REALISTIC INVESTMENT VALUATION: A COMPREHENSIVE REAL OPTIONS MODEL

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Abstract

Purpose – The purpose of this paper is to present the developed real options analysis framework and outline how it complements the traditional investment valuation approach – discounted cash flow model. While real options analysis has gained both professional and academic interest in recent years, Latvian companies are seemingly lagging behind in its application. The framework is intended to demystify real options, demonstrate practical benefit of this theory and is explained in process of investment valuation of a selected logging industry enterprise in Latvia.

Design/methodology/approach – The research is defined as descriptive in its purpose, quantitative in its approach, deductive in its logic and applied as of its outcome. Investigation of the issue is carried out in a non-contrived setting with minimal researcher's interference. Secondary sources of data are used to provide theoretical basis for the framework, while primary data, obtained from entity's representatives during several unstructured interviews, is applied to solve the real options problem addressed in the practical part of the paper.

Findings – The developed real options analysis framework can be successfully applied in solving a real options problem. During valuation of the selected enterprise's real options portfolio, which comprises of deferral, expansion, contraction and switching options, real options portfolio value present value is calculated as 28 246 LVL. If decision to realize either real option is deferred, real options increase net present value of cash flows by 5.55%. By this amount entity management has augmented its investment's value with the introduction of the framework in its capital budgeting process.

Practical implications – Developed real options analysis framework can be used for real options valuation in both academic and professional environments. Model can also be used as a learning tool by those, who seek insight into real options theory.

Keywords: real options analysis, Monte Carlo simulation, binomial model, risk-neutral valuation

1. CONCEPT OF REAL OPTIONS

Discounted cash flow (DCF) method has long been applied in valuation of investments, despite the fact that it is inherent to several limitations in relation to risk and active project management. Even by adjusting cash flows that are subjected to different risks with different discount rates (Mathews, 2009), DCF often cannot account for volatility (Mun, 2002), investment timing (Kodukula and Papudesu, 2006) and – most importantly, managerial flexibility embedded in many projects (Van Putten and MacMillan, 2004). Managerial flexibility can be broadly defined as the ability to choose, time, and quantify investment.

Introduced by Myers in 1977 as "opportunities to purchase real assets on possibly favourable terms" (Myers, 1977), real options have since evolved into a unique branch of financial analysis. Contemporary taxonomy of real options, divides between real options in accordance with their nature, such option to defer (time), contract (reduce), switch (reallocate), or expand an investment (Alleman et at., 2008). Several real options valued together are referred to as portfolio of real options (Tong and Reuer, 2007). In layman's terms, real option in itself is management's right, but not an obligation, to invest or disinvest.

In real options theory the opportunity to purchase (or sell) asset comes from the volatility of the asset and its cash flows. Therefore, somewhat counter-intuitively, real options are of the highest value, when both volatility (Nembhard and Aktan, 2009) and managerial flexibility to capitalize on favorable asset value fluctuations (Brach, 2003) are high. Analogous with financial options, also real option value (OV) is constituted of six determinants of its value (Damodaran, 2005; Vintila, 2007), as it is outlined in the following Table 1.

Table 1

Financial and real option analogy

Financial option	Common designation in literature	Real option
Stock (underlying) price	S, V	Discounted cash flow (NPV)
Exercise price	E, X, K	(Capital) investment
Time till expiration	t, T	Time till decision can be deferred
Risk free rate	r, r_f	Time value of money
Variance of returns	σ	Volatility of the cash flows
Dividend yield	δ, b, q, l	Value lost over real option's duration

Source: Damodaran (2005), Vintila (2007)

All of the determinants must be considered separately for each real option, however, their interconnectedness must also be considered (i.e. project cannot be expanded and contracted at the same time) (Li et al., 2007). Therefore during project's life at any given time management has to weight the benefits versus the costs of each real option; that real option which has the highest profitability index is due for realization (Mun, 2002).

Process wherein real options are valued is known as real options analysis (or valuation) (ROV). ROV encompasses identification, framing, valuation and selection of real options (Nembhard and Aktan, 2009). For ROV to be feasible, it is crucial to understand that (a) neither real option could be realized (there may be more value in waiting) (Kodukula and Papudesu, 2006); (b) real option is only a possibility, not an obligation, to invest or disinvest, thus its value is never negative (Bailey et al., 2003) and (c) valuation parameters (see Table 1 above) will drive option value – in other words "old axiom of garbage in garbage out still holds" (Mun, 2006).

There are numerous ROV approaches proposed, ranging from relatively simple and rough) risk-adjusted decision trees (Mun, 2002) to game theory based models known as Option Games (Ferreira et al., 2009), which are mainly applicable in capital-inense industries. Fuzzy logic based theories are accepted in the academia, but lacks sufficent empirical testing (Collan, 2011), while the Monte Carlo simulation-based Datar-Methews ROV method is primarily focused on high-technology industry projects (Mathews and Salmon, 2007).

Due to its flexibility, analogy with Black-Scholes model and ease of understanding, risk-neutral probability (RNP) based model is one of the most-widely accepted ROV methods in various quarters (Kodukula and Papudesu, 2006; Nembhard and Aktan, 2009).

If a given variable is risk neutral, it is "stripped of its risks", as Mun (2002) characterizes it; thereby indicating two general "risk-stripping" approaches: (a) risk-adjusting the cash flow itself or (b) risk-adjusting probabilities that determine the value of the cash flows at different time periods. The RNP method uses the second approach (Brandao et al., 2005). In risk neutral valuation the probabilities are risk-neutralized. Thus cash flows can be discounted at a risk-free rate not risk-adjusted one.

RNP approach uses lattices (event trees) to solve real options problems. At least two lattices must be constructed to perform ROV by applying RNP method -- and more are required for exotic (sequatial or compound) options (Mun, 2006). Therefore RNP approach to valuation of real options is in many aspects similar to binomial option pricing model of financial option valuation (Damodaran, 2005). Firstly, the lattice of the underlying (event tree) must be constructed. It is calculated beginning with the starting node (where project NPV is input) and proceeding left to right till real options expiration. Secondly, real option valuation lattice is developed and calculated in the opposite direction, back to the starting node, determining each real options value at each of the nodes. The direction of the proceedings in RNP approach are exemplified by Teoh and Shеblè

(2007) in the proceeding Figure 1, wherein lattice of the underlying is depicted on the left and real option valuation lattice – on the right.

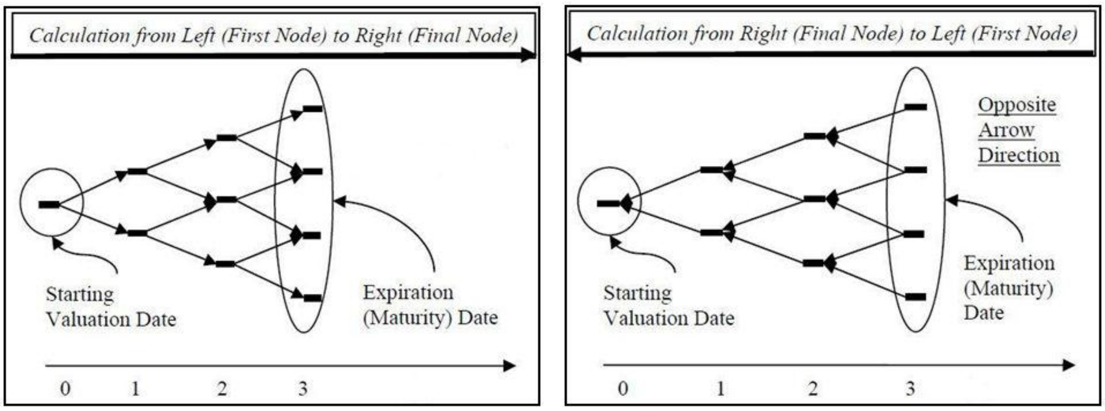

Figure 1. Real options valuation lattices
Source: Teoh and Sheblè (2007)

The process of moving backwards in the lattice is formally known as backwards induction (Bailey et.al., 2003). Using backward induction process the real option valuation lattice is calculated back to the first node (wherein NPV initially was input). The value of this node represents the expanded NPV (eNPV) also known as NPV with real options flexibility ($NPV^{+}O$). eNPV is the present value of project or investment, taking into account also the embedded managerial flexibilities and contingencies. This is considered as the “correct value” of any initiative by ROA adherents (Mun, 2003; Alleman et al, 2008; Nembhard and Aktan, 2009). Difference between the two thus is real options value (OV). While RNP approach is relatively easy to understand, what it cannot provide is illustrative appeal – for that several visual models have been proposed, such as 3D Option Space (Mun, 2003) and Total Project Value graph (Van Putten and MacMillan, 2004). These models greatly enhance ROV, since after all – easy and understandable is what is often needed in order to “sell” ROV result to the Board or an investor.

2. CONSTRUCTION OF REAL OPTIONS ANALYSIS FRAMEWORK

Real options value calculation is often viewed as a standalone proceeding, though it must be considered within the scope of the project and managerial assumptions. Proposed model mitigates these shortcomings by introducing a comprehensive flowchart of ROV analysis, complemented by additional visual models.

Six general steps must be performed in a comprehensive ROV framework: (a) frame the application; (b) identify the input parameters, (c) calculate the option parameters, (d) build the binomial tree; (e) perform backward induction process and (f) analyze results (Kodukula and Papudesu, 2006). In order to fully integrate ROV with traditional DCF analysis, initially DCF analysis itself must be performed. Only on top of that ROV is performed. Despite popular misconception, ROV only supplements, but does not replace DCF (Van Putten and MacMillan, 2004). This entails calculation of the project’s or investment’s NPV, in which managerial flexibilities (real options) are embedded. Once management has input its assumptions into the model, it must establish clear relationships between the real options (i.e. some real options may be mutually exclusive) and estimate the benefits and costs of each real option. If entity has the ability to postpone investment, it by default has a deferral option -- this must also be taken into account in the analysis. Input parameters in ROV entails calculation of each real option’s value determinants, as depicted in Table 1, while third step addresses calculation of binomial lattice parameters necessary for RNP-based ROV. Equations for these variables can be found in the next section of this paper.

Major constraint in these stages often is determination of a “trustworthy” volatility factor or variance associated with the cash flows of the project. For that management may apply a range of volatility estimation approaches, including logarithmic return approaches, financial modeling, (an educated) guesswork, historical data analysis, market data (proxy) analysis and simulation. Either method may be selected, as long as management feels comfortable with the implications that a higher volatility entails (Mun, 2002). Often Monte Carlo simulation is used for the calculation of the volatility (Lewis et al., 2008).

Forth step relates to the creation of binomial tree (also known as lattice of the underlying) as it would be done in standard binomial option pricing model, however financial asset price is replaced with the calculated NPV (Hull, 2005; Mun, 2006). Once binomial tree is constructed for time period equal to the duration of the real option(s), real options valuation lattice is created via a backwards induction process.

RNP approach assumes that, if a certain node (discrete time point of Geometric Brownian motion in the lattice, as depicted in Figure 1) is reached during project's life, management would select such strategy, which gives the highest returns in terms of monetary benefits (Bailey, et.al., 2003; Nembhard and Aktan, 2009). This is commonly known as the profit or value maximizing decision.

To make such value maximizing decision during backwards induction process is needed to compare the value of the underlying (i.e. NPV) without any real options with the value of the underlying with each real options exercise at each of the nodes. Valuation starts at terminal (last) nodes and moves backwards towards the staring node, sequentially making profit-maximizing decision at each of the nodes. As each real option problem is unique, analytical process is necessary to determine what would be the value of the underlying if each real option were exercised. Most authors thus rationally abstain from providing any customized ROV formulas and just explain the logic of the approach (Bailey, et al., 2003; Mun, 2003; Kodukula and Papudesu, 2006; Nembhard and Aktan, 2009).

Once real options portfolio value (which is the difference between NPV and eNPV at the staring node) is determined, results can be depicted onto 3D Option Space and Total Project Value graph. By viewing what the OV of each real option is currently at the starting node of the lattice, management can determine the value maximizing decision it should make. Value will be maximized if that real option, which has the highest value, is realized. Value of deferral option will depend of the range of fluctuations in the subsequent nodes in the lattice. In other words, if later on some real option will have much greater potential value, then there is value in waiting.

Combining the mentioned RNP approach to ROV, as well as visual models, a comprehensive ROV model has been developed. This model is intended to demystify real options, which are traditionally perceived as an (excessively) complex "rocket science" (Frigo, 2003). The developed real options analysis framework, incorporating risk-neutral valuation and visual models is depicted the following Figure 2. This flowchart clearly highlights the steps and variables necessary for a pervasive ROV, as well as interrelation of these variables. ROV is started from top right corner and sequentially completed downwards, thereby permitting for the management to make value maximizing decision at the end of the analysis.

Developed model is applied in the valuation of the selected enterprise's investment plan.

3. APPLICATION OF THE MODEL TO ENTERPRISE INVESTMENT VALUATION

Entity operates in Latvian logging industry and its management recently has considered introduction of real options in its capital budgeting. Its main source of income is the revenue earned from tree logging and forest sales. During budget planning it has identified that within the next 5 years it has several strategic alternatives available within this time period. Entity may continue as planned per budget, invest additional resources in expansion of cutting activity, reduce some of its logging activity and save on fixed costs, as well as also introduce new services to third parties.

Each of these alternatives may be summed in the form of Table 2, where each alternative is listed as a real option, with its management-established realization period as well as benefits and costs of each alternative. These strategic alternatives can be framed as real options as depicted in Figure 3.

In essence entity has a chooser option - only one real option may be selected for implementation. Entity's management may select either one of the possible options with benefits/costs as shown in Table 2 – it can expand its business, contract (reduce) its activities, introduce new services (switch to different clientele) or it could do neither (defer the decision to invest or disinvest). Since each of these options is unique to the entity with benefits/costs applicable to a particular project, they can be considered proprietary to (owned by) the entity. Real options are also mutually exclusive (there is a chooser option) and thus are "duelling" in nature in relation to capital budgeting (Li, et al., 2007).

Table 2

Real option portfolio characteristics

Real Option	Realization period	Benefits, LVL	Costs, LVL
Expansion Option	3	19 % from underlying	(76 120)
Contraction Option	5	74 478	-15% from underlying
Switching Option	4	14 % from underlying	-4% from underlying and (45 500)
Deferral Option	5	underlying	OV loss

Source: developed by the author based on the enterprise data

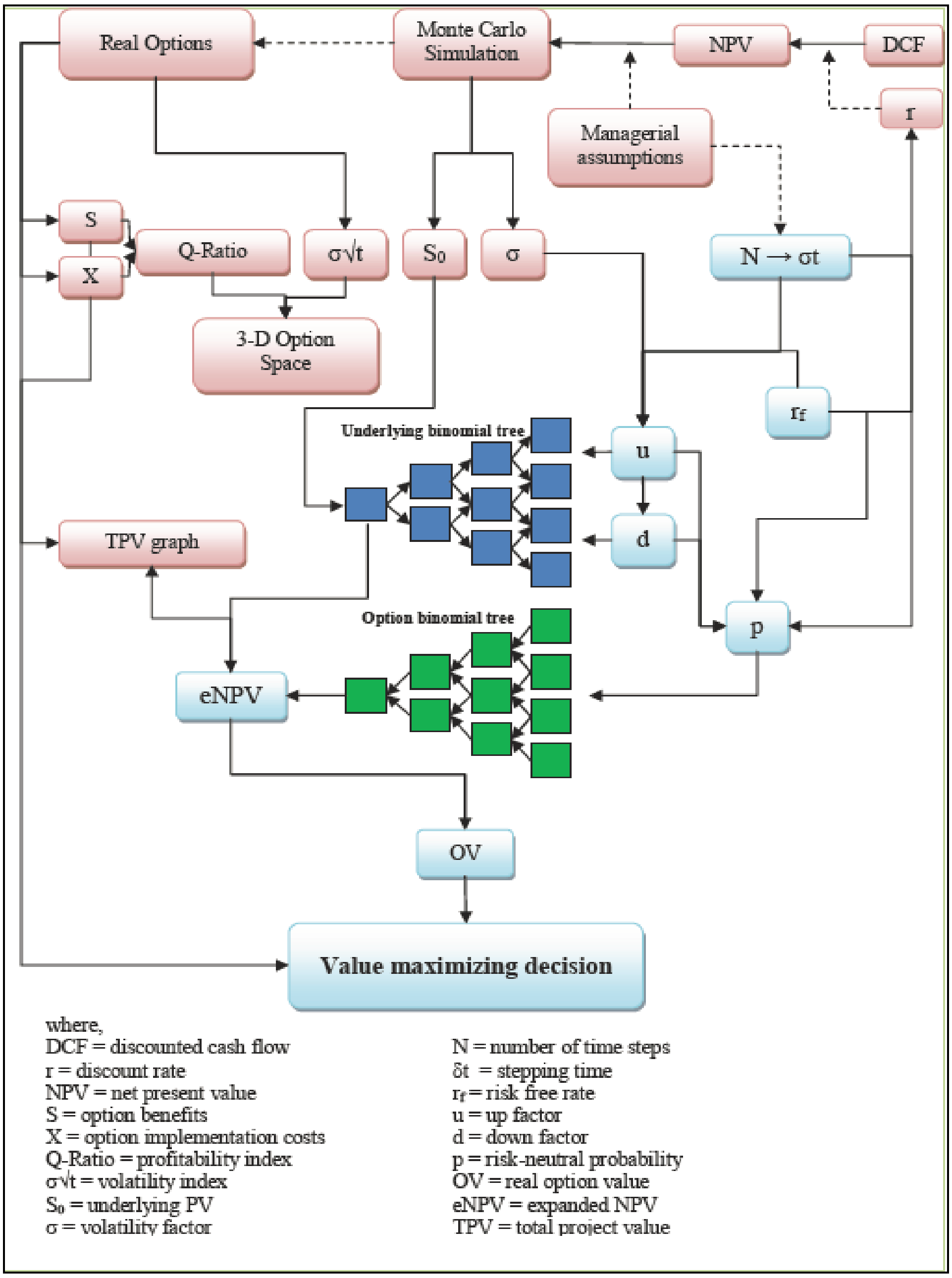

Figure 2. Real options analysis framework

Source: developed by the author based on Bailey, et al., 2003; Mun, 2003; Kodukula and Papudesu, 2006; Nembhard and Aktan, 2009

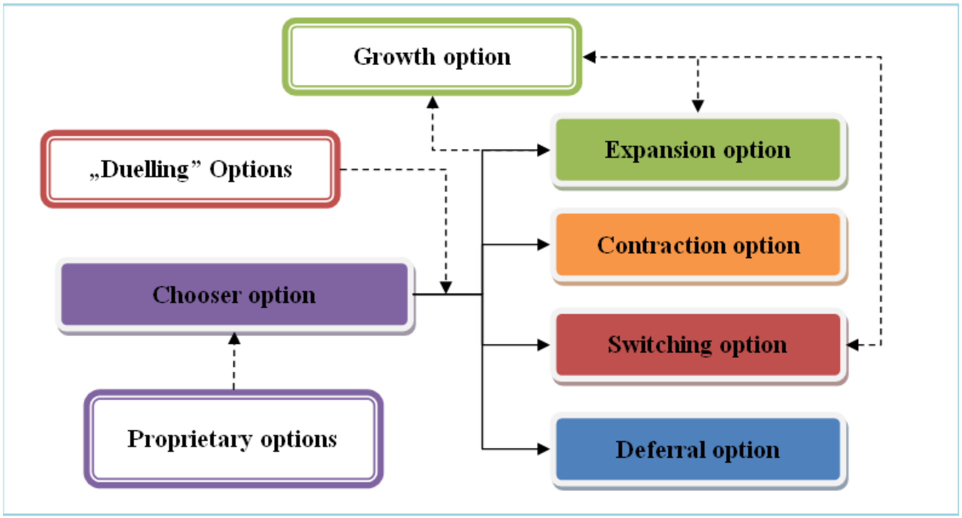

Figure 3. Real options portfolio held by the entity

Source: developed by the author based on enterprise data, Tong and Reuer (2007)

Via traditional DCF calculated NPV of the project (without any real options) amounts to 509 244 LVL (see Table 3). Entity applies weighted-average cost of capital to the discounting of revenue and reinvestment rate, determined on the basis of Latvian government bond yield rate, for discounting of expenses. Main project's characteristics, as calculated on the basis of managerial assumptions, are shown in the proceeding Table 3.

Table 3

Principal project data

Caption	Total in 5 years
Revenue from clear-cut	3 274 449
Revenue from thinning	461 016
Total revenue	3 735 465
Forest maintenance costs	(69 006)
Management and administrative costs	(931 575)
Forest inventory and survey costs	(39 280)
Forest clean-up and planting costs	(164 976)
Other fixed costs	(100 854)
Real estate tax	(111 471)
Total fixed costs	(1 417 162)
Forest clear-cut costs	(991 793)
Forest thinning costs	(224 688)
Total variable costs	(1 216 481)
EBITDA	1 101 821
Corporate income tax	(165 273)
Free Cash flow	936 548
PV of revenue	3 088 498
PV of costs	(2 579 274)
NPV	**509 224**

Source: developed by the author based on enterprise data

Once NPV of the projects is determined, real option characteristics may be expressed via equations incorporating this calculated NPV. Since RNP method will be applied, NPV is replaced with S, which represents the value of the underlying at a particular node. Each of the real options has its own benefit-cost structures. Based on management estimations, at time period zero (which will be the starting node in binomial lattice) OV's are calculated as follows in Table 4.

Table 2 depicts general OV formulas, wherein $S_{0\ i,j\ i}$ in the Table 4 above is the value of the underlying at j-th node at time period i in the binomial lattice (see also equation in Table 6). By replacing $S_{0\ i,j}$ with NPV, OV at time period zero can be calculated for reach real options, being EOV = 20 633 LVL; COV = 0 LVL; SOV = 5 422 LVL. Real option values now must be mutually compared. Expansion option and switching options are *in-the-money*, while contraction option is *out-of-the-money* and is essentially worthless. These results show which real option is currently the most valuable, but they do not show, whether there is value waiting and – if so – what the management can expect to gain by deferring (dis)investment decision? For that construction of binomial trees is needed.

To construct a binomial tree, 6 determinants of ROV outlined in Table 1 are needed. These values are calculated and shown in the following Table 5 as well as found in Figure 4 onwards.

Underlying represents the calculated NPV and 5 years deferral time is equal to the period in which real options may be realized. Time value of money represents the return on Latvia government bonds.

Because the whole portfolio of real options valued together, we also have to account for their interconnectedness in the valuation. Since each of the real options has its own implementation costs, these costs will be taken into account in the binomial lattice.

Table 4

Option value equations

Real Option	**OV equation**
Expansion (duration – 3 years)	$EOV = S - X = MAX\left[19\% S_{0_{i,j}} - PV(76\ 120); 0\right]$
Contraction (5 years)	$COV = S - X = MAX\left[PV(74\ 478) - 15\% S_{0_{i,j}}; 0\right]$
Switching (4 years)	$SOV = S - X = MAX[14\% S_{0_{i,j}} - \left(4\% S_{0_{i,j}} + PV(45\ 000)\right); 0]$

Source: developed by the author based on enterprise data and Mun, 2002

On the basis of management assumptions, cash flows may fluctuate in the range of $-10\% \leq DCF_n \leq +8.5\%$ every year. By applying Monte Carlo simulation on DCF model volatility factor is estimated as 6.97%. Logarithmic present value approach (Lewis et al., 2008) with triangular distribution was used to determine the volatility factor of the cash flows. There is no value lost by deferring the decision identified by the management.

Table 5

Binomial tree parameters

Parameter	**Value at time zero (t=0)**
Underlying or NPV (S_0)	509 224 LVL
Volatility factor (σ)	6.97%
Time till maturity (T)	5 years
Time value of money (r_d)	2.75%
Value lost by deferring decision (b)	0%

Source: developed by the author based on enterprise data and Nembhard and Aktan, 2009

Lattice parameters can be calculated as indicated in the following Table 6 (Mun, 2002; Kodukula and Papudesu, 2006).

Table 6

Parameters of the binomial lattice

Parameter of the Lattice	Equations and Values
Time steps in the lattice (N)	5
Stepping time of binomial lattice	$\delta t = \frac{t}{N} = 1 \text{ year}$
The up factor of binomial lattice	$u = e^{\sigma\sqrt{\Delta T}} = 1.0722$
The down factor of binomial lattice	$d = \frac{1}{u} = 0.9327$
Continuously compounded risk free rate over duration of real options	$r_f = \ln(1 + r_d) = 2.71\%$
Risk-neutral probability	$p = \frac{e^{r\Delta T} - d}{u - d} = 0.6797$
Value of the Underlying at j-th Node at Time i∆t	$S_{0_{i,j}} = S_0 u^j d^{i-j}$ given $j = 0,1,...,i$; $0 \leq i \leq N$ and $0 \leq j \leq i$
Deferral option value (intermediate value)	$IV_p = [(p)\text{up} + (1 - p)\text{down}]e^{-r_f \delta t}$ where up = value of next up node down = value of next down node

Source: developed by the author based on enterprise data and Mun, 2002; Kodukula and Papudesu, 2006; Nembhard and Aktan, 2009

Following the calculations of all lattice parameters, ROA by applying RNP approach can be conducted. Initially lattice of the underlying is constructed and afterwards – real options valuation lattice. Lattice of the underlying is constructed for 5 years with time period (known as stepping time or N) between nodes as 1 year. By applying the generalized formula of the value of the underlying indicated above, binomial lattice of the underlying is constructed for 5 year period.

Once the lattice of the underlying is constructed, real options valuation lattice is built – firstly by valuing the terminal nodes and then proceeding to the starting node via backwards induction. At any node, the value maximizing decision is to be determined by weighting the value of the underlying without real options' exercise (or deferring the decision) against with real options' exercise. Carrying out such process from the 5th time step backwards (to the left), the value of the starting node is determined. The value of the starting node thus shall be eNPV.

At the terminal nodes entity's management can choose to continue the business as usual or alternatively – one of the real options may be exercised. Because after five years real options have reached their maturity, deferral option has no value – i.e. management *must* make a decision. Adhering to the mentioned data, COV at each of the terminal nodes can be calculated using formulae indicated in Table 2. Expansion and switching options are not valued, since have already matured. These real options must be taken into consideration in that period, in which they may be realized. Thus, expansion option will be considered in the first three steps of the lattice, while switching option – in the first four. As entity's management would pursue such strategy, which yields the highest benefits, value maximizing decision is made whenever real option having the highest ROV would be realized.

Once terminal nodes value has been determined, lattice is "rolled back" or backwards inducted one time step at a time. At any time before either real option's maturity (i.e. prior to the last time step) the entity can not only contract, expand or switch, but also postpone decision. Therefore the deferral option should be taken into account in the calculations. The value of deferral option is derived from equation found in Table 2. It is labelled "intermediate value" because the nodes at the next time step have already been calculated and the value maximizing decisions determined in those nodes. Therefore the value of the deferral options is expressed in function to the value maximizing decisions made in subsequent time step (the up node and the down node in the lattice).

Moving backwards in the lattice value maximizing decisions are determined at each node, ultimately arriving at the starting node. Developed real options valuation lattice is depicted in the following Figure 4.

At the starting node (i.e. node "A") it is determined that the value maximizing decision as of present moment is to defer decision (or stated alternatively – postpone any (dis)investment). This is so since none of the real options are so deep-in-the-money zone, that it instantly becomes valuable to exercise either.

Real options portfolio (but not individual option's) value is determined as 28 246 LVL and results in 5.55% increase over the calculated NPV. By this amount entity's management has increased the value of the project by considering real options.

Despite the fact that the ROV has been performed, it is useful to illustrate real options graphically. This makes the ROV comprehensible and transparent analysis of both the analyst and the audience. One of the tools used in the graphic depiction of real option is 3D Option Space that displays which the real option's value due to uncertainty (or volatility) and the Q-ratio is the highest. In order to display the entity-owned real options onto 3D Option Space, it is necessary to calculate the volatility index, as well as Q-ratio via the equations found in Table 7 below (Mun, 2003).

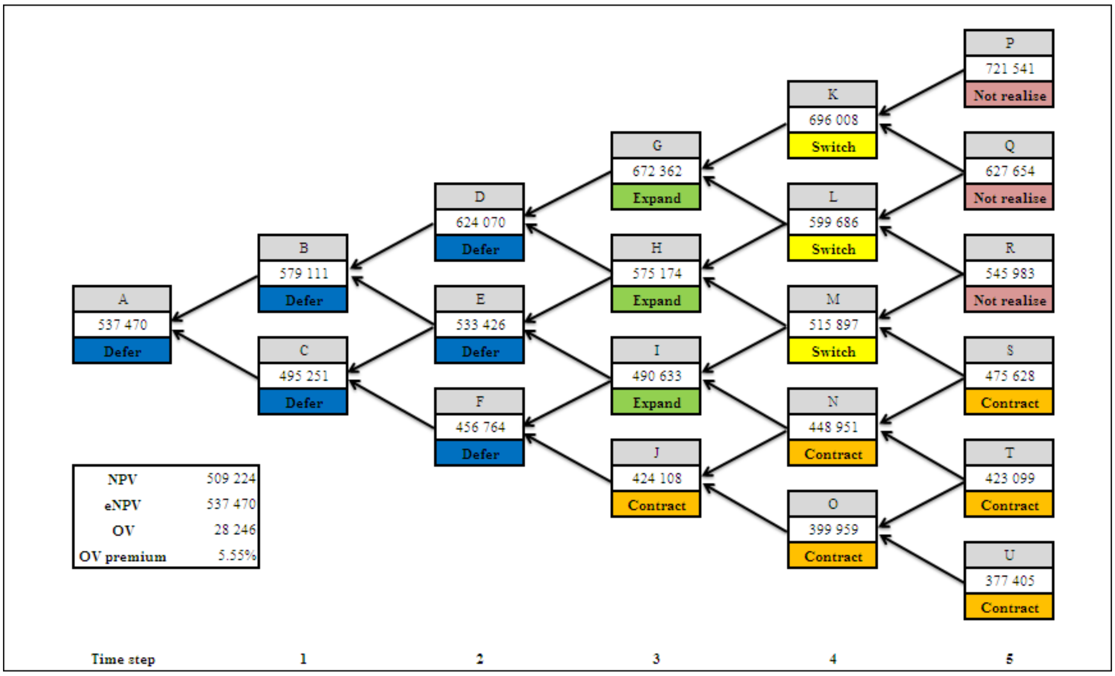

Figure 4. Real options valuation lattice

Source: developed by the author based on enterprise data and Nembhard and Aktan, 2009

Table 7

3D Option space parameters

Parameter of the 3D Option Space	Equations
Q-Ratio	$Q-\text{Ratio} = \frac{S}{X}$
Volatility Index	$\text{Volatility Index} = \sigma\sqrt{t}$

Source: developed by the author based on Mun, 2003

By calculating these parameters separately for each real option (expansion, contraction, switching) at time period zero it is possible to depict them onto 3D Option Space (see Figure 5). Since all real options are subject to the same project, they shall have the same volatility factor in this particular case. It is important also to note that both S and X must be discounted values in the equations.

3D component of the option space comes from width (Q-Ratio scale), height (volatility index scale) and depth (full circle represents real option's benefits, while dashed – its implementation costs). Real options are most valuable when located in Region 1 and become less valuable clockwise. As it can be seen expansion option is the most valuable, since it has the highest Q-Ratio. This also corresponds to the OV's calculated via equations found in Table 4, though 3D Option Space is more comprehensible and greatly complements ROV. Combing results from this model, management can have a clearer picture on the project and real options embedded into it.

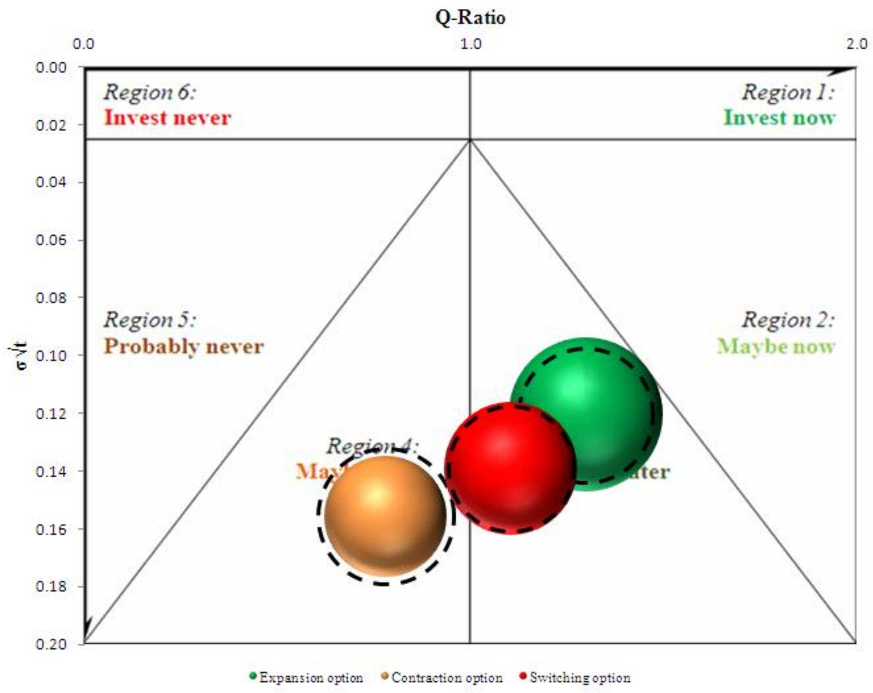

Figure 5. 3D Option space

Source: developed by the author based on Mun, 2003

Another framework applied in the developed ROV framework is Total Project Value (TPV) graph (Van Putten and MacMillan, 2004). TPV graph depicts location of the calculated project eNPV in is divided into 3 zones – flee zone (low eNPV and high volatility), option zone (moderate eNPV and volatility) and deep-in-the-money zone (high NPV and low volatility). Projects with options located inside deep-in-the-money zone must be realized immediately, while those in fee zone – abandoned or postponed till uncertainty is resolved. TPV graph gives management an insight on how the project's value will move from its initiation till maturity. For this TPV graph can be merged with the developed real options value tree, thereby indicating the margins on project value movement. Calculated eNPV alongside its top and bottom borders as per binomial tree terminal nodes is depicted in the following Figure 6.

The top of the triangle represents calculated eNPV with the Monte Carlo simulated volatility of 6.97%. eNPV shall move to the right as time passes, till the time when real options have matured (5 years). Currently eNPV is located (on the basis of management risk/return tolerance) in the option zone, which means that management should strive to either increase the value of real options, introduce new real options or reduce the volatility associated with the project. The latter, however, will also render real options less lucrative, since decrease in volatility also most often entails decrease in OV.

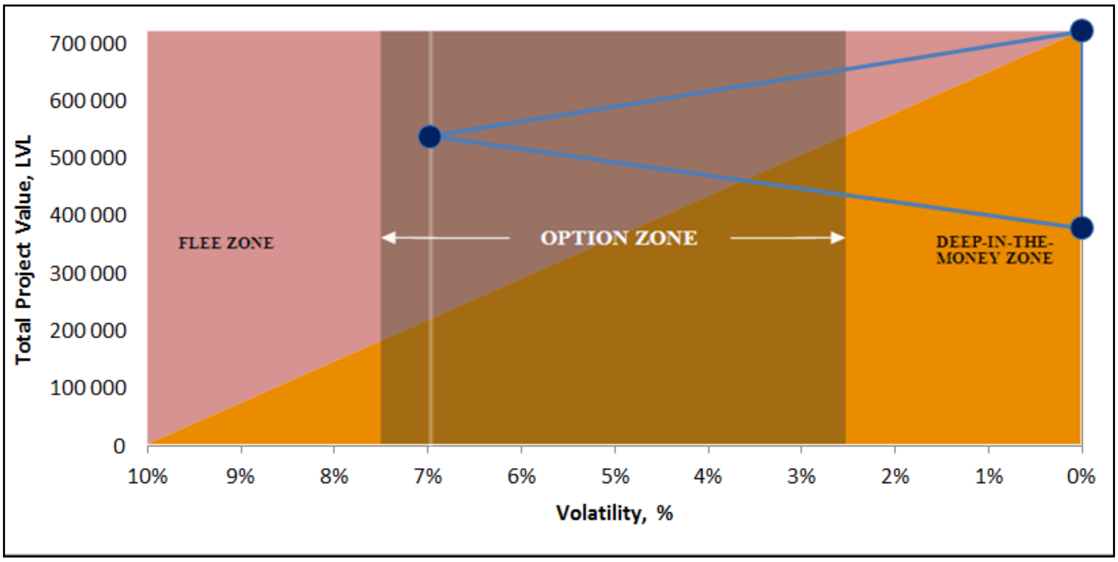

Figure 6. Revised total project value graph

Source: developed by the author based on Van Putten and MacMillan, 2004

Final project value, when all real options have reached maturity, will be between the two points where volatility is zero. As it can be seen in the Figure 6 above, triangle is akin to the binomial real options value tree depicted in Figure 4.

Application of all models of the framework will provide both analysts and the readers of the results with a clear picture of the project, its risks and, mainly, the strategic alternatives, which can be used to shift the project into favorable direction.

4. CONCLUSION

The purpose of this paper was to present the developed real options analysis framework and outline how it complements the traditional investment valuation approach, which was done on the basis of a logging industry enterprise in Latvia.

By considering (and formally including in the valuation) the managerial flexibilities it has project value is augmented by 5.55% relatively to standard DCF method. Given the benefits and costs of each real option, as well as the volatility associated with the project is was determined that the most beneficial strategic alternative is to expand, while management is at its own discretion to perform such investment. Since neither of real options' benefits outweigh its costs enough as to warrant immediate implementation, management is advised to postpone decision. The uncertainty associated with the project is not low enough to make the decision to invest or disinvest currently.

As soon as uncertainty is resolved through passage of time or active project management optimal decision can be made. If current values in the analysis are unchanged, the entity should exercise expansion option only. It is recommended that entity's management updates analysis continually and include additional real options in the analysis, therefore increasing total project value.

The developed model shows a comprehensive and systematic real options analysis framework, which can be followed by any practitioner in both academic and professional fields regardless of industry and/or project specification. Paper demonstrates that ROV complements DCF and its results can be clearly communicated with the help of several visual models outlined in the paper.

It is recommended that this model is applied by those entities, whose projects often are subject to uncertainty, limited funding or rapidly changing business environment. With real options businesses may hedge some of the risks to which they are exposed in the contemporary economic climate.

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