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REAL OPTIONS

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Abstract. *In the real world every business decision is coupled with uncertainty about the future that affects the present value of the projects in consideration. Thus, before making any investment decisions, managers use various approaches to determine whether the investment should be undertaken or not. Traditional approaches for valuing these investment opportunities do not take into account management flexibility to revise its decisions in the future, as well as the interdependence of the project with future investments. Therefore, as a result, real option approach has been introduced. The Real Options Approach attempts to value projects by considering the value of being able to decide among several strategic options. The fact that managers can decide which action to take at different points during the life of the project has proven to be quite valuable. Namely, real-life projects are often complex in that they involve a collection of multiple real options whose values may interact. Hence, the concept of compound options is at the heart of business since there are two possible outcomes for virtually every business idea. The objective of this paper is to apply a real option methodology for the valuation of the compound option. The paper highlights the main concept of real options, its common types, and the numerical example of the compound real options.*

Key Words: *real options, binominal tree, compound options*

INTRODUCTION

The application of option concepts to value real assets has been an important and exciting growth area in the theory and practice of finance. It has changed the way academics and practitioners think about investment projects by explicitly incorporating management flexibility into the analysis [9]. The traditional approach to valuing a potential capital investment project, known as the "net present value" (NPV) approach, has some problems. It involves discounting the expected net cash flows from a project at a "risk-adjusted" discount rate, which reflects the risk of the project [5].

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However, many projects contain embedded options. For instance, if we consider a company which is taking into account possibility of building a plant to manufacture a new product, it has the option to abandon the project if things do not work out well, or it may expand the project if the demand for output exceeds expectations. Hence, these options have quite different risk characteristics from the base project and require different discount rates.

Another problem with the traditional NPV approach lies in the estimation of the appropriate risk-adjusted discount rate for the base project. Namely, the companies that are used to estimate a proxy beta for the project have expansion options and abandonment options on their own; consequently their betas reflect these options and may not therefore be appropriate for estimating a beta for the base project [5].

Furthermore, there are two aspects of extra value that are inadequately captured by a NPV analysis:

- the "operating flexibility" within a project which enables management to revise decisions at future time and
- the "strategic" option value of a project resulting from its interdependence with future and follow-up investments [13].

Therefore, the practice of capital budgeting should be extended, from the NPV approach, by the use of option valuation techniques to deal with real investment opportunities and so help overpass the gap between financial theory and strategic planning [6].

In this paper, the basic concepts concerning real option approach will be introduced. In addition, a numerical example of an investment, with the options to expand and abandon, using binomial tree, will be presented.

REAL OPTION APPROACH

As one of the most important corporate finance decision-making methods, real option valuation method has been introduced in the last two decades. By applying option valuation methods, real option valuation is a useful tool for company managers. The fact that managers can decide which action to take at different points during the life of the project has proven to be quite valuable. The value of these options can be such that makes the difference between entering or not in an investment. Options create value when the future is uncertain, and they support management to draw the highest possible value from an investment. Hence, an accurate project valuation is crucial for the survival of companies. The use of two different valuation methods provides two different option values, which shows the importance of choosing a correct valuation method.

The Real Options Approach attempts to value projects by considering the value of being able to decide among several strategic options [14]. Especially when the value of a project is highly dependent on the level of flexibility that it allows, the real option methodology should be used. Otherwise, the valuation is not accurate because the project is undervalued.

The motivation for using option pricing or contingent-claim analysis in capital budgeting arises from its potential to enable us to quantify properly the option premium or flexibility component of value [12]. The options-based approach is superior to decision tree analysis and NPV, since it combines the best features of these approaches without their drawbacks.

Several option-pricing methods can be used for a real options valuation. However, the complexity of real world projects makes some of these models not flexible enough to consider all its features. Binomial trees valuation method appears to be one of the more flexible option pricing models and probably a more suitable model for valuing investment with high uncertainty.

According to Trigeorgis [12], real investment opportunities can be seen as collections of real call and put options on the value of the project, and hence, option based valuation can be useful in quantifying the value of operating flexibility and strategic adaptability implicit in real opportunities, as well as quantifying the value of flexibility in financial instruments.

The real options approach is an extension of financial option theory to non-financial assets [14]. While options on financial assets are clearly defined in the option contract, real options are embedded in strategy and tactics or, in other words, in the corporate vision of the project. A real option exists if we have the right to take a decision at one or more points in the future. Between now and the time of decision, market conditions will change unpredictably, making one or other of the available decisions better for us, and we will have the right to take whatever decision will suit us best at the time.

TYPES OF REAL OPTIONS

An option is the right, but not the obligation, to take an action in the future [4]. The notion of embedded options is at the heart of business and there are two possible outcomes for virtually every business idea [8]. On the one hand, the business may fail, in which case the managers will probably try to shut it down in the most cost-efficient way. On the other hand, the business may prosper, in which case the managers will try to expand. Thus, virtually every business has both the option to abandon and the option to expand.

There are various types of options – option to defer, option to expand, option to abandon, option to switch, option to contract [5], [7], [12], [13].

Once a project is undertaken, management may have the flexibility to alter it in various ways at different times during its life. Management may abandon the project in exchange for its salvage value before the end of its estimated useful life if market conditions turn unfavourable [12]. If one has the right, but not the obligation, to rid oneself of a risky asset at a fixed (predetermined) price, it is called an abandonment option [2]. This is an option to sell or close down a project. It is an American put option on the project's value. The strike price of the option is the liquidation (or resale) value of the project less any closing-down costs [5]. Abandonment options mitigate the impact of very poor investment outcomes and increase the initial valuation of a project. Abandonment option analysis not only provides an estimate of the value of optimal abandonment, but it also indicated when abandonment should be implemented.

If, however, projects turn out better than expected, it is desirable to invest in expanding them. The extra investment is the exercise price of an expansion option [2]. This is an American call option on the value of addition capacity. The strike price of the call option is the cost of creating this additional capacity discounted to the time of option exercise [5]. If management decide to make additional follow-on investment, then the original investment opportunity can be thought of as the initial scale project plus a call option on a future opportunity [13].

Analogous to the option to expand a project is the option to contract the scale of a project's operation by forgoing planned future expenditures if the product is not as well received in the market as initially expected [13]. In addition, the right to sell off some capacity, thereby shrinking the scale of the operation is also option to contract [2]. It is an American put option on the value of the lost capacity. The strike price is the present value of the future expenditures saved, as seen at the time of exercise of the option [5].

The deferral option, or option of waiting to invest, derives its value from reducing uncertainty by delaying an investment until more information has arrived [1]. Delaying to invest in a project may be beneficial if further information or changing conditions may increase the value of the project if taken later. So, if the investment expenditures are irreversible, option to defer is especially valuable. Nevertheless, the value of waiting or deferring to invest may be diminished or destroyed by the value a company creates from a competitive position or a pre-emptive strategy that does not allow for waiting [1]. The option to wait can be seen as a call option on the gross project value, with an exercise price equal to the required outlay [12].

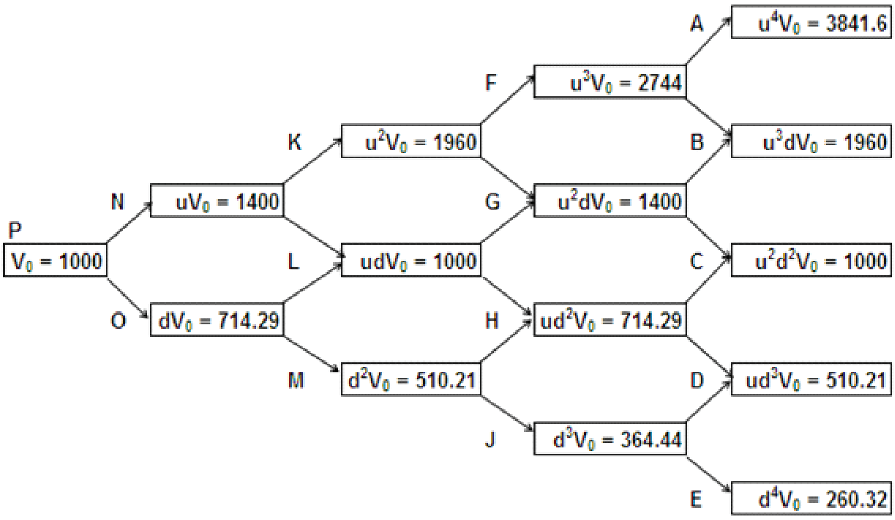
However, real-life projects are often more complex in that they involve a collection of multiple real options, whose values may interact. Therefore, we will look through an example of compound option.

COMPOUND OPTIONS

The compound options are options on options, and these options exist when making an investment is viewed as the prerequisite to obtain the opportunity to enter into the next investment [10]. The combined value of a collection of options usually is different from the sum of their separate values [11]. In order to better understand logic behind compound options we will start with a numerical example.

Suppose that we have a project with a current value of £1000, with a standard deviation of 33.647% per annum. The risk-free rate is 5%. After two years, this project allows expansion of 50% with an additional investment of £500. In addition, after another two years the project can be halved by selling off one part for £500 as well. Hence, up movement factor and down movement factor are: $u = e^{\delta h} = e^{0.33467*1} = 1.4$, $d = \frac{1}{u} = \frac{1}{1.4} = 0.71429$.

The solution proceeds in two steps. First, we value the option to contract, which is assumed to be a European put option since can be exercise only in fourth year. The result is an event tree that becomes the underlying for the option to expand, which is assumed to be a European call option since can be exercised only in second year. We start first with the event tree for the value of the project:



Next, we calculate the value of the project with flexibility to contract at each of five end nodes A, B, C, D and E. The end payoffs are:

$$A : MAX[3841.6;3841.6/2+500] = MAX[3841.6;2420.8] = 3841.6$$
$$B : MAX[1960;1960/2+500] = MAX[1960;1480] = 1960$$
$$C : MAX[1000;1000/2+500] = MAX[1000;1000] = 1000$$
$$D : MAX[510.21;510.21/2+500] = MAX[510.21;755.11] = 755.11$$
$$E : MAX[260.32;260.32/2+500] = MAX[260.32;610.16] = 610.16$$

In previous nodes we can calculate the value of the project with flexibility to contract either by employing replicating portfolio approach or risk-neutral probability approach. The portfolio that can be used to replicate the end-of-project payouts at, for example node F, is exactly N units of underlying plus B bonds, and its current value is [2]

Replicating portfolio: $Nu^3V_0 + B$ = *Value of project with flexibility at node F*

The payoffs of the replicating portfolio in the up state – A, and the down state – B must be equal to the payoffs of the put option in those states [2]

$$StateA : N(u^4V_0) + (1+r)B = 3841.6 ....(state+)$$
$$StateB : -N(u^3dV_0) + (1+r)B = 1960 .....(state-)$$

From these two equations we have two unknowns N and B

$$Nu^3V_0(u-d) = Cu^4 - Cu^3d$$
$$N = \frac{Cu^4 - Cu^3d}{u^3V_0(u-d)} = \frac{C^+ - C^-}{V^+ - V^-} = \frac{3841.6-1960}{3841.6-1960} = 1$$
$$B = \frac{Cu^4 - Nu^4V_0}{1+r} = \frac{C^+ - NV^+}{1+r} = \frac{3841.6 - 1*3841.6}{1+0.05} = 0.... \text{ [12]}$$

Therefore, the replicating portfolio consists only of 1 unit of underlying asset, and its present value at node F is [12]

$$NV + B = 1 * 2744 + 0 = 2744$$

If we use risk-neutral probability approach we will get the same value, but formulas are different [5]:

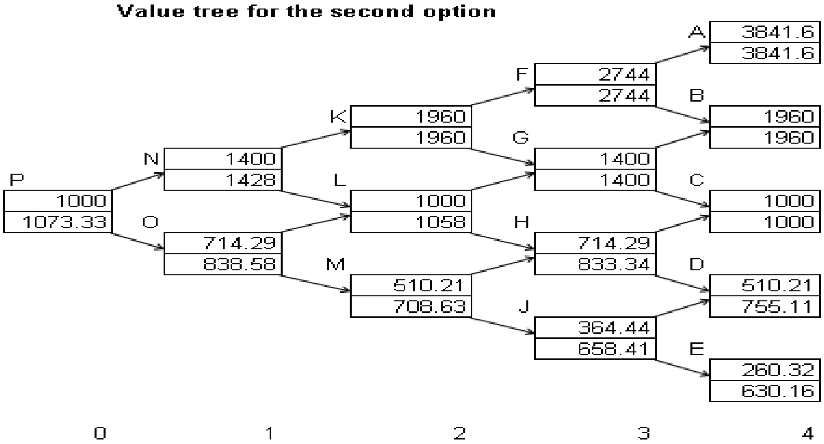
$$p = \frac{e^{rh} - d}{u - d} = \frac{e^{0.05*1} - 0.71429}{1.4 - 0.71429} = 0.49$$
$$1 - p = 1 - 0.49 = 0.51$$
$$V = \frac{pV^{+} + (1-p)V^{-}}{e^{rh}} = \frac{0.49 * 3841.6 + 0.51 * 1960}{e^{0.05*1}} = 2744$$

The advantage of risk-neutral probability approach over the replicating portfolio method is that values of risk-neutral probabilities do not change as we move from node to node, which is not the case with N and B in the replicating portfolio method [2]. However, in this example the replicating portfolio for calculating all necessary values will be used.

Node	End-of-period payoff		Replicating portfolio parameters		Value of the project with flexibility
	Up state	Down state	N	B	
F	3841.6	1960	1	0	2744
G	1960	1000	1	0	1400
H	1000	755.11	0.5	476.19	833.34
J	755.11	630.16	0.5	476.19	658.41
K	2744	1400	1	0	1960
L	1400	833.34	0.826	232	1058
M	833.34	658.41	0.5	453.52	708.63
N	1960	1058	0.94	112	1428
O	1058	708.63	0.71	331.43	838.58
P	1428	838.58	0.86	213.33	1073.33

The value of the second option – European put is calculated all the way back to the present although the option does not exist until the begging of the year 4. This is done because we need to know the hypothetical value of the option during the second year in order to value the first option – European call [3]. Calculating all the values backward in time through the tree, we find the value of the second option plus the value of the project – £1073.33.

Value tree for the second option



Afterwards, we construct the binomial tree for the first option. At the end of the second time period, the first option expires. If it is exercised, the payouts are not directly dependent on the value of the underlying project, but on the value provided by the option to contract at the next stage. Therefore, we use the value of the second option at the end of the second time period as underlying risky asset:

$$K : MAX[1960;1960*1.5+500] = MAX[1960;2440] = 2440$$

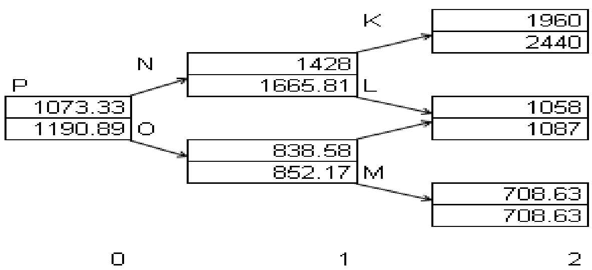
$$L : MAX[1058;1058*1.5+500] = MAX[1058;1087] = 1087$$

$$M : MAX[708.63;708.63*1.5+500] = MAX[708.63;562.94] = 708.63$$

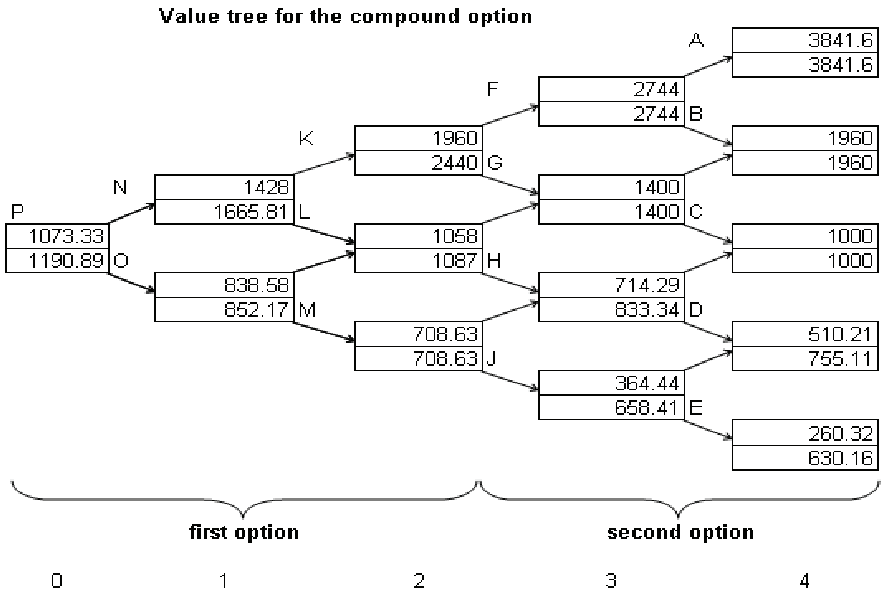
Node	End-of-period payoff		Replicating portfolio parameters		Value of the project with flexibility
	Up state	Down state	N	B	
N	2440	1087	1.5	-476.19	1665.81
O	1087	708.63	1.083	-56.01	852.17
P	1665.81	852.17	1.38	-290.31	1190.89

Using replicating portfolio approach once again, we calculate the value of the project with flexibility in each node, and the value in the first node is £1190.89.

Value tree for the first option



Finally, we can interpret £1190.89 as the net present value of the project with flexibility to expand its capacity for 50% in two years and abandon expanded part in another two years. Hence, if the start-up cost is greater that £190.89, we would reject the project, otherwise we would accept it.



In above present example, we have four time steps, each lasting one year, but we could have taken as much time steps as we want by reducing their duration. "An analyst can expect to obtain only a very rough approximation to an option price by assuming that stock price movements during the life of the option consist of one or two binominal steps" [5, p. 255]. When binominal trees are used in practice, the life of the project is typically divided into 30 or more time steps [5]. From one hand, by increasing the number of time steps, we increase the accuracy of our results, but from the other hand, by rounding numbers in each node we are reducing accuracy. Therefore, the values are still only approximations, and we should take them with cautious.

Furthermore, in the valuation of this compound option we assumed that the volatility is the same over the life of the project. However, in the real world this can be problematic, as the volatility may not be known and may change over the life of the option. This can make valuation even more complex.

CONCLUSION

In the real world every business decision is coupled with uncertainty about the future, which affects the present value of the projects in consideration. Before making any investment decisions, managers use various approaches to determine whether the investment should be undertaken or not. Traditional approaches for valuing these investment opportunities do not take into account management flexibility to revise its decisions in the future, as well as the interdependence of the project with future investments. Therefore, as a result, real option approach has been introduced.

The objective of this paper was to apply a real option methodology for the valuation of the compound option. The paper highlighted the main concept of real options, its common types, and the numerical example of the compound real options.

Compound options are quite common in the real world, since many investments occur in stages that must be carried out in sequence. In the example presented here, we had two stages – expanding stage and contracting stage. We valued contracting option first, and than used the value of that option as the underlying asset for calculating the value of the expanding option. Given that, two approaches are available for calculating these values – risk-neutral approach and replicating portfolio approach, we used the second one. Finally, as a result we calculated the value of the compound option - £190.89 and also the net present value of the project with flexibility to expand its capacity for 50% in two years and abandon expanded part in another two years - £1190.89.

However, these results as mentioned earlier, should be taken with cautious at least for two reasons – assumed unchanged volatility during the life of the project and small number of time steps (only 4).

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REALNE OPCIJE

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U stvarnom svetu svaka poslovna odluka suočena je sa neizvesnošću o budućnosti koja utiče na sadašnju vrednost posmatranog projekta. Otuda menadžeri, pre nego što donesu bilo kakvu investicionu odluku, koriste različite pristupe da bi utvrdili da li treba investirati ili ne. Tradicionalni pristupi za vrednovanje ovih investicionih mogućnosti ne uzimaju u obzir fleksibilnost menadžera u revidiranju njihovih odluka u budućnosti, kao ni međuzavisnost projekta sa budućim investicijama. Kao rezultat toga pojavio se pristup realnih opcija. Pristup realnih opcija pokušava da vrednuje projekte razmatrajući vrednost mogućnosti odlučivanja između nekoliko strateških opcija. Činjenica da menadžeri mogu da odluče koju akciju mogu preduzeti u različitim periodima tokom životnog veka projekta pokazala se veoma vrednom. Naime, projekti sa kojima se srećemo u stvarnom životu su često kompleksi u smislu da uključuju skup više realnih opcija čije vrednosti mogu da deluju jedne na druge. Otuda je koncept složenih opcija srce bilo kog posla zato što postoje dva moguća ishoda za praktično svaku poslovnu ideju. Cilj ovog rada je da primeni metodologiju realnih opcija za vrednovanje složenih opcija. Rad prikazuje glavni koncept realnih opcija, njihove najčešće tipove, i numerički primer složenih realnih opcija.

Ključne reči: *realne opcije, binominalno drvo, složene opcije.*