai 11 ir 20 bazinių punktų. Pagal siūlomą modelį sudaryti portfeliai yra efektyvesni, kadangi prisiimtam rizikos vienetui uždirbo didesnę grąžą. *Atliktas užsienio rezervų valdymo modelio patikrinimas patvirtino, kad pasiūlytas Black Litterman metodu paremtas užsienio rezervų valdymo modelis leidžia efektyviau paskirstyti rezervus tarp obligacijų ir akcijų*.
- Rizikos vertinimo modelio atgalinio testavimo nukrypimai viršijo leistiną 1 % ribą 8 kartus. Šiuos pažeidimus nulėmė ekstremalūs pokyčiai finansų rinkose, tačiau rinkoje padidėjus kintamumui VaR dydžiui buvo pritaikyti atitinkami priedai, kurie leido tiksliai įvertinti portfelio riziką. Kitais nagrinėjamais periodais modelis parodė gerus rezultatus, nukrypimų arba visai nebuvo, arba jie neviršijo 1 % leistinos ribos. *Pagal atgalinio testavimo rezultatus daroma išvada, kad į užsienio rezervų valdymo modelį integruotas, VaR pagrindu paremtas rizikos vertinimo modelis tinkamai ir patikimai leidžia įvertinti skolos VP portfelio riziką ir išskaidyti ją į kredito ir rinkos rizikos dedamąsias*. Sudaryta metodika yra tinkama pritaikant modelį ir nepalankioms rinkos sąlygoms, naudojant užfiksuotą nuokrypį kaip VaR modelio priedą, kuris leidžia modelį pritaikyti išskirtinėms situacijoms rinkoje padidėjus kintamumui.

LIST OF SCIENTIFIC PUBLICATIONS AND PRESENTATIONS ON THE TOPIC OF DISSERTATION

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Fields of Scientific Interest

Investment portfolio
Risk management
Portfolio asset allocation