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THE METHOD OF REAL OPTIONS AS AN INSTRUMENT TO EVALUATE PROJECTS WITH HIGH UNCERTAINTY

The article analyzes the method of real options in terms of its ability to evaluate an investment project with a high level of uncertainty. The method of real options is compared with the classical approaches of project evaluation. The reasons for development of methods of evaluation of start-ups and innovative projects are described and substantiated. The advantages of the method of real options are highlighted by including in the evaluation of investor's possibilities the implementation of managerial decisions in the process of creation of innovative products (project). The necessity of development of scientific and practical literature on evaluation of projects by means of complex options is substantiated. A three-year simple deferral option is described and evaluated for practical understanding of the financial advantages of the method of real options in making an investment decision, which results in the critical importance of correct investment solution at each stage of uncertainty scattering.

Keywords: *real option, evaluation of project, innovation, uncertainty*

Dmytro Shestakov – Postgraduate student, Department of Finance of National University of Kyiv-Mohyla Academy, Kyiv

E-mail: dshestakov.ua@gmail.com
Researcher ID: D-4794-2019
ORCID: https://orcid.org/0000-0003-3652-081X

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Statement of problem. The importance of projects evaluation, that are characterized by some undetermined variations of prospective outputs, is recognized by both financial and scientific literature, since the accurate evaluation is an important step at all stages of the innovative project development and has a profound impact on future investment decisions. Evaluation makes the investment decision reasonable and ultimately creates value for an investor. Nowadays the most popular and time-tested method of start-ups and innovation projects evaluation is Discounted Cash Flow (DCF). Using this approach an investor calculates the Net Present Value (NPV) of the project and based on that makes a decision to invest or not to invest. However, DCF has restrictions. The main one is inability of the investor to make strategic decisions in the innovation creation process. This restriction leads to underestimation of potentially attractive projects and results in refusal of the investor to finance them. The Real Option Analysis (ROA) provides strategic flexibility and, depending on the project, allows the investor to adjust his/her decisions over time when uncertainty about the future is known.

Analysis of recent researches and publications. Theoretical and methodological aspects of the application of ROA in the evaluation of projects with high uncertainty were reflected in research papers of such domestic and foreign scientists as: M. Amram, M. Bilyi, T. Wang, A. Damodaran, A. Dixit, P. Kodukula, N. Kulatilaka, S. Myers, I. MacMillan, Y. V. Pidvysotskyi, R. Pindike, A. Van Putten, H. Smith, J. Tirol, I. G. Tkachuk, A. Triantis, L. Tri etc. Namely, the research papers of A. Damodaran, A. Dixit, P. Kodukula emphasize different approaches to evaluation of strategic flexibility in making investment decisions.

The purpose of the article is to justify the theoretical and practical advantages of the real option method over the classical approaches in evaluation of highly uncertain innovation projects.

Presentation of the main research material. In 1951, Joel Dean and Friedrich Lutz published two research papers: Capital Budgeting and Theory of Investment of the Firm, which opened new directions for DCF investment evaluation [1]. DCF-based approaches such as NPV are straightforward and understandable. As a rule, they forecast the amount of cash flow over the expected life of the project and discount them at a rate that characterizes the value of money in time and the level of risk. NPV is calculated based on input parameters:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t} \ , \tag{1}$$

where CF - cash flows;

r - discount rate;

t – timeframes;

n - number of periods.

The rule for making an investment decision is based on the following: comparing two mutually exclusive projects, the one with higher NPV is more preferable. If a separate project is considered, then its NPV above zero gives grounds for the project to be attractive for investment.

Despite the popularity and simplicity of DCF approaches, they are acceptable if the future can be predicted with high probability. Projects with high level of uncertainty are not in this group, since the real future cash flows may differ significantly from those expected. Therefore, instead of simply evaluating the cost of the project, investment decision makers should evaluate the various possibilities of their actions in the future in order to provide high quality uncertainty management [2]. Considering the impact of uncertainty on the project evaluation process, a considerable amount of research studies shows that one of the most important aspects of most capital investments is investment timing and managerial flexibility, that is, the ability to postpone, refuse, expand, or close an investment opportunity. It is no wonder that a more accurate approach has been developed which enables investors to better understand the impact of uncertainty and to solve directly the issues on managerial flexibility and investment timing.

Indeed, Real Option Analysis (ROA) has received considerable attention in the project management research literature over the last several decades. The “real option” term was suggested by Professor Stuart Myers in 1977 in the article “Determinants of corporate borrowing” [3]. The concept of real option was developed and implemented in response to the inability of traditional DCF evaluation approaches for projects with significant degree of uncertainty to evaluate the impact of decision-making flexibility. Using the methods that underpin the classical theory of financial options, ROA makes it possible to take into account the traditionally difficult to measure quantity-related elements such as managerial flexibility and the ability to change strategic decisions during the development of investment project [4]. In today's world, where unexpected changes are quite commonplace, an investment strategy that incorporates managerial flexibility in decision-making will most effectively respond to different possible ways for further development and future prospects. In fact, ROA is an advanced way of recognizing the way the projects are structured and managed, and combines these additional capabilities with a modern investment evaluation method.

An option is a right but not an obligation of its owner to buy or sell an underlying asset at a predetermined price and on a predetermined date or any date coming before the predetermined one. A financial option is a right to buy or sell an underlying financial asset (e.g. company stock) at a predetermined price and on a predetermined date or any date coming before the predetermined one. A real option is a right to take measures (e.g. to postpone, extend, refuse) on an underlying non-financial asset at a predetermined price and on a predetermined date or any date coming before the predetermined one.

The Tax Code of Ukraine defines an option as “a civil agreement whereby one party of the agreement obtains a right to purchase (sell) an underlying asset and the other party undertakes an unconditional obligation to sell (buy) an underlying asset in the future during the option period or on determined date (due date) at the price of an underlying asset fixed while entering into such agreement. Under the terms of the option, the buyer shall pay to the seller an option premium” [5].

According to the Decree of the Cabinet of Ministers of Ukraine No. 361 dated 02.08.2004 “On approval of methodological recommendations and operation of risk management systems in banks of Ukraine”, the option is defined as “a fixed-term agreement under which one party, the buyer of the option, is granted an exclusive and unconditional right of choice to make a purchase and sale transaction. The other party, the seller of the option, is obliged to execute the decision of the buyer of the option and has no right to waive its obligations. They distinguish between the call option that gives you a right to buy an underlying asset and the put option that gives you a right to sell an underlying asset. There is also a distinction between American Style Option - an agreement that can be exercised at any time throughout its validity period, and European Style Option - an agreement that can be exercised only at the end of its validity period” [6]. In fact, legislation of Ukraine does not define the real option as a separate category, but specifies it as a type of option depending on the underlying asset.

Real options can be grouped into two main categories: simple options and compound options. An example of simple option is option to delay, when we have a choice to invest in a project today with uncertain future cash flows or to postpone a decision until next year, when the expected uncertainty becomes clear and certain. For example, an investor can invest today $100 in a project with an expected profit of $120 in 1 year (estimated profit can be $160 (positive case) with probability of 0.5 or $80 (negative case) with probability of 0.5) (see Pic. 1). However, the investor may delay the decision to invest in the project for 1 year, when the expected uncertainty about the profit is known.

As shown below, using the standard DCF method with a discount rate of 12%, the cost of the project today, after the NPV calculation, makes $7.1. Since the value is greater than 0 and assuming that this level of expected return is acceptable for the investor, he/she will be willing to invest in the project. The NPV, calculated by the formula (1), makes:

$$NPV = \frac{-100}{(1+0.12)^0} + \frac{120}{(1+0.12)^1} = -100 + 107.1 = \$7.1$$

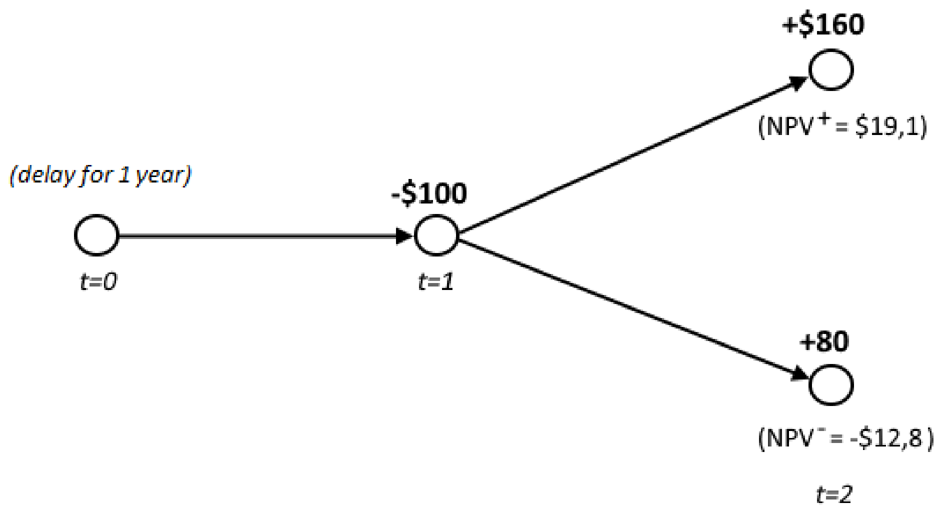
However, there is a mutually exclusive alternative to delay the decision for one year, when the uncertainty of cash flows is clear. We calculate the cost of the project for the positive and negative cases separately (with probability 0.5 each). NPV for positive case:

$$NPV = 0.5 * \left[\frac{-100}{(1+0.12)^1} + \frac{160}{(1+0.12)^2}\right] = 0.5 * [-89.3 + 127.6] = \$19.1$$

NPV for the negative case:

$$NPV = 0.5 * \left[\frac{-100}{(1+0.12)^1} + \frac{80}{(1+0.12)^2}\right] = 0.5 * [-89.3 + 63.8] = -\$12.8$$

Thus, the expected NPV for positive and negative cases is $19.2 and $12.8 respectively. In other words, in 1 year, if it turns out to be a positive case, the investor will invest in the project, otherwise refrain from investing.



Pic. 1. An example of expected profit gain if the decision is delayed for 1 year

Source: made by the author

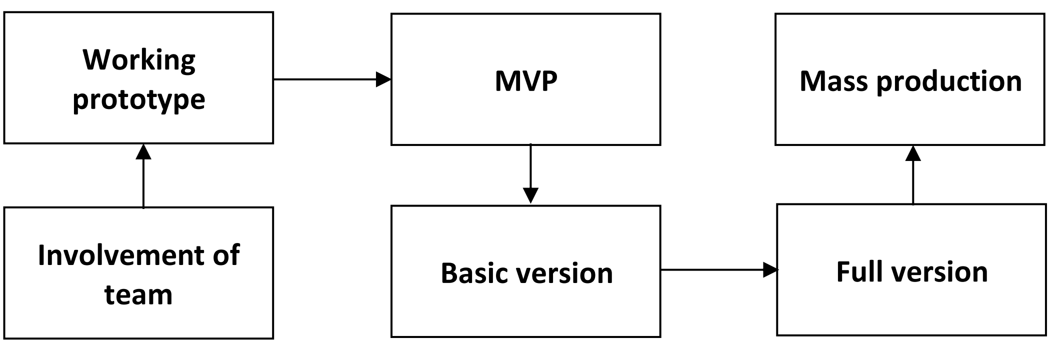
An example shows that a one-year delay decision costs today $19.1, while an investment decision, without waiting for clearness of uncertainty, costs today only $7.1

(applying DCF). Therefore, the added value due to possible delay of investment decision is $12 ($19.1 - $7.1).

Uncertainty is an indispensable input parameter for project evaluation and decision making. However, the level of project uncertainty should not be considered as a purely negative factor. On the one hand, there is an “opportunity” and on the other hand there is a “risk” to accordingly increase or decrease the project revenue. By analyzing the innovative projects, the amount of opportunities may be several times greater than the corresponding risks, providing a high level of uncertainty and high expected results for the investor. Ward and Chapman emphasize that opportunities and risks are interdependent concepts, so it makes no sense to focus on risk reduction without considering the opportunities involved, nor makes sense to use the opportunity without considering the corresponding risk [7].

Traditional DCF methods focus more on risk than project evaluation and decision-making process. Van Putten and MacMillan point out that the DCF approach reflects the risk of uncertainty by applying a high discount rate for projects with a high level of uncertainty, but it does not take into account the rewards in case actual cash flows are higher than the predicted ones [8]. This bias can lead to abandoning the attractive (but with considerable level of uncertainty) projects by investors [9]. On the other hand, ROA provides a systematic approach that actively recognizes and incorporates uncertainty into the process of projects evaluation and appropriate decision making by limiting the risk when using one or another opportunity.

Let's consider a simplified process of creating the innovative product that involves an externally funded project (Pic. 2)



Pic. 2. Simplified process of creating the innovative product.

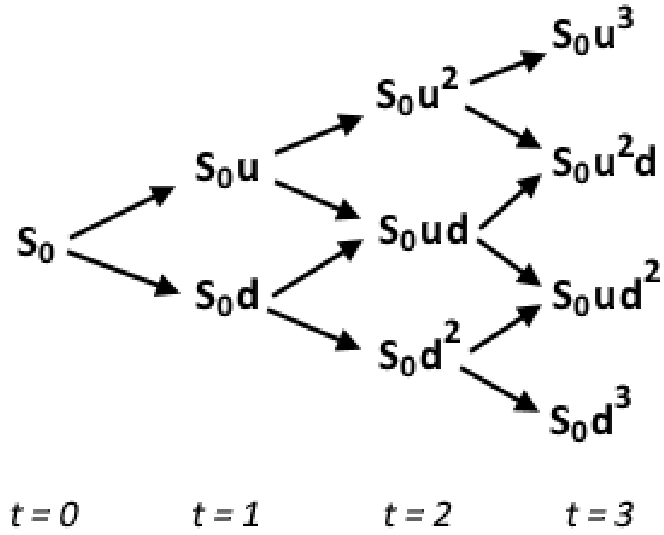
Source: developed by the author

The DCF approach, while discounting the future cash flows received after product sales, involves investing of 100% of the money today. However, innovative projects are projects with a high level of uncertainty that include:

- the ability of team to create a working prototype, a Minimum Viable Product (MVP), a basic and full version of the product (hypothesis of team competence);
- accuracy of technical solution and technology (hypothesis of technological ability);
- conformity of the declared and actual characteristics;
- accuracy of business model (business model hypothesis);
- market depth and demand for newly created products (market depth hypothesis and consumer value hypothesis);
- political, economic and social situation;
- uncertainty associated with time frames;
- inability of the management to respond in a timely manner to changes during the research and development process.

By investing today 100% of the money in a team, that may turn out to be not qualified enough to meet the challenges of product creation, or in a technology that may simply not be in demand at the market, the investor risks to lose the whole capital. The ROA approach allows you to overestimate the project, including strategic flexibility at each stage of innovation creation. Since changes of the environment and uncertainty have a significant impact on managers' ability to set and implement successful strategies, it is important to be able to adapt to such changes [10, p. 122]. The investor has the opportunity to make a decision to leave the project, sell it, expand or reduce it at any stage of the project. Step-by-step financing with the ability to record losses allows the investor to significantly reduce capital at risk and as a result to invest in more projects. The narrower uncertainty, which gradually disappears over time and moves to the next stage, allows the investor to reduce the spread of potential outputs and more accurately estimate the expected returns, which is the basis for making the appropriate decision on further financing of the project.

As an example of ROA investment evaluation we use a binomial tree (Pic. 3), which represents the base value of the asset (S_0) and can be described by the equations below.



Pic. 3. Binomial tree.

Source: developed by the author

Manufacturing company *Newgen* plans to develop an innovative solution for the internal production process in order to minimize the suppliers related risks. This solution will minimize the losses of the company in the case of rising prices for the resources and basic products due to changes in the general economic conditions. Based on its experience with such innovations, the company has an opportunity to wait a maximum of three years before integrating the new solution without incurring significant revenue losses. DCF evaluation, using an appropriate risk-adjusted discount rate, shows that the current value of expected future cash flows under the new activity model will make $100 million, while the investment required to develop and implement the solution is $120 million. The annual volatility of logarithmic returns of future cash flows is estimated at 25%, and the continuous annual risk-free rate over the three years of lifetime is 5%. Let's calculate the real option value (ROV) to delay for the *Newgen* company.

The inputs, required for making a binomial tree and calculation of the option value, are: volatility factor (σ), risk-free interest rate (*r*), the current value of the underlying asset (S_0), the cost of implementing the option (*X*), timeframes of the option (*T*) and time unit for the calculations (δt).

Indices up (*u*) and down (*d*) is a function of the underlying asset volatility and is calculated as follows:

$$u = e^{\sigma\sqrt{\delta t}} \tag{2}$$

$$d = e^{-\sigma\sqrt{\delta t}} = \frac{1}{u} \quad , \tag{3}$$

where σ *- volatility (%) represented by the standard deviation of the natural logarithm of the underlying free cash flow,*

δt *- time associated with each step of the binomial tree.*

Risk neutral probability (*p*) is calculated as follows:

$$p = \frac{e^{r\delta t} - d}{u - d} \quad , \tag{4}$$

where r is the risk-free interest rate or rate of return on the risk-free asset over the lifetime of the option.

For the example described above:

- σ 25%
- r 5%
- S_0 = \$100 million
- X = \$120 million
- T = 3 years
- δt = 1 year

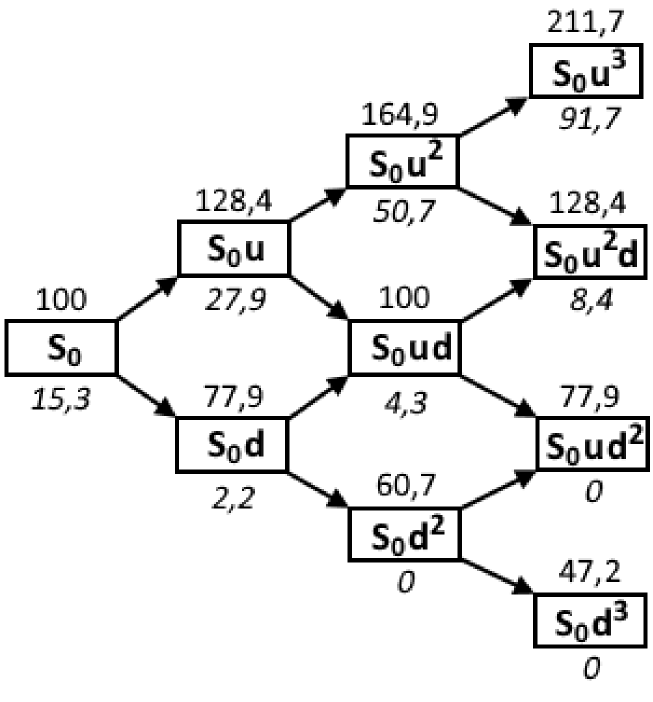
Based on formulas 2-4, the index up (*u*), index down (*d*) and risk neutral probability (*p*) are accordingly:

$$u = e^{0,25\sqrt{1}} = 1.284$$

$$d = \frac{1}{1.284} = 0.779$$

$$p = \frac{e^{0,05*1} - 0.779}{1.284 - 0.779} = 0.539$$

Let's create a binomial tree and calculate the value of the asset at each node over the life of the option, based on Pic. 3 using annual timeframes (Pic. 4).



Pic. 4. Binomial tree for *Newgen* company.

Source: developed by the author

Starting with S_0 and multiplying it by indices *u* and *d*, we will calculate S_0u and S_0d accordingly. By proceeding the similar calculations for each node of the binomial tree to the last step, we calculate the value of the asset (upper figure on Pic. 4) at each of these nodes. For example, S_0u = $ 100 million * 1.284 = $ 128.4 million; S_0d = $ 100 million * 0.779 = $ 77.9 million

Let's calculate the cost of the option (lower figure on Pic. 4) at each node of the binomial tree, using backward induction. Each node represents the maximization of the investing cost at the current moment or waiting until the next period of time. Each node has the opportunity to invest in developing of a solution or to wait until the next time period before the option expires. Let's start with the end nodes representing the last step of time. In the node S_0u_3 the expected value of the asset is $ 211.7 million if the investment is $ 120 million; therefore, the net asset value will be $ 211.7 - $ 120 = $ 91.7 million. If investor decides to wait another 1 year, the returns will make zero, because the option's lifetime is 3 years and after that it is worthless if not implemented in time. Therefore, a rational solution at node S_0u_3 is to invest, but not wait. The cost of the option at this stage will be $ 91.7 million.

At the node S_0ud_2 the expected value of the asset is $ 77.9 million. If the investment is $ 120 million, the investor will receive a net loss of $ 77.9 - $ 120 = - $ 42.1. Therefore, the solution on this node is not to invest in the development of the solution, and the value of the option will be $ 0.

The option value at intermediate stages is calculated as a discounted (risk-free interest rate) average number of the potential future value of the option using a risk neutral probability. At the node S_0u_2 the value of the option is equal to:

$$[p(S_0u^3) + (1-p)(S_0u^2d)] * e^{-r\delta t}$$
$$= [0.539 * 91.7 + (1-0.539) * 8.4] * e^{(-0.05)*1} = 50.7$$

If the option is implemented at this node by investing $ 120 million, the payment will make $ 164.9 million (asset value in S_0u_2), and NPV will be + $ 44.9 million. Since keeping the option open shows a higher value of the asset ($ 50.7 million), the investor will not use this option and will continue to wait; the value of the option at this stage will be $ 50.7 million. The value of the option is similarly calculated for all other binomial tree nodes.

Let's analyze the obtained results taking into account the challenges of the *Newgen* company. The upper figure of the binomial tree on Pic. 4 represents the expected future values of the underlying asset over the lifetime of the option as it is being developed according to the existing uncertainty. For example, at the end of year 2, a production innovation solution of *Newgen* is expected to generate total income of between \$ 60.7 million and \$ 164.9 million, and between \$ 47.2 million and \$ 211.7 million at the end of the last year (under current prices). The lower figures on the binomial tree represent the value of the option based on maximizing investment at this point or on waiting for the next period of time. At the end of Year 3, however, the investor is no longer able to wait for the moment to invest because the option is valid for 3 years.

At the node $S_0d_2$by investing \$ 120 million, the expected revenue is only \$ 60.7 million, resulting in having by investor a net loss of \$ 59.3 million. Leaving the option open and waiting, the expected value of the option will be \$ 0. By minimizing the losses, the investor will not invest at this stage.

The binomial method shows the value of the project in the future for the expected payments and rational decisions that can be made. The idea is that when uncertainty dispels over time, management can make the appropriate strategic decisions by comparing expected return with investment costs.

Comparing the obtained results related to management decision that would be made based on DCF and ROV results. The DCF method, using a risk-adjusted discount rate, shows revenue of \$ 100 million, which is expected to cost the investor \$ 120 million to develop and implement. This means that the NPV of the project will be negative (NPV = \$ 100 - \$ 120 = - \$ 20 million), which does not make investment attractive. Based strictly on NPV, the investor's decision is to refrain from investing in this project. However, the project has an ROV of \$ 15.3 million, created by the option characteristics for a project with high uncertainty. The value added created with this option represents the difference between ROV and NPV based on DCF, which is \$ 35.3 million (\$ 15.3 million - (- \$ 20 million)).

Conclusions and prospects for further research in this area. The comparative analysis of application of real option method and classic project evaluation approaches makes it possible to conclude on its significant advantage by involving the strategic managerial decisions during the process of creating innovative products (projects) in the investor's capabilities assessment, which has been confirmed and illustrated by examples. In particular the Newgen example showed that based solely on the classic DCF approach, the investor would not invest in the project because of the negative NPV value. However, by assessing strategic flexibility in the process of creating and implementing an innovation by using ROA, a project with inherent uncertainty becomes attractive to investors. Over time, when uncertainty disappears, the investor has the opportunity to overestimate the expected future cash flows and make a strategically correct investment decision for this particular project. ROA does not replace the DCF approach, but rather complements and refines it by providing flexible decision making during the lifetime of the option, which increases the value of the project and increases the likelihood of its implementation. By evaluating a simple option to delay and determining the benefits of ROA, further prospective research in this area may be to evaluate complex and comprehensive options when an investor while creating the innovation is able to expand or reduce production, exit the project or sell it, switch to another work mode that will diversify the investment portfolio and increase the possible profit for the investor on the one hand and accelerate innovative development and technological breakthrough for the state and the world on the other.

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Research advisor:

Iryna Hryhorivna Lukianenko, Ph.D. in Economics, Professor, Head of Department of Finance of National University of Kyiv-Mohyla Academy (lukyanenko@ukma.kiev.ua).