

H. V. VIETROVA, V. O. HUZHVA

ANALYSIS OF THE MARKOWITZ'S AND TOBIN'S MODELS FOR SECURITIES PORTFOLIO CONSTRUCTION

The conclusions about the strata of society, various parties are supported by, have been made. The question arises of revising and improving the ways of forming the investment portfolio, since the degree of influence of macroeconomic indicators on the stock market behavior changes. The stock market is one of the key elements of the financial system of any state. The essence of the securities portfolio, the main task and the main objective of portfolio investment, the nature and methods of forming the securities portfolio in the conditions of instability of the Ukrainian stock market are considered. It describes the process of forming a securities portfolio, which is divided into five stages: determining investment objectives and priorities, conducting an analysis of securities, creating a portfolio and choosing management tactics, revising a portfolio and evaluating portfolio performance. On the basis of Markowitz's model and Tobin's model are developed algorithmic, informational and software. The applied capabilities of portfolio investment models are explored, which realize the main idea of Markowitz to form an optimal securities portfolio, while at the same time having fundamental differences. And the main difference Tobin's model, which includes a certain risk-free asset, along with risky securities. An optimal securities portfolio is being built using ten risky stocks of various sectoral activities of Ukrainian enterprises using the Markowitz model and using risk-free assets (government corporate bonds) for the Tobin model. Also the composition, profitability and risk of the optimal portfolio in the Ukrainian stock market are determined. In addition, a graph of profitability and risk dependencies is constructed, where each point of the chart is a certain portfolio with a certain number of investments in the stocks of listed companies. The conclusion is made on the results obtained, focusing on their difference depending on the choice of the model of portfolio formation.

Keywords: securities, investment portfolio, portfolio formation, risk, profitability, Markowitz model, Tobin model.

Г. В. ВЕТРОВА, В. О. ГУЖВА

ДОСЛІДЖЕННЯ МОДЕЛЕЙ МАРКОВИЦА ТА ТОБІНА ПОБУДОВИ ПОРТФЕЛЯ ЦІННИХ ПАПЕРІВ

Останнім часом виникає питання перегляду і вдосконалення способів формування інвестиційного портфеля, оскільки змінюється ступінь впливу макроекономічних індикаторів на поведінку фондового ринку. Фондовий ринок є одним з ключових елементів фінансової системи будь-якої держави. Розглядаються сутність портфеля цінних паперів, основне завдання і головна мета портфельного інвестування, сутність і методи формування портфеля цінних паперів в умовах нестабільності українського фондового ринку. Описується процес формування портфеля цінних паперів, який розділений на п'ять етапів: визначення інвестиційних цілей та пріоритетів, проведення аналізу цінних паперів, створення портфеля і вибору тактики управління, ревізія портфеля і оцінка ефективності портфеля. Розробляється алгоритмічне, інформаційне та програмне забезпечення на основі моделі Марковича і моделі Тобіна. Обговорюються прикладні можливості моделей портфельного інвестування, які реалізуючи основну ідею Марковича щодо формування оптимального портфеля цінних паперів, в той же час мають принципові відмінності. І розглядається головна відмінність моделі Тобіна, яка включає в дослідження поряд з ризиковими цінними паперами певний безризиковий актив. Будеться оптимальний портфель цінних паперів з використанням десяти ризикових акцій різних галузевих сфер діяльності українських підприємств за моделлю Марковича і з використанням безризикових активів (державних корпоративних облігацій) за моделлю Тобіна. Визначається склад, прибутковість і ризик оптимального портфеля на українському фондовому ринку. Крім того, будується графік залежностей прибутковості та ризику, де кожна точка графіка є певний портфель з певною кількістю вкладень в акції наведених компаній. Робиться висновок за отриманими результатами, акцентуючись на їх відмінність в залежності від вибору моделі формування портфеля.

Ключові слова: цінні папери, інвестиційний портфель, формування портфеля, ризик, прибутковість, модель Марковича, модель Тобіна.

Г. В. ВЕТРОВА, В. А. ГУЖВА

ИССЛЕДОВАНИЕ МОДЕЛЕЙ МАРКОВИЦА И ТОБИНА ПОСТРОЕНИЯ ПОРТФЕЛЯ ЦЕННЫХ БУМАГ

В последнее время возникает вопрос пересмотра и совершенствования способов формирования инвестиционного портфеля, поскольку изменяется степень воздействия макроекономических индикаторов на поведение фондового рынка. Фондовый рынок является одним из ключевых элементов финансовой системы любого государства. Рассматриваются сущность портфеля ценных бумаг, основная задача и главная цель портфельного инвестирования, сущность и методы формирования портфеля ценных бумаг в условиях нестабильности украинского фондового рынка. Описывается процесс формирования портфеля ценных бумаг, который разделен на пять этапов: определение инвестиционных целей и приоритетов, проведение анализа ценных бумаг, создание портфеля и выбора тактики управления, ревізія портфеля и оценка эффективности портфеля. Разрабатывается алгоритмическое, информационное и программное обеспечение на основе модели Марковича и модели Тобина. Обсуждаются прикладные возможности моделей портфельного инвестирования, которые реализуют основную идею Марковича по формированию оптимального портфеля ценных бумаг, в то же время имеют принципиальные отличия. И рассматривается главное отличие модели Тобина, которая включает в исследование наряду с рисковыми ценными бумагами определённый безрисковый актив. Строится оптимальный портфель ценных бумаг с использованием десяти рискованных акций различных отраслевых сфер деятельности украинских предприятий по модели Марковича и с использованием безрисковых активов (государственных корпоративных облигаций) по модели Тобина. Определяется состав, доходность и риск оптимального портфеля на украинском фондовом рынке. Кроме того, строится график зависимостей доходности и риска, где каждая точка графика есть некоторый портфель с определённым количеством вложений в акции приведенных компаний. Делается вывод по полученным результатам, акцентируя на их отличие в зависимости от выбора модели формирования портфеля.

Ключевые слова: ценные бумаги, инвестиционный портфель, формирование портфеля, риск, доходность, модель Марковича, модель Тобина.

Introduction. The last global financial crisis made investors, which required a revision of the attitude towards certain adjustments to the investment policy of most the formation of investment portfolios. At the same time,

the previously dominant investment strategies of most investors aimed at international securities markets changed to the opposite, facing domestic investment sources. In this regard, the issues of improving investment strategies become important, allowing not only to optimize them, but also to make timely adjustments depending on the influence of various factors.

The main objective of portfolio investment is to give to set of securities such investment characteristics, which are unattainable from a position of a single security [1]. The portfolio of securities is that tool by means of which the investor provides the required stability of income at minimal risk [2]. The main goal in the formation of the portfolio is to achieve the most optimal combination between risk and income for the investor. The portfolio must include elements of different risk and profit. Moreover, depending on the intentions of the investor, the share of multi-purpose elements may vary. This task arises from the general principle that operates in the investment market: the higher the potential risk borne by the instrument, the higher the potential income it should have [3]. As the portfolio represents a set of various securities, an investment decision is equivalent to choosing the optimal portfolio from a set of possible portfolios. This problem is called the problem of choosing an investment portfolio [4].

The process of forming a securities portfolio can be divided into several stages [5]:

1) Definition of investment goals and priorities.

From the point of view of the formation of the securities portfolio, the goals can be divided into categories:

- investment security, which means protecting investments from market shocks and the stability of receiving income;
- profitability of investments;
- increase in the cost of investments.

2) Conducting analysis of securities.

The analysis of securities is the application of fundamental and technical analysis. Fundamental analysis is a study of the overall economic situation, the financial situation of individual companies, and the state of industries. Technical analysis is based on the study of price movements for financial instruments, the basis of which are the market movement charts for previous periods of time, market statistics, data on changes in stock market rates and forecasts of future price movements.

In addition, the formation of the securities market is influenced by the rating of the company and the securities, which are selected on the basis of stock indices. The result of this stage is a list of securities, the most profitable and least risky, for inclusion in the portfolio in a certain period of time.

3) Portfolio formation.

At this stage, investment assets are selected on the basis of the analysis carried out and taking into account the specific goals of the investor. An investor's portfolio may consist of securities (stocks) of one company if the investor's goal is to become the owner of the company and at the same time receive dividends. If the goal is to

earn on speculation from securities transactions, then the investor forms his portfolio of securities that can be earned. The task of the investor in this case will be to acquire undervalued securities at a certain moment, whose market price at the time of purchase is lower than the true price and to get rid of overvalued securities in time and thereby receive a certain profit in the future [6]. It is very important to apply capital diversification in the formation of a securities portfolio. The more stocks of various companies in the investor's portfolio, the more chances the investor has to make a profit. Therefore, the most common is the so-called "diversified portfolio", that is, a portfolio with a variety of securities. In other words, a portfolio consisting of stocks, bonds and other securities of diverse companies ensures the stability of obtaining a positive result [7].

4) Portfolio audit.

The securities portfolio should be periodically reviewed in accordance with the existing situation in the economy and the goals of the investor.

5) Portfolio performance evaluation.

The last stage of securities portfolio management implies a periodic assessment of the portfolio's efficiency, taking into account the income gained and the risk that arose or could arise during the management period.

Analysis of securities portfolio formation methods. At formation of the portfolio of securities a large number of models and methods from which it is possible to allocate is used:

- Michael O'Higgins and Gardner's method;
- H. Markowitz's model;
- Model Sharp;
- Tobin's model.

In article two models are considered: Markowitz's model and Tobin's model. Markowitz's model [8] is the cornerstone of the theory of the investment portfolio. This model allows you to define indicators characterizing the amount of investment and risk, and makes it possible to compare various alternative capital investment options among themselves.

Cumulative portfolio risk, H. Markowitz divided into two parts. To the first part, he referred to the systematic risk, which is caused by the economic, psychological and political situation in the country, which simultaneously affects all securities equally.

The second is the specific risk that each specific security has, which can be eliminated by managing the securities portfolio. Dividing the risk into components gives the investor the opportunity to analyze securities from all sides and to determine their strengths and weaknesses in optimizing the portfolio.

The critical line method developed by H. Markowitz made it possible to determine the range of acceptable portfolios and to distinguish invalid and effective portfolios.

Effective portfolios are portfolios that contain minimal risk for a given income or bring the maximum possible income for a given level of risk that an investor can take [9].

The theory of H. Markowitz allows investors to measure the level of risk and determine effective portfolios, but it does not specify the relationship between the level of risk and the required profit.

The form of the mathematical model of the direct task of H. Markowitz at which the portfolio risk does not exceed the specified value σ_p :

$$\left\{ \begin{array}{l} \sum_{i=1}^n x_i r_i \rightarrow \max \\ \sqrt{\sum_{i=1}^n \sum_{j=i+1}^n x_i x_j \rho_{ij} \sigma_i \sigma_j} < \sigma_p \\ \sum_{i=1}^n x_i = 1 \\ x_i \geq 0 \end{array} \right.$$

The form of the mathematical model of the inverse task of H. Markowitz, at which the portfolio profit is not lower than the specified value r_p :

$$\left\{ \begin{array}{l} \sqrt{\sum_{i=1}^n \sum_{j=i+1}^n x_i x_j \rho_{ij} \sigma_i \sigma_j} \rightarrow \min \\ \sum_{i=1}^n x_i r_i > r_p \\ \sum_{i=1}^n x_i = 1 \\ x_i \geq 0 \end{array} \right.$$

where portfolio profit is:

$$r_p = \sum_{i=1}^n x_i r_i,$$

where x_i – the share of the i -th financial asset in the portfolio;

n – the number of securities that make the investment portfolio;

r_i – average profitability (mathematical expectation) of the i -th financial asset;

r_p – expected value of the portfolio profit.

The average profit of the i -th financial asset is the formula:

$$r_i = \frac{1}{T} \sum_{t=1}^T r_{it},$$

where T – the period for which the profit of the security is considered;

r_{it} – profit of the security in a particular month t .

The risk of the securities portfolio is:

$$\sigma_p = \sqrt{\sum_{i=1}^n \sum_{j=i+1}^n x_i x_j \rho_{ij} \sigma_i \sigma_j},$$

where σ_p – investment portfolio risk level;

x_i, x_j – the share of the i -th and j -th financial asset in the portfolio;

σ_i, σ_j – standard deviation of returns of the i -th and j -th securities;

ρ_{ij} – coefficient of correlation of i -th and j -th securities profits.

The standard deviation of the profit of a security is calculated by the formula:

$$\sigma_i = \sqrt{\frac{1}{T-1} \sum_{t=1}^T (r_{it} - r_i)^2}.$$

The correlation coefficient of the securities is found by the formula:

$$\rho_{ij} = \frac{\text{cov}_{ij}}{\sigma_i \sigma_j}$$

where cov_{ij} – the covariance of the i -th and j -th securities yields, which is calculated by the formula:

$$\text{cov}_{ij} = \frac{\sum (r_{it} - r_i)(r_{jt} - r_j)}{T}.$$

The problem of using the Markowitz model in the practical financial activities of enterprises for the selection of an optimal investment portfolio is due to the following factors:

- the model does not take into account the time factor, in particular, it gives an answer to the question regarding the number and type of securities at the expense of which an investment portfolio should be formed, but ignores the question of the most optimal time to acquire and sell assets;
- the complexity of collecting information and statistical calculations on which investment decisions are based;
- the model does not take into account the methodology of fundamental and technical analysis of stocks.

The main conclusion that follows from the concept of Markowitz is that within the framework of the strategy of minimizing investment risks, one should select an investment portfolio in which priority is given not so much to the securities, the risk level of each of which is minimal, but the combination of assets with minimal correlation between their levels of profitability.

Such a strategy is more pragmatic than choosing the most profitable or least risky financial assets. Moreover, at a given level of profitability, the risk will be the smaller, the greater the level of diversification of the investment portfolio [10].

The most successful attempts, actual and in modern conditions, are the models of J. Tobin and W. Sharp, developing the theory of H. Markowitz. In the model of H. Markowitz, the securities portfolio was formed exclusively of risky assets. This shortcoming was overcome in the Tobin model, which includes, along with risky securities, a certain risk-free asset in the study. He focused on the behavior of an individual investor who invests money in securities, guided by his own ideas about the optimal ratio of profitability and risk.

The model of J. Tobin is based on the assumption that, in addition to risky portfolio investments, there are risk-free

securities on the stock market (the risk value of which tends to zero), which allowed it to significantly simplify the task of forming an optimal portfolio.

These risk-free assets J. Tobin attributed bonds as securities, income and return amounts that are fixed by the terms of the loan. The second assumption that underlies the J. Tobin model is that the price of bonds is not accidental, and is dictated by market conditions. The assets, the risk level of which is high and must be taken into account when choosing the optimal investment portfolio, J. Tobin attributed the stocks.

Proceeding from this, J. Tobin made an obvious assumption that when individual assets are included in their portfolio, an investor should be guided by the rule that the non-random price of risky securities (stocks) r_i should be higher than the non-random price of risk-free securities (bonds) r_0 , that is an indispensable condition of the optimal investment portfolio is inequality performance: $r_i > r_0$.

It should be emphasized that in the model of J. Tobin, the solution to the problem of portfolio optimization does not depend on the structure of the risk part of the assets; when it changes, it is enough just to recalculate r_i with each change in the structure of the portfolio. The optimization problem is solved by the inequality $r_i > r_0$, where the risk part of the portfolio is considered as one average stock.

Mathematically, the task of optimizing the investment portfolio in the J. Tobin model is a linear objective function with quadratic nonlinear constraints. It can be solved both to minimize the risk at a given level of profitability and to maximize profitability at a given level of risk [11].

The economic-mathematical model of the problem of forming a portfolio with a maximum profit is as follows:

$$\left\{ \begin{array}{l} r_0 x_0 + \sum_{i=1}^n r_i x_i \rightarrow \max \\ \sqrt{\sum_{i=1}^n x_i^2 \sigma_i^2 + 2 \cdot \sum_{i=1}^{n-1} \sum_{j=i+1}^n x_i x_j \rho_{ij} \sigma_i \sigma_j} < \sigma_p \\ x_0 + \sum_{i=1}^n x_i = 1 \end{array} \right.$$

Economic-mathematical model of portfolio formation with minimal risk:

$$\left\{ \begin{array}{l} \sqrt{\sum_{i=1}^n x_i^2 \sigma_i^2 + 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^n x_i x_j \rho_{ij} \sigma_i \sigma_j} \rightarrow \min \\ r_0 x_0 + \sum_{i=1}^n r_i x_i \geq r_p \\ x_0 + \sum_{i=1}^n x_i = 1 \end{array} \right. ,$$

where r_0 – expected value of risk-free asset profit;

x_0 – share of a risk-free asset in a portfolio.

The values of input variables and coefficients discussed earlier.

The Tobin model is simpler than the H. Markowitz model, it allowed us to more clearly formalize the notion of profitability and risk. However, it did not answer the question about the effect of individual assets on the level of risk and return on the investment portfolio.

Consider the assets of companies in various sectoral areas of activity, we estimate their profitability and risk indicators, and by forming investment portfolios we reduce the degree of risk to a possible limit.

Purposes and research problems. The purpose of this work is the implementation of software for solving the problem of forming a portfolio of securities.

To achieve this goal, the article solved the following tasks:

- analysis of common models for the formation of a securities portfolio on the Ukrainian stock market;
- selection of suitable models for the formation of the investment portfolio;
- developed algorithmic software and mathematical for the implementation of the selected methods;
- developed information and software for the task of forming a portfolio of securities.

The subject of the research is the process of forming an investment portfolio of high-risk assets based on the Markowitz model, and high-risk and risk-free assets using the Tobin model, taking into account the specifics of the Ukrainian stock market.

The object of the research is stock quotes in the period from 11/06/2016 to 11/06/2017. Quotations of securities were taken from a source [12]. Depending on stock price fluctuations, we calculate average rates of return, variances and risk indicators for each of the companies under consideration.

On the basis of the Markowitz and Tobin models for the task of building a minimum risk portfolio by diversifying securities, a software product was developed, which was implemented in the Microsoft Visual Studio 2012 development environment, to write the program code, the C # programming language was used. For the formation of portfolios of securities were used securities presented in table 1.

Table 1 – Securities

Company	Ticker	Profit	Risk
Ukrnafta	UNAF	3,02 %	9,87 %
ASTARTA HOLDING	AST	-0,15 %	8,89 %
KSG AGRO	KSG	0,97 %	14,97 %
Ovostar Union	OVO	2,23 %	3,93 %
Motor Sich	MSICH	4,82 %	6,89 %
Raiffaizen Bank Aval	BAVL	8,78 %	15,32 %
Tsentrenerho	CEEN	0,96 %	6,13 %
Dniproblerho	DNON	24,99 %	44,12 %
Ukrtelekom	UTLM	1,01 %	9,18 %
Donbasenerho	DOEN	4,75 %	9,94 %
Government corporate bonds		1,458 %	

Tables 2 and 3 show the results of solving the problem of forming a securities portfolio using these models. The results are obtained using implemented information, algorithmic and software.

Table 2 – The calculation results for the Markowitz's model

Company	Share of securities in the portfolio	
Ukrnafta	4,86 %	
ASTARTA HOLDING	9,53 %	
KSG AGRO	0 %	
Ovostar Union	19,43 %	
Motor Sich	11,27 %	
Raiffaizen Bank Aval	06,13 %	
Tsentrenerho	21,06 %	
Dniproblerho	3,58 %	
Ukrtelekom	24,12 %	
Donbasenerho	0 %	
Portfolio performance	Profit	3 %
	Risk	0,01689 %

Table 3 – The calculation results for the Tobin's model

Company	Share of securities in the portfolio	
Ukrnafta	0 %	
ASTARTA HOLDING	2,19 %	
KSG AGRO	0 %	
Ovostar Union	10,59 %	
Motor Sich	14,67 %	
Raiffaizen Bank Aval	6,71 %	
Tsentrenerho	15,56 %	
Dniproblerho	2,79 %	
Ukrtelekom	13,47 %	
Donbasenerho	0 %	
Government corporate bonds	34,05 %	
Portfolio performance	Profit	3 %
	Risk	0,01084 %

The result of the calculations are the graphs presented in fig. 1 and fig. 2, which show the dependence of profitability and risk.

Each point of the chart has a certain portfolio with a certain number of investments in the shares of the listed companies.

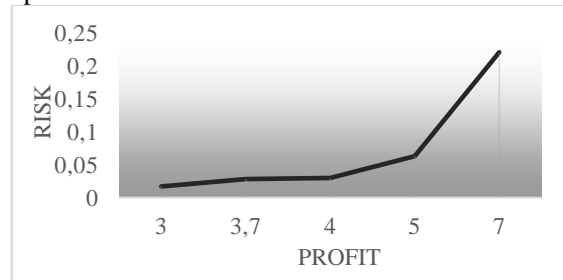


Fig. 1. The dependence of profitability and risk on the Markowitz's model

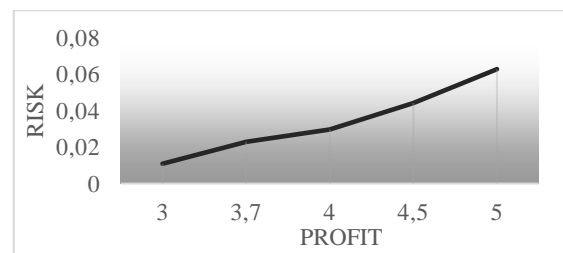


Fig. 2. The dependence of profitability and risk on the Tobin's model

Forming portfolios with different income level it is possible to make a conclusion:

1 Minimum acceptable level of income according to the Markowitz's model of 3 %, on Tobin's model of 1,5 %.

2 The difference of results is proved by the fact that unlike the Markowitz's model, Tobin's model considers also risk-free assets.

Besides, these models have various formula of calculation of risk of the investment portfolio.

Nevertheless, the presence of a huge number of factors directly or indirectly affecting the dynamics of listed issuers does not allow one to unambiguously predict and reduce to zero the risk of losing investments, but it is possible to reduce it to a minimum with optimal yield.

Conclusion. In this research work, on the basis of the developed algorithmic and information support software was created, with the help of which the securities portfolio was formed taking into account the specifics of the Ukrainian stock market.

References

1. Лубинец С. С., Никонова Я. И. Формирование инвестиционного портфеля физическими лицами. *Студенческий научный форум*, 2015. URL: <https://scienceforum.ru/2015/article/2015014172/> (access date: 07.09.2018).
2. Гридасов В. М. *Инвестирование*. Киев: ЦУЛ, 2004. 164 с.
3. Боровкова В. А. *Рынок ценных бумаг*. СПб: Питер, 2007. 272 с.
4. Тимирова А. Н. *Свойства модели Марковица при задании параметров средствами теории нечетких множеств*. URL: [http://www.intsys.msu.ru/magazine/archive/v16\(1-4\)/timirova-203-214.pdf](http://www.intsys.msu.ru/magazine/archive/v16(1-4)/timirova-203-214.pdf) (access date: 15.09.2018).
5. Щербаченко А. С. Особенности выбора метода формирования инвестиционного портфеля в условиях нестабильности

- фондового рынка. *Интернет-журнал «Науковедение»*, 2014, вып. 1. С. 11–18.
6. Зверев В. А., Зверева А. В., Евсюков С.Г. *Рынок ценных бумаг*. Москва: Дашков и К, 2016. 496 с.
 7. Грищенко Ю. И. Портфель ценных бумаг: оценка доходности и риска. *Справочник экономиста*, 2009, вып. 9. С. 14–20.
 8. Шапкин А. С. Экономические и финансовые риски. Оценка, управление, портфель инвестиций. Москва: Дашков и К, 2003. 544 с.
 9. Боди З., Кейн А., Маркус А. *Принципы инвестиций*. Москва: Вильямс, 2002. 984 с.
 10. Терещенко А. О. Финансовая деятельность субъектов хозяйствования. Киев: КНЭУ. 2003. 554 с.
 11. Филиппов К. В. Существующие подходы к оптимизации современных инвестиционных портфелей ценных бумаг. *Горный информационно-аналитический бюллетень*, 2008, вып. 2. С. 270–278.
 12. *Котировки акций online*. URL: <http://investfunds.ua/markets/stocks/> (дата обращения 11.10.2018).

References (transliterated)

1. Lubinets S. S., Nikonova Ya. I. Formirovanie investitsionnogo portfelya fizicheskimi litsami [Formation of the investment portfolio by individuals]. *Studencheskiy nauchnyy forum*, 2015. Available at: <https://scienceforum.ru/2015/article/2015014172/> (accessed: 07.09.2018).
2. Gridasov V. M. *Investirovanie* [Investing]. Kiev, TsUL Publ., 2004. 164 p.
3. Borovkova V. A. *Ryнок tsennyih bumag* [Securities market]. SPb, Piter Publ., 2007. 272 p.
4. Timirova A. N. *Svoystva modeli Markovitsa pri zadanii parametrov sredstvami teorii nechetkih mnozhestv* [Markovits model properties when specifying parameters using the fuzzy set theory]. Available at: [http://www.intsys.msu.ru/magazine/archive/v16\(1-4\)/timirova-203-214.pdf](http://www.intsys.msu.ru/magazine/archive/v16(1-4)/timirova-203-214.pdf) (accessed: 15.09.2018).
5. Scherbachenko A. S. Osobennosti vyibora metoda formirovaniya investitsionnogo portfelya v usloviyah nestabilnosti fondovogo ryinka [Features of the choice of the method of forming the investment portfolio in conditions of instability of the stock market]. *Internet-zhurnal «Naukovedenie»*, 2014, vol. 1, pp. 11–18.
6. Zverev V. A., Zvereva A. V., Evsyukov S.G. *Ryнок tsennyih bumag* [Stocks and bonds market]. Moskva, Dashkov i K Publ., 2016. 496 p.
7. Grischenko Yu. I. Portfel tsennyih bumag: otsenka dohodnosti i riska [Portfolio of securities: an assessment of profitability and risk]. *Spravochnik ekonomista*, 2009, issue 9, pp. 14–20.
8. Shapkin A. S. *Ekonomicheskie i finansovye riski. Otsenka, upravlenie, portfel investitsiy* [Economic and financial risks. Evaluation, management, investment portfolio]. Moskva, Dashkov i K Publ., 2003. 544 p.
9. Bodi Z., Keyn A., Markus A. *Printsipy investitsiy* [Principles of investments]. Moskva, Williams Publ., 2002. 984 p.
10. Tereschenko A. O. *Finansovaya deyatel'nost' sub'ektov hoz'yaystvovaniya* [Financial activities of business entities]. Kiev, KNEU Publ., 2003. 554 p.
11. Filippov K. V. Suschestvuyushchie podhody k optimizatsii sovremennyih investitsionnyih portfelye tsennyih bumag [Existing approaches to the optimization of modern investment securities portfolios]. *Gornyy informatsionno-analiticheskiy byulleten*, 2008, issue 2, pp. 270–278.
12. *Kotirovki aktsiy online* [Stock quotes online]. Available at: <http://investfunds.ua/markets/stocks/> (accessed 11.10.2018)

Received 13.11.2018

Відомості про авторів / Сведения об авторах / About the Authors

Ветрова Галина Вікторівна (Ветрова Галина Викторовна, Vietrova Halyna Viktorivna) – бакалавр, Національний технічний університет «Харківський політехнічний інститут», студент програмної інженерії та інформаційних технологій управління; м. Харків, Україна; ORCID: <https://orcid.org/0000-0001-6839-7049>; e-mail: vetrova33b@gmail.com

Гужва Віктор Олексійович (Гужва Виктор Алексеевич, Huzhva Viktor Oleksiiovych) – кандидат технічних наук, професор, Національний технічний університет «Харківський політехнічний інститут», професор кафедри програмної інженерії та інформаційних технологій управління м. Харків, Україна; ORCID: <https://orcid.org/0000-0001-6832-4480>; e-mail: guzhva.v.a@gmail.com