

# REAL OPTIONS COMPARED TO TRADITIONAL COMPANY VALUATION METHODS: POSSIBILITIES AND CONSTRAINTS IN THEIR USE

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## Abstract

*The subject of the article is the presentation of an unconventional method of establishing the value of the company together with investment ventures – basing on the concept of real options (Real Option Valuation – ROV). The option calculation can be applied in many areas, such as: evaluation of investment effectiveness, valuation of the company and its separate parts, estimating the value of company assets and liabilities, credit risk assessment. The concept of real options is very popular all over the world. However, in Poland we rarely use option methods in the above areas, although the method is currently considered a revolutionary solution to the problem of underassessment of huge risk projects.*

**JEL Classification:** G12, G32, M21

**Keywords:** real options, company valuation methods, binomial model, Black-Scholes model

**DOI:** <https://dx.doi.org/10.65748/fiqf-2012-0016>

Received: 16.01.2012

Accepted: 30.04.2012

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## Introduction

Business conditions in which contemporary companies are operating are burdened with some uncertainty and risk. Affected by time and events, uncertainties become clearer and managers are able to adjust their actions through interventions in company strategies or changes of business decisions. When estimating the company value, we must indicate how the planned changes in its way of operating increase the value of the basic variant of its functioning in a particular market environment.

To do so, it is necessary to analyze and evaluate the options of the company's future operations. In case of traditional valuation methods, this aspect is omitted, which may result in undervaluation of the company (Buckley, 2002, p. 66).

The method which allows us to value the company and its investment projects in conditions of uncertainty, taking into consideration the ability of the company to react to changes taking place in the economy, is defined as *Real Option Valuation* (ROV), also often termed *Real Options Analysis* (ROA). There are a number of versions of this term in Polish, but they all mean the same.

There are a number of books dealing with the issue of using real options both in the evaluation of profitability of investment projects and in the valuation of the company. These are mainly foreign publications as Polish contribution to this area of science is not very impressive. The review of specialist literature shows clear differences in this field. Significant contribution was made by, among others: Lenos Trigeorgis, Eduardo S. Schwartz, Martha Amram, Nalin Kula-

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tilaka, Marion A. Brach, Thomas E. Copeland, Vladimir Antikarov, Michael Kopel, Wolfgang Kürsten, Johnathan Mun, Prasad Kodukula, Chandra Papudesu, Graeme Guthrie, F. Peter Boer, Marcus Schulmerich, Sydney Howell, and others. Their publications are often extensive, some of them have around 1000 pages, and contain numerous examples and case studies, as well as, which is of particular value, specialist software on an attached CD. Trigeorgis was the first to systematize the wealth of dispersed knowledge in the real options area, proved their usefulness and possibilities of valuation, relying on the discovery of three outstanding economists: Fisher Black, Robert Merton and Myron Scholes. They all worked on the same problem – option valuation - for many years. Their innovative work was rewarded with the Nobel prize in 1997. The model developed by Fisher Black and Myron Scholes (the Black-Scholes model) is still widely used in valuation of both real and financial options.

In time more and more American authors interested in the assessment of profitability of investment and high flexibility projects, began to take into consideration the concept of real options in their work. In 1977, Stewart Myers first introduced the term *real options* in his lectures. The concept of ROV was gradually gaining theoretical significance. It was not until 1990s that the first attempts to apply it in practice were made (Wrobel, 2010, p. 6). Aswath Damodaran, professor of finance at Stern School of Business in New York analyzed the concept of real options in his successful Ph. D. dissertation. In his extensive work (especially in two editions of “Damodaran on Valuation”) the author characterized all methods used for assessing the value of the company and investment projects, focusing especially on the ROV concept. What is particularly valuable, most of the useful material and fragments of his work were made available on his webpage. Peter Boer, founder of Tiger Scientific described the issue from a slightly different perspective. In his work titled: “*The real options solution: finding total value in a high-risk world*” not only did he characterize the ROV concept, but also indicated the possibilities of applying it in various sectors of the industry. A renowned scientist in this field is also Jonathan Mun, founder and chairman of Real Options Valuation, Inc. (ROV) located in California. The ROV Inc. company offers training and consulting services in application of real options and provides a wide range of specialist software to value options, such as: Risk Simulator, Real Options SLS, Employee Stock Options Valuation, etc. In his extensive work Mun paid attention to the analysis of examples of using the ROV concept by global companies and the models for their valuation. Readers may test the software to value real options which is attached on a CD to his works. It is particularly important that the manual for using the software is described in detail and in a comprehensible way in his works. The most valuable publications on the ROV concept are listed and briefly characterized in Table 1.

**Table 1: The most important and useful English language publications on application of ROV concept**

Author	Year of publishing	Short description of the work
Lenos Trigeorgis	1995	<p><b>Real options in capital investment: models, strategies, and applications</b></p> <p>It is one of the first publications so extensively describing the use of real options. It outlines not only the concept of real options, but also the possibilities of applying particular types of options in selected industries.</p>
Adrian Buckley	1998	<p><b>Real options: managerial flexibility and strategy in resource allocation</b></p> <p>In this work the author systemized the knowledge of real options. He also presented the findings of his research on flexibility in allocating corporate resources and changes in the way of evaluating profitability of investment; from static discount methods to a dynamic real options model.</p>
Martha Amram, Nalin Kulatilaka	1999	<p><b>International Investment: Value Creation and Appraisal</b></p> <p>The book refers to problems related to making investment decisions, especially those concerning specificity of foreign direct investment. The author analyzed the evaluations of investment projects carried out abroad. In 2002 the book was translated and published in Poland.</p>
Sydney Howell, Andrew Stark, David Newton, Dean Paxson, Mustafa Cavus, Jose Pereira, Kanak Patel	2001	<p><b>Real options: managing strategic investment in an uncertain word</b></p> <p>The authors presented the real options method as a new way of effective investment management, reflecting both high risk of a venture and great flexibility in making decisions by managers. In extensive <i>case studies</i> they showed the managers how to apply the concept of real options in planning investment and forecasting its results.</p>
		<p><b>Real options: evaluating corporate investment opportunities in a dynamic world</b></p> <p>The book gave its readers an in-depth description of real options concept and the possibilities of its application, especially:</p> <ul style="list-style-type: none"> <li>- a presentation of what real options are, why they are so essential and when and how they should be used;</li> <li>- basic terms related to real options analysis were explained here;</li> <li>- models for evaluating options were discussed;</li> <li>- numerous <i>case studies</i> and examples of applying this concept in real estate market, energy market and in sports were provided.</li> </ul>

Aswath Damodaran	2002	<p><b>Investment valuation: tools and techniques for determining the value of any asset</b></p> <p>This book described all methods used for valuation of investment projects, with special attention paid to the ROV concept.</p>
F. Peter Boer	2002	<p><b>The real options solution: finding total value in a high-risk world</b></p> <p>This book was an exhaustive presentation of the real options concept. The author focused both on models for their valuation and on possibilities of applying real options in various branches of industry. The author showed in which situation the ROV concept works best and should be used.</p>
Johnathan Mun	2002	<p><b>Real options analysis: tools and techniques for valuing strategic investments and decisions</b></p> <p>This analysis brought a lengthy description of the real options concept and methods used for their valuation. Moreover, it included exhaustively analyzed <i>case studies</i>. The book was available with software, its operations were described in a comprehensive way – it was useful in real options valuation. In 2002 it was one of the most comprehensive guidebooks on theoretical presentations of real options available in the market.</p>
Johnathan Mun	2003	<p><b>Real options analysis course: business cases and software applications</b></p> <p>This publication was a logical continuation of “Real Option Analysis” described above. It characterized the possibilities of applying real options in decision planning and the ways of their valuation in particular methods using specialist software. Thanks to numerous examples of applying real options in particular sectors, it offered better understanding of the concept.</p>
Marian A. Brach	2003	<p><b>Real Options in practice</b></p> <p>The author translated theory into practice. He described the possibilities and ways of applying the real options concept in various branches of industry, such as: pharmaceutical, fuel, energy, advanced technologies and companies operating in e-commerce, biotechnologies, etc.</p>
Thomas E. Copeland, Vladimir Antikarov	2003	<p><b>Real options: a practitioner’s guide</b></p> <p>This was an updated edition of “Real Options”, describing the real options concept from its basics to more advanced possibilities of implementation. It contained experts’ guidelines on implementation of the ROV concept in order to maximize investment possibilities through using uncertainty as an element of assets and minimizing potential losses.</p>

Eduardo S. Schwartz, Lenos Trigeorgis	2004	<p><b>Real options and investment under uncertainty: classical readings and recent contributions</b></p> <p>Research on investment under uncertainty did not progress for some decades until the moment when discoveries in real options area provided tools which allowed its analysis. The authors described particular types of options, valuation models and possibilities of applying them in evaluating investment projects under uncertainty on the example of selected industries.</p>
Han T. J. Smit, Lenos Trigeorgis	2004	<p><b>Strategic investment: real options and games</b></p> <p>The book was dedicated to managers and scientists alike as well as to students. It showed the possibilities of using real options in various situations.</p>
Johnathan Mun	2006	<p><b>Real options analysis: tools and techniques for valuing strategic investments and decisions, II edition</b></p> <p>The book brought extensive characteristics of the method based on real options and methods used for their valuation. In order to present the real options theories better the author described its practical use by global companies and presented many <i>case studies</i>. This book was accompanied with a CD with software allowing the Monte Carlo simulation as well as valuation of particular types of options using the binomial model (SLS – Super Lattice Solver).</p>
Prasad Kodukula, Chandra Papudesu	2006	<p><b>Project valuation using real options: a practitioner's guide</b></p> <p>This book described the concept of real options and methods of their valuations 'step by step', in a way which was comprehensible for both practitioners and top management. It proved the usefulness of real options in both planning investment and evaluation of its profitability.</p>
Graeme Guthrie	2009	<p><b>Real Options in theory and practice</b></p> <p>The work characterized particular types of real options and accessibly described the possibilities of their application and valuation. It focuses on presenting situations in which real options should be successively used. The publication contained a CD with spreadsheets which could be used in a wide range of real options applications.</p>
Aswath Damodaran	2011	<p><b>Damodaran on Valuation: Security Analysis for Investment and Corporate Finance</b></p> <p>This was the second edition of "Damodaran on valuation", considered the most reliable and extensive book on valuations. In it Damodaran answered the most important questions related to valuation which had appeared in the world of finance.</p>

Source: Own elaboration

In Poland, the concept of real options as a new innovative tool enabling valuation of even the riskiest investment and offering the possibility of taking into account flexibility in managerial

decision, interested experts as late as in 2003-2005. The main researchers into this issue at that time were: Jacek Mizerka and Tomasz Wiśniewski. Initially they published some articles in scientific journals and online, but gradually books on this subject began to appear. Other scientists analyzing this issue included Waldemar Rogowski, Wiktor Patena, Grzegorz Urbanek, Zbigniew Krzysiek, Piotr Saługa, Jerzy Dzieża, Marek Capiński and others. Currently, experts are mostly focusing on the possibilities offered by the ROV concept in evaluating the profitability of high-flexibility investment projects.

Experts, articles and scientific publications bring sufficient information on the possibilities of applying real options, their valuation, strengths and weaknesses.

The present economic situation in Poland is quite uncertain and unstable, therefore it is particularly important to be able to make decisions flexibly during the realization of the project, as it allows us to react quickly to changes which take place. Evaluating real options we can numerically present the company's added value resulting from future development opportunities, which is essential.

## **Company valuation**

Specialist literature distinguishes many reasons for conducting valuation, such as: sale transaction, privatization and restructuring, building investment portfolio, taking over or comparing companies, merger, company bankruptcy and liquidation, strategic and operational planning, etc. Various purposes of valuation usually require different methods. Contrary to popular belief that company value should be identical regardless of the reason of valuation, it is clear that the expected value of a company valued for tax purposes will be lower than the value calculated for the sale purpose (Patena, 2011, p. 11).

Poland's accession to the European Union, development of capital market, internationalization of enterprises, changed accounting regulations and their amendment modeled on International Accounting Standards, increased significance of intangible assets and other factors account for growing interest in company valuations in Poland (Buckley, 2002, p. 8). In finance theory, the search for the best methods of company valuation still continues. Classic discount methods often turn out to be insufficient to correctly evaluate the profitability of investment as far as investment in new technologies, pharmaceutical and mining industry or expansion into new markets are concerned.

To better understand the essence, scope and aims of company valuation, we should learn what benefits for potential parties of the transaction result from the knowledge of this value. Valuation helps sellers to: determine the selling price, strengthen their price argumentation in negotiations, make a decision to sell, to offer shares in public or to liquidate the whole or part of the enterprise, to determine the range in which (according to current and future economic conditions) the value of the company is. For buyers, on the other hand, valuation is useful in: making sure that the proposed price for purchasing the enterprise is not too high; consolidating the knowledge of the sector and competitive position of the purchased company as well as determining available and optimal methods of financing the purchase transaction (Szczepankowski, 2007, p. 191).

According to Panfil (2009), in Poland the most frequent reasons for company valuation are sale/purchase transactions in private market, court cases and balance sheet updates. Other sources mention privatization, that is the process of transferring state property into private hands, as the most common reason for company valuation in Poland (Obtained from: bankier.pl, 15.01.12).

## The most frequently used methods of company valuation

Scientists provide a number of classifications of company valuation methods. In the USA the division into three main groups: asset-based, income-based and relative ones, dominates (Fierla, 2008, p. 11). In Poland, a slightly different classification has developed, namely into two main groups: asset-based and income-based methods. There are also: mixed methods – between asset and income methods; relative methods, which are often referred to as multiplier methods; and unconventional methods. Such classification was proposed by Zarzecki (1999), Fierla (2008), Michalski (2001), Nita (2007) and Szczepankowski (2007). A wide choice of valuation methods gives the valuing person a possibility of choosing a technique fitted to the company operations, though it also creates the problems related to choosing the most appropriate one. There are authors who opt for income methods and treat relative and real options methods as alternatives to it.

Real options are generally treated as an asset method, as the valued stock is treated as a financial instrument. Koller, Goedhart and Wessels (2010) claim that “so far scientists have focused on the DCF method. There are, however, two more valuation techniques: comparative and real options” (p. 129). The classification proposed by Damodaran (2002) is similar and comprises three basic types of methods: income valuation, relative valuation and contingent claim valuation. He also mentions the asset-based approach used in company valuation (p. 11).

In Poland, according to the Regulation of the Council of Ministers from 17th February 2009, assessment of the value is made by means of at least two valuation methods. They are mostly selected from the following methods: DCF method, replacement value method, adjusted net asset method, liquidation method and comparative method using the earnings ratio (Journal of Law, number 34, position 265). The reason for such division are the resources that the Ministry of Treasury wants to value, which are commercialized state enterprises, characterized with large fixed assets, but small possibilities of generating positive financial results. Such enterprises are often doomed to liquidation, therefore one of the valuation groups preferred by the Ministry of Treasury is that of asset methods (Patena, 2011, p. 62).

In the contemporary world, using the concepts of company valuation we may determine the price at which the company should be sold. Therefore we should assess all benefits which the company owner will achieve after purchasing the company. The traditional valuation concentrates on methods which allow us to assess the value of company assets (asset methods) or the stream of incomes generated by it (income methods). It does not reflect the benefits resulting from the change of the owner and their his/her possibilities. Contemporary valuation concepts base on a broad valuation formula and, while determining the potential price, take into account the fact that the owner will change. As a result, the company has a different value for different buyers, which allows us to choose the one who offers the highest price. A certain constraint of these methods is the fact that they do not take into account the value of organizational capital (Duraj, 2001, p. 226 – 227).

The choice of the valuation method and technique is also greatly influenced by value standards. A standard can be defined as a typed of sought value. In the USA value standards are mostly defined by acts, tax regulations or judicial decisions. In case of financial reporting these issues are regulated by accounting standards (Fishman, Pratt and Morrison, 2007, p. 21). As Grudziński and Zarzecki claim, the concept of value standard was practically absent and unknown in Poland in the last decade, and the lack of a clear definition of this term generates the risk of making serious mistakes in the process of choosing valuation methods and interpretation of results. Summing up, the model of company valuation should be adjusted to the specific areas of its operations, have a scenario form and reflect risk factors, be transparent and relatively simple

(Szczepankowski, 2007, p. 201). Currently, there is no single objective method which could become a standard and, irrespective of the situation, determine correct values. The most popular methods are: DCF and the method based on multipliers. Unfortunately, none of the methods can predict the economic situation in the country, political changes, terrorist attacks, changes in business cycle, changes in valued companies (Panfil, 2009, p. 54 – 55). Therefore more and more attention is paid to the theory of real options, which allow us to reflect in our valuation the flexibility of decision-making process and possibility of changing the strategy depending on market conditions.

### **The description of the method based on real options**

Options are one of the most complicated financial instruments. It is a derivative instrument related to the asset (Damodaran, 1996, p. 356). In a broad meaning – option is the right, not the obligation, to perform a certain action. It is very difficult to define real options in one sentence. They have their origin in financial options, and the idea of their valuation is based on similar assumptions as in case of financial options. According to Podszycalow (in: Szablewski and Tuzimek, 2007) these methods allow us to look at company equity and at investment projects as at the options. The key to success in using the concept of real options is the ability to identify, classify and value them.

The Real Option Valuation method (ROV) allows us, at least partially, to evaluate such aspects of an investment project as flexibility of its realization, high risk or possibility of waiting for new information. In the contemporary world, the concept of ROV is most frequently used for evaluation of the profitability of high-risk and high-uncertainty investment projects. The option method is also often applied when a company is entering a new area of activities, which is connected with the risk of market reaction to its offer.

The most popular models of real option valuation are analytical solutions proposed by Black-Scholes and numerical solutions known as a binomial model (Panfil and Szablewski, 2006, p. 50). According to Szczepankowski (2007, p. 278) the assessed value of real option increases the company value obtained from the income approach (DCF) or from the discounted economic profit approach.

The area of real options application are usually the company intangible assets, which, in turn, are the source of many development opportunities for the company. They may be used or not – depending on circumstances. The value of intangible assets is hard to calculate using only traditional valuation methods, due to their flexibility of application. In the DCF valuation we can only determine the likelihood of future actions, not their optionality. In case of valuing the company basing its operations on intellectual capital or when evaluating investment in intangible assets, when we apply classical methods, we will receive a lowered value. Such valuation of investment may lead to the rejection of the project, while added value calculated thanks to an option may guarantee its realization. The use of real options in investment valuation is of vital importance in the projects where the value calculated with traditional DCF method is around the break-even point (Urbanek, 2008, p. 138). The concept of real options may help us identify how to limit the risk and how to design an alternative “B” plan in order to effectively prevent risk and minimize losses (Brach, 2002, p. 10 -11).

Mun (2002, p. 10) compared in his work the real option valuation method to a road map, full of roads, junctions and turns. When planning a trip, a man tries to choose the fastest and shortest way which he then follows until he encounters some obstacle on it. In this situation the map turns out to be very useful, as it indicates other available routes and gives us the possibility

of continuing our journey. Investment projects are similar – at the beginning we assume that investment will be static and we establish the execution plan, but we should be prepared for all kinds of obstacles. In this situation real options may be compared to a map, as they indicate other solutions and allow us to adjust the plan to existing market conditions.

According to Szczepankowski (2007, p. 279) the essence of options consists in the fact that they allow investors to increase the value of their ventures by reducing losses or increasing income. Analyzing the practical use of the real options concept, Copeland and Keenan (1998, p. 130) identified sectors in which the ROV concept is most frequently used for evaluating the profitability of investment ventures realized in them. These are: chemical, electronic, energy, metal, pharmaceutical, wood and paper, retail, e-commerce, aviation and defense, telecommunication, media and entertainment, transport, banking, car, production and e-business sectors.

### Classification of real options

The division of real options can be made taking into account two basic criteria: the first one refers to finding analogies between the construction of real and financial options, while the second one consists in finding specific types of real options. It is difficult to classify real options, especially in Polish literature, as various authors use various terms interchangeably. The division of real options presented in Table 2 is the outcome of the analysis of available classifications.

**Table 2: Division of real options**

Type of option	Typical features
<b>Option to abandon, exit option</b> – American sale option	The decision maker has the right to abandon the venture in a situation when there are unfavorable external conditions (for example prices) or internal ones (financial situation), that is when there is clear and lasting deterioration of market situation and the company does not want to bear fixed costs.
<b>Option to defer, option to delay</b> – American purchase option	Depending on the company situation, it may defer the decision to invest and the investor does not have to make a ‘now or never’ type of decision. Sometimes, in order to minimize investment risk, it is worth waiting for the development of the situation in the market environment, and when it develops positively - investing.
<b>Options to change the volume of activities</b>	Options to change the volume of activity covers both contracting and expanding the volume of investment venture. The former one could be compared to the financial option to sell, the latter to the option to purchase.
<b>Option to contract</b> – American sale option	In changing market conditions, it is useful for the company to have a possibility to actively manage the production volume. The expected benefit is the reduction of some costs.
<b>Option to expand</b> - American purchase option	Option to expand exists when a company has a possibility to speed up the project realization. Realization of option to expand requires additional investment expenditure.

<p><b>Option to switch, flexibility option</b> – a portfolio consisting of American options to sell and options to purchase</p>	<p>This is related to the possibility of suspending and starting again activities, as well as the change of used raw materials, technologies and other factors of production, as well as finished goods. It is usually defined as flexibility option, as it allows us to adjust to varied demand structure through changes in production, service or technology range. In practice it allows us to quickly adjust to the current trend (product flexibility).</p>
<p><b>Growth option</b> – option to purchase</p>	<p>Growth option mostly concerns the projects whose realization gives the investor the possibilities to undertake other related ventures. It usually requires additional expenditure. It is most frequently treated as a compound option, as it is connected with realization of the ventures divided into stages.</p>
<p><b>Staging option</b></p>	<p>It is a developed form of growth option. It consists in completing successive stages which lead to increasing the volume of activity dependant on the previous project results, as well as it allows us to avoid the necessity to lay out all expenditure for a given venture at once. The decision to allocate resources in the next stages of company development may be deferred in time until favorable investment conditions appear.</p>

*Source: Own elaboration, on the basis of Dzieza, J., Ficak, B. (2004). Opcje realne, Materiały Szkoleniowe, No. 3/2004, p. 16; <http://www.min-pan.krakow.pl/Wydawnictwa/GSM2433/zarczyński.pdf>, retrieved on 08.08.11, p. 359-360; Rogowski, W. (1981). Opcje realne w przedsięwzięciach, p. 31-33; Jajuga, T., Jajuga, K. (1981). Inwestycje. Warszawa: PWN, p. 367-368*

Usually investment projects are a set of a greater number of related options. Quite frequently the use of option excludes the use of another one, etc. Therefore, we should preset another division of options: simple options and compound options, as well as the so-called rainbow options. A rainbow option is an option set on two or more base instruments, while each instrument is analyzed separately (Retrieved on: <http://finance.mapsofworld.com>, 15.01.12)

The division of options into their types allows us to distinguish American and European options. The American type can be used at any time in the option life, while the European one can only be used after its expiration (Fierla, 2008, p. 175).

## The comparison of real options to traditional valuation methods

Traditional approaches to valuation assume static ability to make decisions, while real options predict a dynamic series of future decisions, in which a managing person has a lot of flexibility in acting and thus can quickly adjust to changes taking place in the economy. The DCF method does not take into account active management of the company related to flexibility and enabling us to modify the strategy during its execution, due to changing internal or external conditions. In practice, managers make investment decisions in constantly changing circumstances and the options available to them are to make, defer or resign from a particular course of action (Urbanek, 2008, p. 129). The real options method corrects the shortcomings of the discounted cash flow method, which, due to not taking into account the value of options portfolio and the flexibility it offers in future actions, may underestimate the real value of the company. In both cases

the strategy of making investment decisions is totally different. The DCF model is a static valuation method, therefore decisions are made on the basis of possessed information about future events. The real options model, on the other hand, provides flexibility in the process of making decisions, which, in turn, depend on changes taking place in the economy (Panfil, 2009, p. 87). Classical methods often lead to wrong conclusions if the valuation takes into consideration such situations as, for example: deferring investment in time, possibility of expanding/contracting the area of activity, etc. In some situations, especially in the sectors of modern technologies, mineral resources and pharmaceuticals, a more reliable valuation is obtained while using the real options methodology. They offer the possibility of calculating the value of the investment project reflecting the managerial decisions taken in the course of its realization. Real options eliminated the main weakness of the NPV method, which assumes that investment expenditure on realization of a venture are irrevocable. The theory of real options does not deny traditional valuation methods, on the contrary, it relies on their results.

The NPV investment value is supplemented with the flexibility value of the investment, established thanks to the assessment of risk and possibilities of reacting to it (Rogowski, 2004, p. 178). According to Mizerka, the projects in which methods based on expected cash flows may fail include:

1. projects whose realization should be suspended until we obtain more detailed information on market situation. This usually happens in case of branches related to new technologies,
2. multi-stage projects in which the realization of one stage depends on the success of the realization of the previous stage. Such situation usually happens with investment which requires huge initial expenditure on, for example, conducting research (pharmaceuticals, biotechnology, information technologies, etc.),
3. whose effective realization opens possibilities of implementing others, thus utilizing the development opportunities. It often happens with infrastructural investment,
4. projects in which it is clear from the beginning that during their realization we will have to make decisions concerning the change of production volume,
5. whose realization can be suspended, deferred in time or abandoned.

Despite the fact that real options have significant advantage over classical methods, Scholleova points at the situations in which the ROV concept cannot be used:

1. the decisions made are certain and risk-free; in this case the value of options disappears, and ROV valuation brings the same results as the DCF valuation,
2. there is no possibility of modifying or deferring in time investment decisions in the course of the project; there is no point in using the option measuring flexibility when it is unattainable in this situation,
3. low budget projects in which the value of assessed option would exceed total costs of the project,
4. double options, in case of which the value of options would be assessed for a bigger number of mutually dependent projects; in this situation flexibility could be overvalued (Scholleova, 2005).

Saluga, Kicki and Dzieza analyzing the possibilities of using real options method in an economic assessment of investment projects in mining. One of the few practical work on real options is the publication of Saluga titled "Economic evaluation of projects and risk analysis in the mining industry." According to the Dzieza, "many practitioners in the mining, energy or fuel industry are not fully satisfied of the use of traditional methods in economic evaluation of a new venture. In

his article titled “Real Options - dilemmas and suggestions for making investment decisions in the mining industry,” the author lists three main drawbacks of classical valuation methods. The first is one of the main disadvantages of DCF - fixed data, and therefore no possibility of providing flexibility in decision-making managers. Another disadvantage is the need to forecast future cash flows, which is essential to estimate the future prices of raw materials, mining operating costs, exchange rates etc. and also the prediction of state tax policy what is not an easy task. The problem causes the need to choose the appropriate discount rate, which in practice is often chosen ad hoc and characterized by a relatively large dose of subjectivity, which in turn may bring a significant systematic error in the DCF calculation. Quite often it turns out that the market values of mining companies are higher than those previously measured using discounted cash flows method. To justify the above statement I am going to present quote from the article “estimates made by the U.S. Geological Survey for 21 mining companies, including oil and natural gas, were on average 22% lower than the average prices offered for them. Nesbit Research Professionals also claimed in 1989 that the Net Present Value of 10 U.S. and Canadian mining companies involved in the operation of gold, were on average 300% less than their market capitalization. At first glance, the real options method, which allows measuring the value associated with the flexibility of decision making, is a tool for precise measurement of investment projects. But why is it so rarely used in practice of mining? The main reason is the previously mentioned complex calculations mechanism that requires the use of advanced mathematical tools. According to practitioners the methodology used to calculate the result is hardly verifiable, which means that this method is met with distrust and distance (Obtained from: [www.teberia.pl](http://www.teberia.pl), 15.01.12).

Luigi Sereno in his article titled “Real options valuation of pharmaceutical patents. A case study” in a very transparent way described the possibility of using ROV to value patents in medicine. He demonstrated the calculations on the example of patent evaluation, using the binomial model and Mathematica programming. The value of the patent gained using Mathematica was similar to value obtained with the implementation of the binomial model. The results showed that the value of the patent increases when the value of the project and volatility increase. The simulations also showed that firstly the higher value of the patent was obtained using the ROV concept compared to the DCF and secondly the patent value is sensitive to variations in significant value drivers (Sereno, 2010, s. 22-23).

Real options can also be used to evaluate investment projects relating to the coke industry. Their use can help to solve many dilemmas associated with the analysis of the efficiency which appear during the implementation of basic methods. Zarczyński in his article titled “Pricing methodology and possibilities of application the real options in coke industry” presents the genesis of real options, their types and areas of application, two basic options pricing models: the Black-Scholes model and Binomial Lattice model, and finally exemplified some of the areas of real options application in coke making industry.

Summing up, compared with income or asset methods, the company valuation using the concept of real options is reliable and necessary for proper assessment of company value. Unfortunately, it is rarely used, as it is necessary to use complicated formulas, the understanding of which requires advanced mathematical knowledge and adoption of sometimes unclear and quite rigid assumptions. The use of option methods may lead to lowering investment risk, which is connected with revaluation of companies. The ROV concepts are recommended in high-risk and high-uncertainty investment ventures which have great flexibility in realizing investment. In case of company valuation, real options are more a supplement to traditional valuation meth-

ods, taking into account flexibility of company activity, which is its quick reaction to changes and adjusting decisions to existing economic conditions. According to Patena (2011, p. 249) the use of options in Polish business practice has met a lot of resistance and the whole theory is regarded with mistrust – due to its complicated calculation process.

### Models of real option valuations: barriers to their use

According to Mun (2002, p. 38), before starting the analysis of real options, analysts should be aware of several constraints. Firstly, there are the following five requirements must be met before it is conducted:

1. **there must be a financial model.** The analysis of real options requires the use of an existing model of discounted cash flows. If there is no such model, it means that strategic decisions have already been made and no financial justification is required,
2. **there must be uncertainty.** Otherwise an option is worthless. If we know everything ‘upfront’, in this case the model of discounted cash flows is sufficient,
3. **uncertainty must affect decisions made by a company during the realization of a venture as well as it must affect the results of the financial model.** The appearing uncertainties will become risk then and real options may be used to secure the risk of failure,
4. **the manager must have the possibility of flexible decision making or the possibility of implementing changes during the active realization of the project.** You cannot use the concept of real options in case there are no options or flexibility in managing the value,
5. **the decision-maker must be predicting and credible enough to realize an option at the optimal moment.** In other words, all existing options are useful when they are realized in proper time and in appropriate conditions.

There is widely held belief that the methodology used for calculations is hard to verify. Indeed, it is sometimes the case. In the assessment of real option valuation we use two basic methods: the Black Scholes model and the binomial model based on the decision tree analysis. The former method is a theoretical foundation for other methods, whereas its application in valuation is restricted to only a few cases. The most important assumptions of the model which cannot be repealed and account for serious restrictions in its use are: there are no transaction costs, the market is effective, there is no possibility of arbitration and there is a fixed risk-free return rate. Attempts at changing these assumptions lead to complicated formulas which become less useful to valuers (Pindelski, in: Panfil and Szablewski, 2006, p. 329). To describe the prices of base assets which are subject to uncertainty and vary in time, we use stochastic processes (Nita, 2007, p. 185). The Black-Scholes model adopts an assumption that the process causing price changes of a base asset is the so-called Geometric Brownian Motion, which assumes that the value of a base asset changes continuously and that the distribution of these changes in any time interval is a normal distribution. This explains the appearance of the Euler number  $e=2.71828$  (Rogowski, 2008, p. 55 – 56).

Although the Black-Scholes model is treated as the best tool for real option valuation, it has a number of constraints, such as: (Rogowski, 2008, p. 58):

1. it concerns European options (the option may be realized only on the day of expiry), while most real options are American type options,
2. it assumes the existence of one source of uncertainty which influences the price of a base asset, while there are usually more such sources during the realization of material investment,
3. it assumes the knowledge and stability of investment expenditure on realization of a particular option; sometimes this is not the case, for example in a situation when we have

- a compound option in which successive stages of realization depend on the success of previous stages,
4. it assumes the logarithmic and normal distribution of the value of base asset with a fixed level of variation; in case of real options the value of a base asset may change, for example, as a result of changing economic conditions,
  5. it is not appropriate in valuation of compound options or to value investments which have a number of excluding options.

The analytical equations – the Black-Scholes model are difficult to explain although they offer a quick way of calculating the value of options. This method has a limited ability to model flexibility. Appearing objections related to the implementation of Black-Scholes model in practice describes the work of Hubalka and Schachermayer. The main assumptions presented in the article informs that (under certain conditions) if we can't find the replicating portfolio for real options, but only the portfolio enabling replication with the estimated accuracy, than "every number in the interval may, without breaking the principle of no arbitrage, be a possible price of the option." The authors emphasize that the main message of the article doesn't mean that the use of Black-Scholes methodology to value real options is wrong. It should be noted, that using it to value real options, which underlying asset is out of the market, we should keep vigilant caution. As a consolation, we can add that if the portfolio in almost a mirror reflects the payment of the option, after rejecting a few percent less possible scenarios the likely range of prices is shrinking (Hubalek and Schachermayer, 2001, p. 361-373).

Trigeorgis notes that "the existence of the twinning instrument in the market (or portfolio of instruments), which is perfectly correlated with the underlying asset of real option is a sufficient condition for the valuation of real options." In comprehensive way, this kind of approach to the use of real options, describes the work of Howell and Luehrman. On a basis of this approach Boer and Kellogg trying to measure the real options value.

Copeland and Antikarov made a step further apropos that concept. They noted that the use of an approach using the twin instrument is highly frustrating as finding the asset being traded, which cash flows are perfectly correlated with the flows generated by the underlying asset in real option for the entire duration of the project, is virtually impossible. As an aid in unraveling the problem they introduced the concept of *Market Asset Disclaimer* (MAD). In it, the most optimal solution is to use the project value without considering flexibility as the best available replica of an investment project (Żarczyński 2008, p. 363).

The authors suggest the use of a basic NPV value (without options) of the project. Speculate that this NPV is the best and free from any burden estimate price that the project could obtain on the market, if it will be traded. The variability of returns, in turn, is determined by identifying risk factors and Monte Carlo simulation.

The binomial model assumes that changes take place irregularly and abruptly and the values, depending on prevailing market conditions, may in the next period of time take two possible forms: the increasing or decreasing ones (Brach, 2002, p. 52). The real option valuation by means of the binomial model allows us to assess both European sale and purchase options and American ones. The use of the binomial model to value real options was also criticized, mostly because:

1. it is believed that after adding some options to the model, the decision tree transforms into a complicated system, which hinders strategic planning related to its use,
2. scientists question the possibility of reliable assessment of physical probabilities;
3. the identical cost of capital was used for discounting all cash flows, whereas the variation of option returns and project returns may differ,

4. the method does not take into account the existence of the market in which many of the formulas of cash flow appearing in the project may already have their prices established – it is believed that their revaluation opens the door to arbitration (Patena 2011, p. 12).

In the binomial model, the more time stages are taken into consideration, the closer the result is to the result obtained from the Black-Scholes equation. In order to check the reliability and correctness of the outcome Rogowski (2008, p. 63), it is recommended to use both methods simultaneously. It is true that both methods have been borrowed from the world of finance and rely on the possibility of replication. In case of real options, their use is only justified when there is a value in the market which could be used for replication of option payment. According to Patena (2011, p. 253), finding a twin value which generates cash flow ideally correlated with the base instrument of an option is a daunting task.

One of the biggest problems with real option valuation is the lack of ability to recognize them in reality. Other problems are related to the calculation procedure. The assessment of assets and projects using the real options method is connected with several constraints, the most important being listed below (Urbanek, 2008, p. 148):

1. the influence of third parties on option value – for example the value of options for manufacturing a new product falls when a competitor decides to launch a similar product – basic models of options do not take into account the possibility of other entities' influence on option value,
2. lack of exclusivity – many sector companies often have identical options, therefore the use of options by one competitor causes the decline in value for other entities,
3. contrary to financial options, trade in real options is quite difficult, as they are usually unique and may have different value for different companies,
4. current asset value for a real option is mostly unknown and based on estimates of future cash flows,
5. the existence of compound options – realization of some options leads to creation of new real options – the consequence is the difficulty of calculating the original value, as when assessing we have to take into account newly-created options,
6. assumptions of option valuation models – they are not always identical with the real situation.

The most common errors in the valuation of real options describe Pablo Fernandez in the article "Valuing real options: frequently made errors" (Fernandez, 2001). He found that the best way of doing it is through an examples. According to the author some of the errors and difficulties related to the valuation of real options include:

1. assuming that the option is replicable and using Black-Scholes model,
2. the estimation of the option's volatility is arbitrary and has a crucial effect on the option's value,
3. as riskless arbitrage is absent, the value of the option to expand basically depends on expectations about future cash flows. However, Damodaran assumes that the option is replicable and this parameter does not influence the option's value,
4. it is not appropriate to discount the expected value of the cash flows at the risk-free rate because the uncertainty of costs and sales in the exercise date may be different than that estimated at that moment,
5. Damodaran's valuation presuppose that we know exactly the exercise price,
6. belief that options' value increases when interest rates increase,
7. valuing contracts as real options when they are not.

Fernandez proved below statements on the example of Damodaran proposal to value the option to expand the business of Home Depot and others. To sum up, the concept of real options is definitely a valuable supplement of traditional valuation methods, but also we can encounter some problems when valuing them.

## Conclusions

Real options are an indispensable tool in valuating investment ventures, as the contemporary world creates highly uncertain market conditions and managers appreciate flexibility in their decisions. The methods based on discounted cash flows do not take into consideration active company management or flexible actions related to the possibility of modifying plans and, as a result, changing external and internal conditions (Rutkowski, 2001, p. 270).

There are two basic methods of real option valuation: the Black-Scholes model and the binomial model. The former is considered to be one of the best tools for valuating real options, but it does have some constraints. It works best when valuating own equity and growth options, which are of the European purchase type, but in case of American option valuation, it only gives approximate valuations. The binomial model is more widely used than the Black-Scholes model, as it can be used for valuating not only European purchase and sale options but also for American ones. It does not require assessing variation – it uses probability distribution.

The popularity and use of the real options method is constantly growing all over the world. In Poland, though, the use of the real options concept is rather rare, though increasing uncertainty related to conducting business activities and competitors' pressure will force companies to use real options as a tool supporting decision-making process. The issue of real options is more and more often discussed by renowned financiers in prestigious economic magazines, which will definitely affect the popularity of this method and the ROV concept will be more often implemented in strategies of Polish companies.

One of the problems encountered in real option valuation is the lack of ability to recognize them in reality. Other problems are related to the calculation procedure. It requires the use of complicated formulas which can be understood only by people with advanced mathematical knowledge and adoption of sometimes unclear and quite rigid assumptions. They demand that managers have specific mathematical skills without which they are unable to deal with them and to use their full potential. A certain constraint in the use of the ROV concept is the need for very good historical data that generally only exist in financial markets for typical assets that are subject to systematic trading. Taking into account not only benefits but also drawbacks of the method, we can state after professor A. Triantis from University of Maryland: "Real options are like extreme sports. People watch them with pleasure and say: Wow, that's cool. But if you want to try them alone – everything immediately becomes complicated".

To summarize: the option approach to company valuation undoubtedly supplements the result obtained in the discounted cash flow method (DCF), the economic profit method or the model of market multipliers. In spite of the complicated valuation process, correctly identified and properly valuated real options may be of key importance in the decision-making process. One of the problems with the real option valuation is the lack of ability to recognize them properly. Other difficulties are related to the calculation procedure. It requires the use of complicated formulas which can be understood only by people with advanced mathematical knowledge and who will adopt sometimes unclear and quite rigid assumptions.

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