REAL OPTION ANALYSIS - DECISION MAKING IN VOLATILE ENVIRONMENT

Ivana Tomas, dipl.oec.,
Faculty of Economics, University of Rijeka,
Ivana Filipovića 4, 51000 Rijeka, Croatia
E-mail: ivana.tomas@efri.hr

Josipa Višić, dipl. oec.,
Faculty of Economics, University of Split,
Matice hrvatske 31, 21000 Split, Croatia
E-mail: josipa.visic@efst.hr

ABSTRACT

Since the capital investments absorb significant amount of cash and determine future business activity, valuation of investment project is considered to be one of the most important decisions companies must make. For the last two decades developed countries have been using contemporary methods of valuation of investment projects that include the possibility of adjusting future decisions depending on the conditions in the business environment.

Capital investment efficiency assessment cannot be a reliable or an objective basis for making investment decisions unless it also takes into account real option analysis. Although real option approach questions reliability of traditional methods of valuation of investment projects, it should primarily serve as a supplement rather than a substitute for traditional methods of valuation of investment projects aiming at more successful investment decisions making.

Key words: investment, risk, uncertainty, discounted cash flow, net present value, real option.

1. INTRODUCTION

During the process of evaluating acceptability of an investment project, traditional discounted cash flow method presume that company will hold its assets passively i.e. they ignore the adjustments company could make after the project has been accepted and implemented. Adjustments which allow flexibility of changing old decisions when project related conditions change, are known as *real options*. The term *real option* has been introduced by Steward Myers in year 1977. According to Myers, evaluation of investment possibilities using net present value method ignores the value of the option which arises from the uncertainty which is inevitable in every project. A decade later, real option method has spread to investment decision making, partially due to contribution of numerous authors, such as: Dixit (1989), Dixit and Pindyck (1994), Pindyck (1988, 1991), Brennan and Schwartz (1985), Kemma (1988, 1993), Sick (1989), Trigeorgis (1988, 1991, 1993, 1995, 1996), Ingersoll and Ross (1992), Myers and Maid (1990), Maboussin (1999), etc.[19].

Unlike traditional methods of investment projects valuation which treat investment project as a static process determined by basic variables and projected cash flow, contemporary methods regard an investment as a dynamic process that gives the management the flexibility in decisions making involving future investment projects. In fact, binding the chosen scenario to the life cycle of the investment project is not consistent with "real life" conditions, so it is almost certain that management will react to certain occurrences that could appear after the acceptance of investment project. If the unexpected circumstances that occur are favorable, management will try to use the given opportunities in order to increase net present value of a project. Also, if unexpected circumstances are unfavorable it is hard to believe that there will be no reaction of managers [14].

According to Dixit and Pindyck [9] net present value of a project is generally easy to calculate but it is based on false assumption that investment is irreversible and impossible to postpone. In fact, even if a project has a positive net present value, it does not necessarily mean it should be implemented right away. Sometimes delaying the implementation of a project can additionally improve its value. Techniques of real options evaluation can assess components of managerial adaptability that are hard to perceive and which are neglected or underestimated by traditional approach [18]. Traditional approach does not include existence of additional adjustments to circumstances that could not be perceived during analysis of financial efficiency of a project. Therefore, it is impossible to ignore the assumption that traditional (conventional) project evaluation methods actually underestimate the value of a project [14].

2. TYPES OF OPTIONS ON REAL ASSETS

When making investment decisions, real option approach includes risk and uncertainty management with the help of the various options that can be used or abandoned, depending on future changes in markets and technology. Greater the uncertainty surrounding the investment project, greater is the possibility that the option will be exercised, thus making its value higher. Some of the available real options are: 1) option to expand, 2) option to abandon, 3) option to change inputs and outputs and 4) timing option.

1) Option to expand - Option to expand allows expansion of production if market conditions become favorable. It appears in the infrastructural and strategic industries, high technology industry, research and development, IT and pharmaceutical industry. The value of this sort of project comes not from within, but from the opportunities that growth provides. For example, the first generation of products of high technology even with a negative net present value, can serve as a foundation for lower costs and proven quality in products of next generations. Option to expand has characteristics of the call option. It offers a limited loss in the amount of negative net present value of initial suboptimal (pilot) investment. Limitation of the maximum loss reduces the risk of the investment project which would occur if overall investment in the amount of optimal capacity was immediately taken. In this way, the option to expand appears as a kind of call option, which provides limited loss in unfavorable circumstances, and significant profit prospects in favorable [14].

2) Option to abandon - If the project causes financial loss company can activate the option to abandon the project. While the abandonment may seem like an act of cowardice, this option often saves the company from large financial losses. Therefore the value of the project can be increased if it has the option to abandon [5].Option to abandon can be evaluated as an American put option on the value of the project with the cost of realization; this is practically equal to the rest of the value, or the value of the best alternative use of the assets. When the present value of the project sinks below the liquidation value, assets can be sold, which is actually a realization of the put option. This option is very important for the large, capital intensive projects such as nuclear plants, air and rail traffic.

3) Option to change inputs and outputs - Many manufacturing sectors have built-in flexibility of production, depending on changes in demand. The possibility of using different inputs (option to change inputs) in order to manufacture a certain output is significant in sectors such as agriculture, power generation and chemical industry [15]. In industries where the demand is variable and dominated by a small series of products, such as automotive and electronic industries, the ability to adjust is offered with option to produce different output with the same input. Option to change the inputs is particularly valuable in terms of frequent changes in oil price (companies no longer want to depend on one source of raw materials so they resort to the use of cheap gas boilers or dual gas/oil boilers that are less sensitive to the oscillations of the oil price). Additional cost of investments in flexible system is justified if the option to switch energy sources has a greater value of fixed variants of usage of energy [5] and [1].

4) Timing option - Timing options as well as other options are directed to reduction of the risk of investing in real investment projects facing significant uncertainty. While waiting, investment project is frozen in the existing stage of its life, with the intent to be activated when/if more favorable circumstances appear. There is no commitment for management to activate the investment project if favorable circumstances do not appear [14]. When decision on investment can not be delayed, or when it is a "now or never" investment, net present value (traditional tool) of the project equals the value of the project calculated using real option methods. If there is no possibility to delay investment, the standard deviation as a measure of volatility of a project does not influence the calculation of the value of an option and in this case, the value of the project is the same as the call option [15]. However, if there is a possibility to delay an investment, net present value of the project will differ from the value of the project obtained by real option method due to following reasons: the time value of money (money today is worth more than same amount in the future) and the value of assets invested (if asset value increases, the decision on investment is valid, and if asset value decreases, the project is rejected) [15].Timing option can be used when considering the large investment projects that show a large probability of realizing a negative net present value. Therefore, it is necessary to compare the value of the lost cash flow caused by delay in investment with the possibility of obtaining valuable information [14].

3. EVALUATION OF REAL OPTIONS

Traditional methods of discounted cash flows are relatively easy to understand since the theoretical framework of this method is clear, and the concept of time value of money is the only prerequisite for their understanding. In comparison with the traditional tools of projects evaluation, real option analysis is considerably more complex and requires a higher degree of mathematical understanding.

In the real option approach, investment opportunities are observed as financial options (derived securities). Namely, the option (call or put) represents the right (but not the obligation) of purchase or sale of any security, on a pre-determined price. Following the logic of financial options, the investor has the opportunity (the right, but not the obligation) to invest in a project. If you invest, you realized that option. If you do not "enter" in the project, the option remains the unused portions of the right since the minimum price of the option is 0 (zero),

$$C = \text{Max}\ (S-X,0),$$

where:

C = the value of call option
S = market price of one share,
X = price of option's realisation

Investment opportunity, being right, but not the obligation of investment in a project, cannot diminish the value of the project (minimum value is equal to zero). Therefore, the value of real options (investment opportunities) is always positive, or zero, and can only increase the value of investment projects. With all the above mentioned, several additional features, which are offered to the investor, make the investment project more flexible and more valuable. [17].

If there was a call option sufficiently similar to investment project, its value would indicate the value of an investment project. Hence, when setting up models of real option valuation, it is necessary to translate variables of European call option directly into "real" investment analogs as shown in Table 2:

Table 1: Comparison of financial and real options variables

CALL OPTION	*VARIABLE*	*INVESTMENT OPPORTUNITY*
Stock price	S_0	Present value of project's Free Cash Flow
Exercise price	**X**	Expenditure required to acquire project assets
Time to expiration	**T**	Length of time the decision may be deferred
Risk-free interest rate	**r**	Time value of money
Standard deviation	σ	Riskiness of project assets

Source: Luehrman, Timothy A., 1998., p. 53. [11].

The analogy between the realization of financial call options, and taking investment, refers to the analogy of owning call options and the ownership of investment opportunity (a project). When the investor decides to invest, he is actually exercising the option. In this case, the investment cost is a price of an option's exercise, while the assets in which he invests, i.e. the future value of investments shown through discounted cash flow, is a share price equal to the reference option [15].

Real option valuation method of investment projects is actually the extension of the theory of financial options on real property. Then as for financial options, the value of real options depends on the five basic variables and significant sixth, which includes the lost cash flows due to the competition [6] and [12].

Depending on available input data, there are several ways which make possible to reach the value of option that includes investment project. For the calculation of the value of options it is necessary to have the option valuation model - a formula with which it is possible to obtain the value of options. The two best known and most widely used Option calculators are Black & Scholes option valuation model and the Binomial option valuation model.

3.1. Black&Scholes option valuation model

The most common model based on partial differential equations and used for the evaluation of financial and real options is the Black & Scholes option evaluation model [11]. Fisher Black, Myron Scholes and Robert Merton set in 1973. a well known Black & Scholes formula for evaluation of derivatives. Formula can be used for valuing options on stocks, currencies, real property, and it is used by options traders, investment bankers and financial managers.The basic model is based on the following assumptions [4] and [3].No payment of dividends in the period to options maturity;

- The model does not take into account transaction costs or taxes;
- Non-risk interest rate is constant through time;
- Options can be carried out only at its maturity (European option);
- Return on shares has the lognormal distribution, which means that it is a natural logarithm of return on a stock ln (1 + r) in the form of the normal curve.

This model was initially developed for assessing the value of call options on a stock. The theory of financial options, within which is developed Black & Scholes model for valuing financial options needs to be adapted to be applied to real property. Initial model can be applied to evaluating investments in real property since the investment project, ie, investment opportunity, is similar to call option because it allows the right, but not the obligation to invest. Value of call option (C) shown with Black&Scholes formula:

$$C = S_0 * N(d_1) - \frac{X}{e^{rt}} N(d_2)$$

$$d_1 = \frac{\left[\ln\left(\frac{S_0}{X}\right) + \left(r + \frac{1}{2}\sigma^2\right) * T \right]}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Given variables in the equations are: C = value of call options, S0 = present value of future cash flows of assets in which we invest, X = price realization of option or the cost of the investment, r = non-risk interest rate for continuous compounding, T = time of maturity of the option σ= standard deviation, d_1, d_2 = deviation from the expected value of the normal distribution, $N(d_1)$ and $N(d_2)$ = the probability that a standarized, normally distrubuted random variable will be less than or equal to *d*, ln = natural logarithm e = 2.71828, base of natural logarithm [16].

The easiest way to calculate the value of options is by using Black & Scholes equation in which is easily to identify S0, X, T and r variables, while the $N(d_1)$ and $N(d_2)$ can be calculated using Microsoft Excel. Standard deviation (σ), which expresses the risk that occurs when investing in stocks, can be found in the financial markets or in the financial statements. However, when evaluating options that appear when investing in real property, determining the value of standard deviation is more difficult. According to Orsag, the possibility of perception of risk through the distribution of probabilities is possible to conduct in scenario analysis based on a small number of cases, computer simulations or by breaking the life cycle of the project on the specific phases of decision-making tree, thus determining specific scenarios of operation of each stage [14]. Moreover, Luehrman lists several approaches of evaluation of standard deviations [11]. One of them is the preference value of the standard deviations, where the value of standard deviation will be higher in projects that have greater market risk and using more discount rates. In the last 15 years, the standard deviation of market portfolio of U.S. shares, which are included in the formation of the most known joint-stock index was 20%. With investment projects, it can be expected even higher standard deviation; on the American market, depending on the risk, it is between 30% and 60% a year. Another approaches are related to determining applied volatility by using historical data and simulation of the standard deviations using Monte Carlo simulation techniques.

3.2 Binomial option valuation model

The second most popular model is the Binomial option valuation model. Binomial model looks like a decision tree in which the possible values of the basic property change depending on time of option's maturity. This model tracks the movement of asset prices as a binomial process in which assets can move in two possible directions, i.e. may fall or increase. The changes in the property value are marked with *u* and *d* factors, where u> 1 and d <1 [7].Basic assumptions of the Binomial option valuation model are as follows [2]:

- The market is efficient: all the relevant information is available simultaneously to all investors and each investor is acting rationally;
- There are no tax or transaction costs;
- Non-risk interest rate is constant through time;
- Share price (the value of real property) follows the multiplicative binomial process in discrete time.

The Binomial model shows that as the uncertainty clears in the future, management can make appropriate decisions at that time by comparing the expected payoff with the investment cost.

Initial point S_0 in the Binomial model shows the current value of the underlying asset. Probability of changing asset value in the future indicates the p. Conversely, the probability of falling asset value is expressed with 1-p. In the first step (node) of the binomial model asset value can move in two directions, up to (S0u) or down to (S0d). The next (second) step results in three possible assets values such as (S0u2, S0ud, S0d2), the third time step in four (S_0u^3, S_0u^2d, S_0ud^2, S_0d^2) etc. The last step in the Binomial model indicates the range of possible assets values at the end of the of the options life [10].

Up and down factors, u and d, depends on the volantility of the underlying asset and they can be expressed as follows:

$$\mathbf{u = \exp(-\sigma\sqrt{\delta T})}$$

also equation can be rewritten as:

$$\mathbf{d = \frac{1}{u}}$$

Through every time period there is a probability p that asset value will grow for percentage d, respectively the probability (1-p) that the assets will fall for percentage d:

$$\mathbf{p = \frac{\exp(r_f * \delta * T) - d}{u - d}}$$

where r is risk-free rate corresponding to the option life and $\delta * T$ is the time associated with each time step of the binomial tree.

The inputs required for setting Binomial model and calculating the option value are: the present value of the underlying asset (S_0), present value of implementation cost of the option (X), time to expiration in years (T), volatility of the natural logarithm of the underlying free cash flow returns in percent (σ), risk-free rate or the rate of return on a riskless asset (r) and the time-steps or time scale between steps ($\delta * T$) [13].

4. PROJECT VALUATION USING REAL OPTIONS (case study)

An example of investment project evaluation using the Black & Scholes and Binomial model is shown below.

Problem:

Pharmaceutical company is considering development of new product that would complement existing products of company. Previous experience with similar products have shown that companies can wait for a maximum of five years with the launching of new product without suffering significant losses of revenue. Discounted cash flow methods (DCF) that uses an appropriate risk-adjusted discount rate have shown that the present value of expected future net cash flows from the exploitation of new product amounts to 200 million, while the investment cost to develop and market product is expected to be 240 million. Uncertainty of future cash flows (annual volatility) is estimated to be 30%, and the annual risk-free interest rate over the option's life is 5%. What is the value of the option to wait (delay)?

1) *Black&Scholes model*[1]

The option to wait or delay appears as a kind of a call option, which offers the possibility of acquiring a positive net present value in the future, due to circumstances that affect the

[1] Results obtained using Excel and Risk@ software application.

formation of the net present value of the project [14]. The following input parameters are known: S_0 = 200 million it, X = 240 million it, σ = 30%, r = 5%, T = 5 years.

$$\mathbf{d_1 = \frac{\left[\ln\left(\frac{S_0}{X}\right)+\left(r+\frac{1}{2}\sigma^2\right)*T\right]}{\sigma\sqrt{T}} = \frac{\left[\ln\left(\frac{200}{240}\right)+\left(0.05+\frac{1}{2}*0.30^2\right)*5\right]}{0.30\sqrt{5}} = 0.43629926}$$

$$\mathbf{d_2 = d_1 - \sigma\sqrt{T} = 0.43629926 - 0.30\sqrt{5} = -0.2345211\,3}$$

$$\mathbf{C = S_0 * N(d_1) - \frac{E}{e^{rt}} * N(d_2)}$$

$$\mathbf{= 200 * N(0.436299\,26) - \frac{240}{2.71828^{0.05*5}} * N(-0.23452\,113) = \underline{\underline{57.755\ million}}}$$

2) *Binomial Model*

After identifying inputs required for setting up model that are the same as in the Black & Scholes model with the exception that δ = 1 years, it is necessary to calculate, the u, d and p parameters:

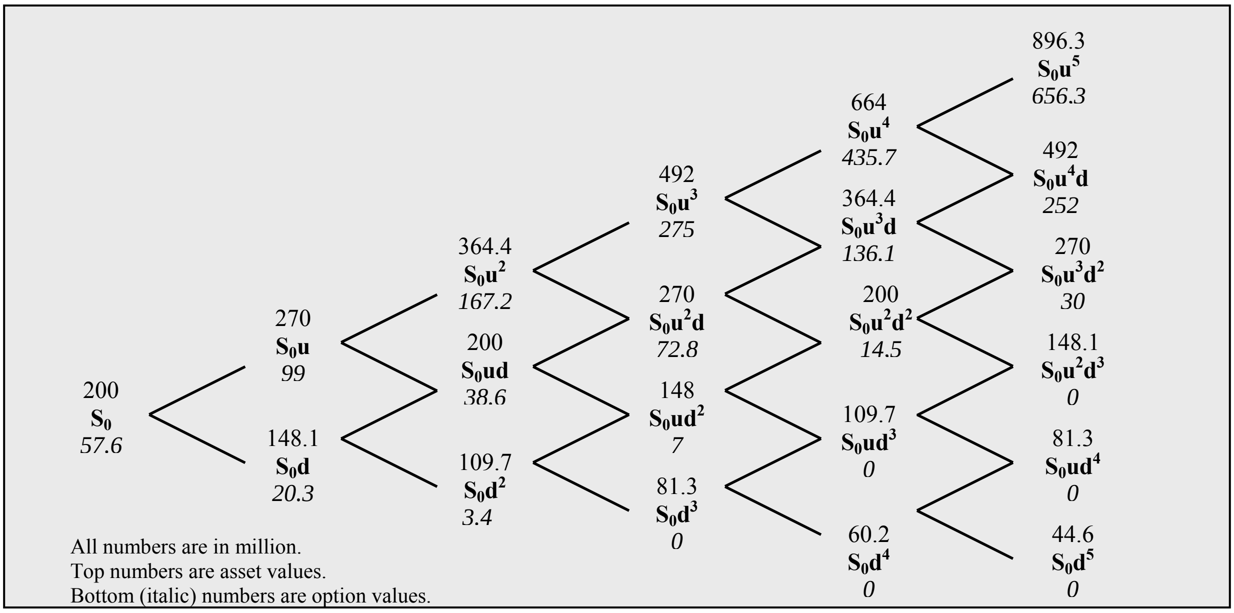
$$\mathbf{u = \exp(\sigma\sqrt{\delta T}) = \exp(0,30 * \sqrt{1}) = 1.349859}$$

$$\mathbf{d = \frac{1}{u} = \frac{1}{1.349859} = 0.740818}$$

$$\mathbf{p = \frac{\exp(r*\delta*T) - d}{u - d} = \frac{\exp(0.05*1) - 0.740818)}{1.349859 - 0.740818} = 0.509741}$$

Then, it is necessary to create a Binomial tree and calculate the asset values on each node of the Binomial tree, using one-year time interval. Time of options maturity can be divided into several phases. Upon completion of each phase, management has option whether to invest in product development at that point or delay its implementation and wait until next time period. The upper numbers on the Binominal tree present expected future asset values over the option life and bottom numbers indicate option values as it is shown in Figure 1.

Figure 1: Binomial Tree for Option to Wait



Source: Modified according to Kodukula & Papadesu

When preparing Binomial tree it is necessary to present the value of expected cash flows arising from investing in development of new product, S_0, multiply with the up factor u and down factor d to obtain S0u and S0d. Moving to the right, with the same procedure it is necessary to calculate the expected value of cash flows for every node of the Binomial tree until the last step [10]. For example; S_0u = 200 million*1.349859 = 270 million; S_0d = 200 million*0.740818 = 148.1 million.

At the end of the second year, introduction of new product is expected to generate cash flow between 364.4 million and 109.7 million, and at the end of the fifth year possible values of expected cash flows vary between 896.3 million and 44.6 million.

Once have learnt the value of expected future cash flows at each node of the Binomial tree which are shown in the form of the above values, it is necessary for each node to calculate the value or price of the options (below italic values in the scheme). The option values are calculated from the extreme right values in the scheme according to the initial values to the left ("backward induction"). On each node there is the possibility of investing in the development of new product or deferral of investment to further. At node S_0u^5 expected asset value is 896.3 million. If option is exercised in the fifth year, and investment cost of developing new product is 240 million, then net asset value of the introduction new product is: 896.3 million – 240 million = 656.3 million. But if we delay realization of option and wait until next time period, the revenues will be zero because option expires (becomes worthless) at the end of the fifth year due to the impact of competition and other influential factors on the market. Hence, at node S_0u^5 the option value is 656.3 million and rational decision will be not to wait but rather invest in the development of new product.

Expected asset value at node $S_0u^2d^3$ is 148.1 million but the option value at this node is zero because the investment of 240 million is resulting in a net loss of 91.8 million. In these circumstances, rational decision would not join the investment in the development of new product.

Furthermore, at the intermediate node S_0u^4 we can calculate the expected asset value for keeping the option open as discounted weighted average of potencial future option value [10].

$$\begin{aligned}&\left[\mathbf{p}\left(\mathbf{S_0u^5}\right)+(\mathbf{1-p})*(\mathbf{S_0u^4d})\right]*\mathbf{exp(-r*\delta t)}\\&=\left[\mathbf{0.509741*(656.3\ million)+(1-0.509741)*(252\ million)}\right]\\&\mathbf{*\,exp(-0.05)*(1)=435.73\ million}\end{aligned}$$

If the option is exercised and we invest 240 million in developing new product, the net asset value would be 424 million (664 million - 240 million). However, holding the options open until the next period (fifth year) gives possibility of realizing higher asset value (435.73 million). Therefore, it is better to continue to wait, rather than to exercise the option.

Similarly, at the node S_0ud^3, the expected asset value for keeping the option open is zero. Payoff at this node is 109.7 million and if the option is exercised by investing 240 million, it would result in a net loss of 130.3 million.

$$\left[\mathbf{0.509741*(0\ million)+(1-0.509741)*(0\ million)}\right]*\mathbf{exp(-0.05)*(1)=0\ million}$$

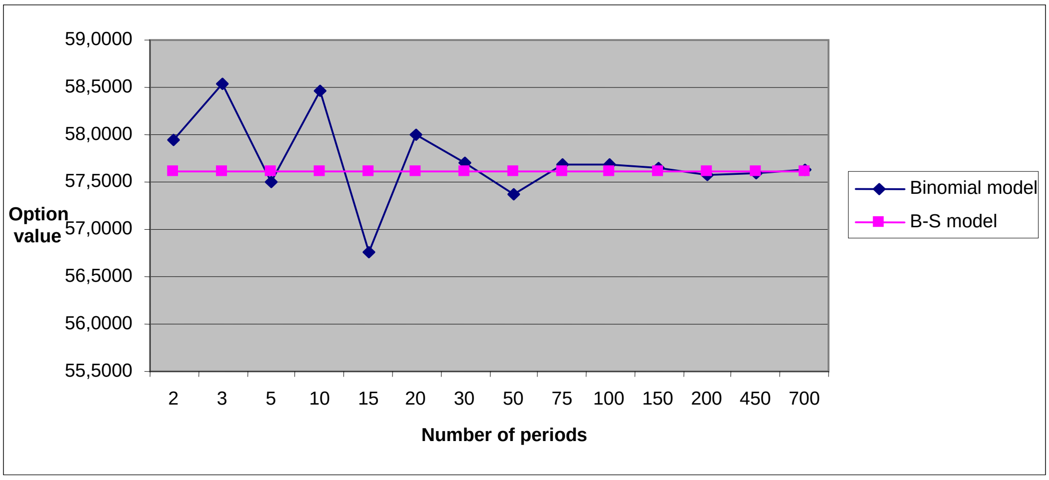
The same procedure has given the option values until the time 0, where we can perceive the value of the introduction of new product of 57.6 million, which is approximately value provided by Black & Scholes option valuation model. Also, as it can be seen in the table below, as the number of periods to maturity option grows towards infinity, binomial formula, with certain assumptions converge to Black & Scholes formula [8] and [1].

Table 2: Values obtained with the Binomial and Black-Scholes model

n	Binomial model	B-S model
	57.4924	57.61051914
2	57.9536	57.61051914
3	58.5437	57.61051914
5	57.4924	57.61051914
10	58.4719	57.61051914
15	56.7524	57.61051914
20	57.9970	57.61051914
30	57.7095	57.61051914
50	57.3743	57.61051914
75	57.6879	57.61051914
100	57.6807	57.61051914
150	57.6521	57.61051914
200	57.5683	57.61051914
450	57.5986	57.61051914
700	57.6220	57.61051914

Source: author's calculations according to Aljinović, Marasović, Šego, 2008, p. 217.

Chart 1: Convergence Binomial option valuation model with Black-Scholes model



Source: author's calculations according to Aljinović, Marasović, Šego, 2008. p. 217.

The Binomial model value is evident from the comprehensibility of model by showing that as the uncertainty clears over time, decision-makers are able to make appropriate decisions on implementation, or rejecting the project simply comparing the expected cash flows at each node of the Binomial tree with investment costs which are performed in order to implement the project.

5. DISCOUNTED CASH FLOW METHODS VS. REAL OPTION ANALYSIS

One of the most popular methods of discounted cash flows used in evaluating investment projects is the method of net present value (NPV) at which decisions about the acceptance or rejection the project largely depend on the adequacy of estimation of project's cash flow but also on the selection of appropriate discount rates which are used in discounting future net cash flows.

If we compare the decisions based on discounted cash flow methods and real option approach we can see that the introduction of new product from the previous evaluated example using discounted cash flow methods (DCF), would result in a negative net present value of 40 million (expected payoff of 200 million less the investment cost of 240 million).

This would lead to the rejection on investment in a new product. However, traditional methods of valuation, which still occupy the main spot in the evaluation of investment projects, ignore the value of options that may come in the life cycle of the project so the traditional analysis should complement with optional methods of evaluation of projects.

Real option approach values covered options to wait or delay, which serves as a supplement to the method of net present value and increases the value of an investment project. The project has real option value of approximately 57.6 million created by the option characheristics of the project related to high uncertainty.

Aforementioned, total value of the project represents the sum of net present value of the project and option to wait. Therefore, decision based on real option analysis increases the value of project (i.e. introduction of new product) whose total value is positive and approximately 17.6 million (net present value of -40 million + option value of 57.6 million). Real options approach provides additional value to project and offers managers a choice of decisions also helping to be more rational in their decision making.

6. CONCLUSION

Among the contemporary methods of assessment and evaluation of investment projects, important role has the real option analysis, whose evaluation is based on the analogy of financial options to real options. All above mentioned real options have equal motive - limiting bad business results. With the growth of uncertainty related to future, option value increases and that affects initial decision on acceptance or rejection of a project. Decision on rejection made on basis of traditional methods can be altered if the option value is high enough. Likewise, decision on acceptance of a project can be changed if compensatory value of an option is higher than the lost cash flow; but, if an investment is very prosperous or completely uninteresting to investors real option analysis will not change the outcome.

Supporters of contemporary methods emphasize imperfections of traditional methods assessment and evaluation of investment projects, such as choice of adequate discount rate, static approach, subjectivity in determining expected cash flows and regarding an investment to be "now or never" decision without evaluating potential possibility of postponing investments. Yet, significance of traditional methods has never been denied. However, many business decisions are part of so called “gray area” which demands rational reasoning, making real option method an indispensable tool in decision making process. It is necessary to accentuate that *real option method should only be used as a supplement, rather than a substitute for discounted cash flow method*.

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