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VALUATION OF PHOENICS

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Abstract

This work presents theoretical background for diverse valuation methods, with special attention paid to the real options method and its advantages over traditional methods for valuation of young entities. Additionally, it presents a case study of a start-up company, the value of which is found using diverse methods. The main result shows that the value of the company obtained with the real options approach is much higher than the one found with traditional discounted cash flow (DCF) method. Moreover, it shows that the difference in the obtained valuations leads to different strategic decisions: according to DCF certain projects should not be undertaken, whereas according to the real options approach the company should expand its operations.

Keywords: *real options valuation, discounted cash flow valuation, start-up companies*

JEL Classification: *M13, M21, M41*

Abstract – Portuguese

Esta dissertação apresenta uma base teórica para diversos métodos de avaliação, com especial atenção para o método de opções reais e as suas vantagens em relação aos métodos tradicionais de avaliação de entidades jovens. Além disso, apresenta um *case study* de uma empresa start-up, cujo o seu valor é encontrado usando diversos métodos. O resultado principal mostra que o valor da empresa obtido com a utilização de opções reais é muito maior do que o encontrado com o método tradicional de fluxos de caixa descontados (DCF). Também mostra que a diferença entre as valorizações obtidas, leva a diferentes decisões estratégicas: de acordo com DCF determinados projectos não devem ser realizados, no entanto segundo as opções reais, a empresa deve expandir suas operações.

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Executive Summary

This work aims to show the reader the theoretical environment of the valuation of young companies as well as apply the diverse methods to a case of a start-up. Furthermore, the thesis compares the differences and strategic impacts of DCF methods and the real options approach.

Since the importance of start-up companies is growing worldwide there is also a need for financing them. The need for financing creates a need for evaluating the entities. Unfortunately, traditional valuation methods, mainly DCF methods do not provide satisfactory results. This is mainly because start-ups or young companies' assets mainly consist of intangible components, which provide the company with opportunities to create value in the future but usually are not accurately reflected in the DCF valuation. The lack of flexibility and the immense impact of high discount rates are the main reasons for the failure of DCF in these cases.

The real options approach provides a framework which can help solve that problem. It forces one to calculate possible opportunities which arise of the possibilities given by intellectual property within the young company. It further sees risk as an opportunity and therefore high volatility of profits has a positive impact on the value of the entity. Due to this, the real options approach usually results in higher valuations than DCF methods do.

Both valuation methods have been applied to the case of the Austrian company Phoenics OG. Phoenics OG invented a 360° video wall and holds patent rights over it. Currently, this product is rented in Austria. One idea for expansion of the business model is selling the product, which however requires an investment of EUR 100.000. The company is also considering expanding to the German market.

DCF valuation leads to a result of EUR 1.429.387. This result does not take into account any strategic opportunities arising from the patent. It is obvious that there is a need for improvement of this valuation. Phoenics has three main options: either the company expands to Germany, invest in the product to sell it, or to do both. These three scenarios serve as an input to the real options analysis, which provides answers as to whether the company should follow one of these opportunities or not. The result shows that Phoenics should expand to Germany but should not produce the product serially. The third scenario, doing both, could also be followed.

Real options valuation of the scenarios leads to a value of EUR 4.611.621 for the expansion scenario and EUR 4.202.726 for the sale scenario, taking into account the compounding effect. Consequently, the value of doing both can be calculated as EUR 8.814.347. Adding the base case to the sum of the real options the value of the firm is seven times higher than the value found with DCF.

The difference in values reflects what has been expected. An additional result of the valuation is the strategic impact of different valuation methods: whereas DCF would have led to the decision of not producing it serially, and therefore missing the opportunity to do both, valuation with real options suggests the opposite.

In sum, the result reflects the theoretical predictions. However, one should not solely account for this additional information on the side of the real options valuation. The real options approach is much more than a valuation method: it is a way of thinking and identifying strategic options. Of course, due to the fact that volatility positively influences the result, real options valuations will be in most cases higher than the DCF result. Still, the main advantage of this method is a careful and detailed analysis of all scenarios and opportunities.

1 Introduction

1.1 Overview of the Problem

In a globalized world, small but innovative ventures are able to serve various markets even at a very early stage of their existence. What makes it hard to value their equity is their huge potential to quickly explore new markets, however, accompanied by substantial uncertainty.

Due to high risk, it is hardly possible to refer to debt as a major source of financing. Therefore, in the absence of public subsidies young firms have to rely on business angels or venture capitalists, depending on the development stage of their firm. In this case, a valuation of the entity or the patent as a major part of it is necessary to determine the fair value of the equity.

The aim of this work is to present and analyze different methods of corporate valuation applied to young companies. As previously noted, the companies in question are operating in a high uncertainty environment and often the major part of their equity consists of intangible assets such as patents or brands. Therefore, this thesis concentrates on presenting what methods can be used to valuate such innovative ventures, and analyzes why some of them are more suitable than others. Moreover, it show how different methods result in different estimates, and provide the explanation of these differences.

For sure, the Discounted Cash Flow method (referred to throughout as DCF) is still the widest used method to value companies. But since especially start-up ventures have high flexibility in management choices and high uncertainty in decision-making, it seems to be more suitable to use a Real Options approach in order to value these entities.

This work is structured as follows. Firstly, the company in question and its current stage of evolution will be described. Secondly, an overview of the different quantitative valuation methods together with their advantages and disadvantages are discussed. Thirdly, the work provides a quantitative analysis of the company using the various valuation techniques (discounted cash flow analysis with diverse assumptions, the real options method). Finally, the results of the analysis are discussed.

1.2 Problem Statement

The main goal of this thesis is to present the Real Option Valuation (henceforth ROV) method and apply it to the case of a start-up as well as to show that this method offers a reasonable alternative to traditional valuation methods for the case of high tech companies. In order to achieve this goal, the theory behind the traditional valuation methods, including the limitations of these in case of high tech companies is discussed. This first step already sheds light on the problems that traditional valuation methods encounter when applied to start-ups. Subsequently, the thesis presents the alternative offered by Real Option Valuation methods, and both techniques are applied to a case of a high tech start-up. In the latter step, it is presented how the traditional valuation methods such as DCF exhibit weaknesses when the company in question has a non-conservative financing structure. As is shown, the problems arising from the DCF become even more severe whenever the company does not provide full accounting information about its financing sources. The lack of reliability of data as well as a nonstandard capital structure of the company is shown to result in a non-trustworthy DCF valuation. This work also shows how ROV can become handy in such a situation.

1.3 Synopsis of the goals

This thesis has six key goals:

- Describe in an exhaustive way, the valuation methods which are used in practice,
- Show the limitations of the traditional valuation methods for valuing high technology start-ups,
- Describe the Real Option Valuation methodology, with a particular emphasis on its applicability for high tech companies,
- Use both valuation methods in a practical case study of a start-up,
- Compare and analyze the results of different valuation methods as well as formulate conclusions about the practical applicability of diverse methods for valuation of start-ups,
- Show the possible different implications for strategic decisions of DCF and ROV.

1.4 Fixing the boundaries

The interpretation of the results of this study is not limited to the companies operating in high tech industries only. The results will be applicable to the cases of companies for which the main asset is intellectual property and which are in early stages of development such as in IT industries, innovative internet platforms and others.

This work will not focus on all special applications of the Real Options method. In particular, it will provide a method which allows us to value this specific case study. Furthermore, this thesis will not focus on in depth discussion of Black-Scholes or binomial trees, but on practical application of these.

1.5 Target Audience

This work is aimed to shed new light on corporate valuation of companies with intellectual property assets. It is targeted at scholars who work in the field of corporate valuation, in particular in young industries. Moreover, it could be an interesting point of reference for practitioners (e.g. young entrepreneurs) who seek information about valuation of their companies as well as venture capitalists and public authorities who provide subsidies and need information about the performance of the ventures.

1.6 Data Collection

The necessary data has been gathered mostly from the balance sheets and income statements of the Phoenics Creative Studio[1]. Moreover, the owners of the analyzed company provide forecasts of the company's performance prepared for internal use. Data provided by these forecasts will also be used – after revision. Some methods of evaluation such as the real option method require knowledge of the financial and macroeconomic indices of the economy such as risk free interest rates. These have been gathered from various public data sources including the OECD database, the ECB database, the database of the IMF as well as the National Statistical Office of the Republic of Austria.

Regarding market forecasts the main sources of data are Gewista, for the Austrian market, Fachverband Außenwerbung e.v (FAW) for the German and Magnaglobal for worldwide industry outlooks.

Gewista is the biggest Austrian out-of-home advertising company held by the French multinational advertizing company JCDecaux (JCD). Due to its former public ownership it is still the most reliable source regarding advertizing in Austria. FAW is a German association members

[1] The company under scrutiny is described in detail in Section 4.1

of which are nearly all German companies in the out-of-home advertizing industry. Its main aim is to connect, consult and promote all members of the industry all over Germany. Magnaglobal is a New York based Investment company. Their main focus is on investments in the media industry and they provide a yearly overview of the industry. For the comparison with the biggest competitors, JCD and Stroehr, their websites and annual reports have been consulted.

As this work is a case study, it is based on data provided by a single entity. Data will comprise their balance sheets and income statements since 2008 as well as forecasts of these for the next five years.

As it is suspected that these forecasts have been prepared under different circumstances than current, they will be revised jointly with the CEO of the company.

2 Valuation Theory

2.1 Introduction

The purpose of this chapter is to provide a theoretical framework on which further analysis will be based. Diverse approaches to calculating the value of the company are presented. Furthermore, this chapter describes the advantages and disadvantages of these core valuation techniques. Additionally, for every valuation technique, it is discussed, if or how it can used for the specific problem given.

One can group the valuation methods into three categories: Entire approaches, which take into consideration the overall situation of the firm, single approaches which concentrate only on one aspect of the firm e.g. its liquidation value and other methods which include mixed methods, real options and other. The first group of approaches comprises several aspects of the overall company picture: the assets, growth potential, future earnings, the position in the market and so on. On the other hand, the second group concentrates only on the current condition of the firm, by analyzing solely the balance sheets. The overview of the basic methods is presented in Figure 1. Of course, the list is not complete, but rather serves as an overview of the methods available and their basic features for the purpose of explaining the shortcomings of traditional valuation methods when applied to high tech companies.

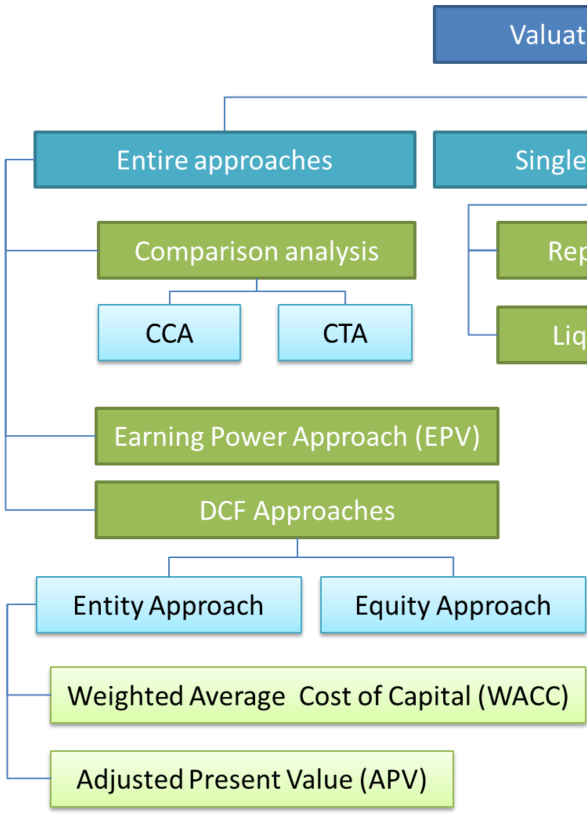


Figure 1: Overview of valuation methods

Source: own work based on Koller *et al.* (2010)

2.2 Brief description of basic traditional methods

The following description is just an overview of some specifically selected valuation methods. The purpose of this chapter is not to show all possible valuation techniques but only to summariye the most relevant ones. The description of the DCF method, its limitations and extensions is based on Brealey *et al.* (2011) and Mun (2006), unless otherwise stated.

2.2.1 Discounted Cash Flow Methods

The basic idea behind the discounted cash flow methods is to value a project or a company using the time value of money and recognizing the asset's risk. Most generally the future cash flows are estimated and discounted back to obtain their present values. The value of the company is therefore the sum of discounted future cash flows. As this method is by far the one mostly used in business practice it will be described in full detail. Moreover, the purpose of the detailed presentation is to show the limitations of the DCF method for valuing start-up high tech firms, as well as in order to present the benchmark valuation technique which is then to be compared with the real options valuation.

Discounted Cash Flow methods always require four steps:

1) Forecast of future revenues, which in turn determine other key financial statements.
2) Forecast of Cash Flows: either Free Cash Flows in the entity methods or Equity Cash Flows in the Flow-To-Equity method described in detail below.
3) Determine the discount rate.
4) Calculate the intrinsic value of the company.

Each of the steps is explained in more detail in the following sections.

2.2.1.1 Forecast of future revenues

First step of the analysis involves estimation of future revenues. The choice of methods to do so is very broad and includes both ‘soft’ methods as well as econometric techniques; in fact it usually requires the simultaneous use of both. One needs to start with estimation of the forecasting period. These may vary according to growth features of the industry as well as characteristics of the company in question. In the next step one has to consider what factors will affect future earnings such as historical growth, market share, macroeconomic situation, behavior of the competitors and so on. Combining the manager’s intuition and internal knowledge with relevant econometric techniques, should allow estimation of the future revenue. Among econometric techniques one should consider models which incorporate historical data with market growth such as autoregressive models including market features as explanatory variables.

2.2.1.2 Calculation of Free Cash Flows to the firm (FCF)

The basic formula for calculation of FCF is

$$FCFF = EBIT * (1\text{-}r)+DEPR\text{-}CAPEX\text{-}\Delta NWC, \tag{1}$$

where *EBIT* stands for Earnings before interest and taxes, *r* for the corporate tax rate, *DEPR* for depreciation and amortization, *CAPEX* for capital expenditures and Δ*NWC* for the increase in the net working capital. Instead of *EBIT* one can use the formula including the net profit, which is

$$FCFF=Net\ Profit + INT\text{-}CAPEX\text{-}\Delta NWC\text{-}TaxINT, \tag{2}$$

where *INT* stands for interest expense and *TaxINT* is the tax shield on the interest expense.

2.2.1.3 Calculation of Free Cash Flow to Equity

Similarly to the Free Cash Flows to the firm one can calculate the Free Cash Flow to Equity (FCFE) as a basis for the discounted cash flow analysis. FCFE is calculated as follows:

$$FCFE=Net\ Income-CAPEX-\Delta NWC+(NewDEBT-DEBTRepay), \tag{3}$$

where *NewDEBT* is the new debt issued and *DEBTRepay* are debt repayments.

2.2.1.4 Terminal Value

An additional aspect that has to be taken into consideration is that it is not possible to estimate the cash flows forever, therefore it is necessary to impose a closure in the DCF calculation, by stopping the estimation of the cash flows at some point in the future and finding a *terminal value* that reflects the value of the firm at that point. There are three basic methods of finding the terminal value, and shall be described them in turn (Allman, 2010).

If it is reasonable to assume that the firm will cease operations at some point in the future, or that there are no expected cash flows beyond a certain point terminal value can be found as a liquidation value of the firm's assets. The liquidation value methodology will be discussed in more detail in Section 2.4.1. The second possibility to calculate the terminal value is to use the multiples approach which is described in Section 2.3

The third commonly used method is *the stable growth approach* (the Gordon Growth Model). In this approach one assumes that the cash flows continue into perpetuity in the future and grow at a constant rate (it is possible to assume a non-constant growth here only the basic version of the model is described). The formula for calculation of the terminal value is

$$TV = \frac{Cashflow_T(1+g)}{k-g}, \tag{4}$$

where the Cash Flow in period T is the last estimate of the cash flow for the forecasting period; note that depending on the method used it will be either FCF or FCFE. *k* denotes the assumed discount rate (e.g. the weighted average cost of capital for the WACC approach) and *g* is the assumed stable growth rate of cash flows. This formula heavily relies on the assumption that the cash flow in the last projected year will stabilize and continue growing at the same rate forever, therefore for certain market situations and individual firm conditions it might not be reasonable to use this approach.

2.2.1.5 Discount rate

Discount rate or the cost of capital refers to the opportunity cost of making a specific investment. It is the rate of return that could have been earned by putting the same money into a different investment with equal risk. Thus, the cost of capital is the rate of return required to persuade the investor to make a given investment. In other words it is the required rate of return of the debt and equity holders. The fact that it is the rate that could have been earned from a different investment is the reason for which it is used as discount rate in the DCF methods. It reflects the standard discounting concept explaining the time value of money known from other financial applications: it is the rate of return that providers of capital demand to compensate them for both the time value of their money, and risk (Kruschwitz and Loeffler, 2005).

When it comes to choosing the discount rate there are many possibilities. Still, this step is crucial, as small changes in the discount rate generate big changes in the estimated discounted cash flows. The choice of the discount rate also determines the method that one actually uses. For the FCFF method one discounts with the weighted average cost of capital, whereas in the adjusted present value (APV) method the discount factor is the unlevered cost of equity.

2.2.1.5.1 Weighted Average Cost of Capital (WACC) Approach

The most appropriate rate for discounting future cash flows to the firm is the weighted average cost of capital, which captures the rate at which a company is expected to finance all its assets. Usually it comprises the cost of equity and the after-tax cost of debt with relevant weights stemming from the capital structure of the firm. Since in practice companies finance their assets from many different sources, it may include not only common equity and straight debt, but also diverse kinds of debt such as convertible and exchangeable bonds, warrants, options, subsidies and so on. In the simplest form, the WACC formula comprises the cost of equity and the cost of debt.

2.2.1.5.2 Calculation of the Cost of Equity

Cost of equity captures the return that a firm is supposed to pay to its equity investors. Unlike the cost of debt, which is usually a set interest rate, the cost of equity is not fixed, but simply has to reflect the additional risk that the investors have to bear in order to invest in the firm. That is the cost of equity has to be estimated using the relation of the firm to the market as well as other components such as e.g. prediction of future dividends.

The most common way to find the cost of equity is to use capital asset pricing model (CAPM) in which

$$Cost\ of\ Equity\ (R_e) = R_f + \beta(R_m - R_f) \tag{5}$$

where *Rf* is the risk-free rate, usually taken to be interest on long term stable bonds (e.g. 10 year government bonds), β is the measure of how a company's share price moves against the market as a whole, and the term inside the brackets is the Equity Market Risk Premium which represent the returns that the investors expect over the risk-free rate or in other words the difference between the risk-free rate and the market rate. The beta coefficient is found using the following formula:

$$\beta = \frac{Cov(r_a, r_b)}{Var\ (r_b)} \tag{6}$$

where r_a is the rate of return on the asset and r_b is the rate of return of the benchmark asset (for listed firms typically a stock market index). For listed firms, the choice of the rates of return used for calculation of the beta coefficient is usually straightforward, whereas in the case of a start-up as the one in question in this work, the problem of choosing the relevant rates of return is a more sophisticated one Section 5.2.1.1.1 returns to describing the estimation strategy in this particular case.

2.2.1.5.3 Calculation of the Cost of Debt

The cost of debt is fairly straightforward to find. The rate to apply should be the current market rate the company is paying on its debt. Most commonly this should be the rate on a risk free bond whose duration matches the term structure of the corporate debt plus the default premium. Additionally to obtain the rate which is easily comparable with the cost of equity, the cost of debt should be calculated as an after tax cost. The formula is therefore

$$Cost\ of\ debt\ (R_d) = (R_f + credit\ risk\ premuim) * (1 - r) \tag{7}$$

where *r* stands as before for the corporate tax rate. In practice one can approximate the cost of debt with yield to maturity of a bond with correctly chosen duration.

In the absence of recent debt issues and publicly traded debt, another method of estimating the cost of debt is simply through its accounting system. This is done by dividing capital expenditures of the income statement through net debt from the balance sheets.

2.2.1.5.4 Calculation of WACC

Finally, WACC is the weighted average of the cost of equity and the cost of debt based on the proportion of each component in the capital structure of the firm. The formula is, therefore

$$WACC = \frac{E}{V} * R_e + \frac{D}{V} * R_d \tag{8}$$

where *E* is the market value of the equity and *D* is the market value of the debt of the firm.

Finally, the present value of the firm using the WACC approach is found according to the following formula:

$$\mathrm{NPV} = \sum_{\mathrm{t}=1}^{\mathrm{T}} \frac{\mathrm{FCFF_t}}{(1+\mathrm{WACC})^{\mathrm{t}}} + \frac{\mathrm{TV_T}}{(1+\mathrm{WACC})^{\mathrm{T}}}, \tag{9}$$

whereas the Terminal Value is normally given by

$$TV_T = \frac{FCFF_T(1+g)}{WACC-g}. \tag{10}$$

2.2.1.6 Adjusted Present Value (APV)

In the APV approach one begins with the value of the firm without debt. As one adds debt to the firm, the net effect on value by including both the benefits and costs of borrowing is considered. Therefore, one considers primarily the tax benefit of borrowing and the increased risk of bankruptcy as a main cost. In this method one determines the levered value of a company by first calculating its unlevered value and then adding the value of the interest tax shield. The formula is therefore

$$APV = V^U + PV(Tax\ shield) - PV(financial\ distress), \tag{11}$$

where V^U stands for the unlevered value of the company. The first step is to find the unlevered value of the firm. It is done by calculating the value of the free cash flows using the project's cost of capital as if it were financed without leverage. In order to correctly discount the cash flows, it is necessary to find the unlevered cost of capital. For firms that adjust their debt to maintain a target leverage ratio, it can be simply found as a *pretax* WACC. Therefore, the formula for the unlevered cost of capital will be the same as the WACC formula above, with the sole difference that the cost of debt is not multiplied by the *(1-r)* component:

$$Pretax\ WACC = R_e^U = \frac{E}{V} R_e + \frac{D}{V} R_d^U, \tag{12}$$

where

$$R_d^U = R_f + R_P, \tag{13}$$

and *RP* stands for the risk premium.

Alternatively, one can find the unlevered cost of capital using the unlevered beta coefficient of the firm. The unlevered beta coefficient is found according to the following formula:

$$\beta^U = \frac{\beta}{1+(1-r)*\frac{D}{E}}, \tag{14}$$

and use the formula

$$R_e^U = R_f + \beta^U (RP). \tag{15}$$

The second step is to find the tax shield, which is simply the interest paid on debt times the marginal corporate tax rate, thus

$$Tax\ Shield = r * (interest\ on\ debt). \tag{16}$$

2.2.1.7 Equity Approach

In the equity approach ("Flow-To-Equity Method"), the cash flows to equity are discounted at the cost of equity. As introduced above, it is a valuation method that calculates the free cash flow available to equity holders taking into account all payments to and from debt holders. In other words, the free cash flow that remains after adjusting for interest payments, debt issuance and debt repayments. The exact formula of calculation of cash flow to equity has already been presented in (3). The value of the equity (also called shareholder value, SV) is then calculated by discounting these cash flows with the required rate of return on equity instead of the WACC.

$$\mathrm{SV} = \sum_{t=1}^{T} \frac{\mathrm{FCFE_t}}{(1+R_e)^{t}} + \frac{\mathrm{TV_T}}{(1+R_e)^{T}} \tag{17}$$

2.2.1.8 Comparison of the Methods

The three apporaches to DCF valuation have certain aspects in common and some which differentiate them. However, eventually they result in the same valuation.

The obvious similarities lie in the proess of valuation itself. The process of valuation starts with predicting future cash flows for a given timeframe, determining a terminal value and, eventually, calculating the cost of financing.

The specific company under scrutiny eventually determines which approach is the best in the given situation. Comparing the FCFF as an entity approach with FCFE approach shows how the two differ. The first major difference is that instead of the FCFF in the FCFF approach one uses the Cash Flow to Equity for the FCFE valuation. The second difference is that one uses the required rate of return of shareholders in the FCFE method instead of the WACC. Nevertheless, one can consider both methods very similar.

In many cases, however, especially for the case of young companies, the capital structure or the tax rates change over time. In nearly all european countries a special tax or cash incentives are given to young companies. These influence the WACC in an obvious way. In most of these situations it is easier to use the APV method instead of the FCFF approach to value the company.

2.2.1.9 Limitations of the DCF methods

Discounted Cash Flow methods while being relatively simple to implement and widely accepted, have several shortcomings, which make them less useful for modern project and company valuation. The practical problems with DCF include undervaluing assets which currently produce little or no cash flow, the estimation of an asset’s economic life, forecast errors in creating the future cash flows and the non-constant nature of the weighted average cost of capital discount rate through time. Moreover, even if one is able to overcome the issues discussed above, several of the assumptions of DCF do not correspond to the reality of strategic decisions under uncertainty. Let us discuss some of the disadvantages of DCF as compared to the Real Options Approach. First of all, DCF assumes that strategic decisions are made now, and they decisively determine the future cash flows. In reality, future outcomes are uncertain and variable. Moreover, not all decisions are made today; some may be deferred to the future, once the uncertainty becomes resolved. Secondly, DCF assumes no active management throughout the course of the project, whereas projects are usually actively managed through life cycles of products, budget constraints and so on. Thirdly, DCF assumes that future free cash flows are highly deterministic and predictable. This assumption, while sometimes being a useful simplification in mature industries, cannot be reliably applied in most market situations in which uncertainty plays a role. In reality, it might be difficult to credibly estimate future cash flows, as they are in nature stochastic and risky.

A huge disadvantage of DCF is the fact that this valuation method assumes that all risks and factors affecting the outcome of the project and value of it to the investors are completely accounted for. DCF assumes that the NPV perfectly reflects all the important aspects of the project and that the discount rate captures all the potential risks. In reality, one cannot asses the future risk, only by looking at the current discount rate, as risks may change during the course of the project. Moreover, for project of high complexity, or those which involve externalities or network effects it might be difficult or impossible to quantify all factors in terms of cash flows. Unplanned outcomes might be of high strategic importance. Last but not least, classical DCF completely neglects intangible assets and immeasurable factors, which are in turn valued at zero. In reality, and of great importance for emerging industries, intangible assets might play a huge role in project valuation.

As the major drawbacks of the DCF method have been recognized, this chapter continues with description of a few methods that help ease these faults. Scenario analysis and Monte-Carlo simulation are not valuation methods *per se*, but serve as an extension to the valuation obtained by DCF.

2.2.2 Scenario analysis

Normally, in a scenario analysis there are three different underlying scenarios which in sum aggregate to the final value of the investment. These three scenarios are: best case, worst case and the most probable case. Each of them is related to different assumptions in the DCF model. Additionally each of these scenarios is assigned a probability of occurring. In sum the NPV of the project is the average of the scenarios weighted by the probabilities.

This model is widely used in practice together with the DCF method. It is, however, also not free of problems. Scenario analysis boils down to expressing cash flows in terms of key project variables and then calculating the consequences of misestimating the variables. It forces the manager to identify the underlying variables, indicates where additional information would be most useful, and helps to expose inappropriate forecasts. One drawback to scenario analysis is that it may give somewhat ambiguous results. For example, what exactly does *optimistic* or *pessimistic* mean (Brealey *et al.* 2011)? Moreover, a manager must be able to identify exactly the key variables or consistent combinations of these, which produce each scenario. If the market situation is complicated and involves many factors, it might be very difficult to determine which exact variables influence the final outcome of the valuation.

2.2.3 Monte-Carlo Simulation

Sensitivity analysis, which is a standard tool in finance, allows the manager to consider the effect of changing one variable at a time. By looking at the project under alternative scenarios, you can consider the effect of a *limited number* of plausible combinations of variables. Monte Carlo simulation is a tool for considering *all* possible combinations. It therefore enables inspection of the entire distribution of project outcomes (Brealey, 2011). In this, it should be seen as a further extension of the classical scenario analysis, which allows for a higher level of computational complexity. Moreover, Monte-Carlo simulation allows for incorporating not only uncertainty of individual variables, but also any kind of correlations between the key variables that influence the NPV of the company or project.

As in the traditional sensitivity analysis, the key step is to identify the variables which are heavily affected by uncertainty and their impact on the final valuation. Next, one needs to estimate the distributions of these variables, using the knowledge about market conditions or statistical methods. For example, normal distribution might be a reasonable assumption for the beta coefficients, whereas sales might rather follow a triangular distribution. The choice of the distributions of parameters as well as correlations between them is a task that requires deep knowledge of the market as well as of the mathematical background on the side of the manager. Having identified the necessary assumptions, the simulation task itself is simple, and can be implemented with appropriate software (such as the well-known Risk software). A big advantage of the Monte-Carlo method is, that given current computational power, even the most complicated scenarios can be evaluated within seconds. After the distribution of NPV has been found for the combination of input variables, it allows also estimating probabilities of certain events e.g. the probability and borderline values of variables for which the company becomes unprofitable.

2.3 Comparison Analysis

2.3.1 Comparable Companies Analysis

Comparable companies analysis (CCA) is a method of estimating the value of a company (or a single asset) by comparing it to the values assessed by the market for similar companies (assets). In the first step one has to choose a sample of comparable companies (‘’the peer group’’), with regard to several factors: the industry in which they operate, their business model, geographic location, accounting policies, capital structure, size and others. This step of the analysis can be performed either using ‘soft’ methods or econometric techniques such as correlation analysis, simple regression analysis or propensity score matching. In the second step one needs to estimate the relation of the company in question to the selected comparable entities, to be able to obtain reasonable comparison basis. In this, *multiples* are found. That is, one needs to find the market values of compared firms and relate them to some key financial items. The most common multiples are relating the market value of the compared firm with EBIT (earnings before interest and taxes), Free Cash Flows, Operating FCF and Net Operating Profit. In the last step of the analysis one applies the multiples obtained for the peer group firms to key financial statements of the firm in question and calculates the market value of the firm (Meitner, 2006).

2.3.2 Comparable Transactions Analysis

Comparable transactions method (CTA) is often used for valuing companies for mergers or acquisitions. One looks at transactions that have taken place in the industry that are in some ways similar to the transaction under consideration. Similarly to the method above one needs to distinguish a key parameter for valuation and obtain multiples of the key considered factors, and afterwards use the multiples to find the value of the company in question. However, CTA cannot be considered a valuation method itself, as it is rather relying on past valuations of other entities. Nevertheless, it is worth mentioning in the context of this work as it is often used as a benchmark for valuation of young companies.

As the name suggests, in the CTA, one looks at transactions that have taken place in the industry that are in some ways similar to the transaction under consideration. Similarly to the

CCA method one needs to distinguish a key parameter for valuation and obtain multiples of the key considered factors, and afterwards use the multiples to find the value of the company in question. The key challenge is, therefore to find the correct multiples for the valuation. If a start-up or young company provides a completely unique service or product this might be a difficult task. On the other hand, multiples can be safely applied in cases in which similar companies have been sold for instance in different countries. This method can be a useful tool to analyze young companies with the mentioned restrictions. Furthermore and this is the reason why it will not be applied here, it is usually either very difficult or very expensive to obtain data about past transactions.

2.4 Single Valuation Approaches

2.4.1 Liquidation Value Approach

Liquidation value is obtained as a value that would be received if the company actually sold all of its assets and paid all its liabilities. This method provides a useful benchmark of the lowest value of the company, since in practice the liquidation value will be lower than fair market value, as owners on the brink of bankruptcy may be forced to sell the assets below their fair price (Hitchner, 2011). Moreover, the method does not take into consideration intangible assets, which at least for some industries (as for example in the company analyzed in this work) have much higher value than the sum of tangibles. Although it is very simple to implement, the method does not capture the earning potential of the company's business e.g. for the case of start-ups. On the other hand, unprofitable companies may be worth more as a sum of the tangibles than when being operational.

2.4.2 Replacement Cost Approach

The idea of this method is to find the value of the company by estimating the cost of reproducing all the company's assets. Originally used in property valuation and insurance, it can be applied to corporate valuation as well. In the first step of the analysis one splits the company into parts that can be separately valued. For each object the question to answer is what the cost of replicating each object belonging to the company's value is (Fernandez, 2007). As it is often considered in current market prices, without allowing for depreciation, the overall valuation might exceed the book value. Therefore, *a contrario* to liquidation value the method tends to overstate the value of tangible assets. Additional critiques are the same as in the previous case: the method is, therefore not appropriate for valuation of start-up companies, particularly in high tech markets.

The third group, thus other methods of valuation including the real options approach will be described in more detail in Chapter 3.

2.5 Applicability of valuation methods to high tech start-ups

2.5.1 High Growth Features of Valuation

In order to determine specific issues relevant for the valuation of high growth ventures it has to be determined in advance what makes it so special. When talking about high growth ventures one normally assumes the following circumstances (Achleitner and Nathusius, 2004):

- High degree of innovation
- Short corporate history
- Scarce resources
- High value of intangible assets
- High need for flexibility
- High risk but also high chance

Due to these specifications some requirements for valuation methods for ventures can be determined.

Firstly, they have to be oriented towards the future. As there is a short corporate history, it does not seem reasonable to value the corporation on the basis of its historic data.

Secondly, an adequate picture of the company has to be shown, one which takes into account the high value of intangible assets, the opportunity of flexible decision making, but also high chances and risks. This requirement shows a major difference to all other valuation methods, as it concentrates on the major differences between ventures and mature companies.

Thirdly, practicability has to be mentioned. As there is normally little or no historic data available it is hard to reflect the whole company's picture within a valuation model. To avoid major valuation mistakes, all data used should be valid and as such within certain quality criteria. In addition, the valuation should not exceed a certain level of complexity in order to assure certain usability.

2.5.2 Discounted Cash Flow

DCF methods may serve to value high-tech start-ups under certain conditions. The overview of what has to be taken into account when carrying out the valuation of a young company with DCF is presented below (based on Achleitner and Nathusius, 2004).

DCF methods are by definition future-oriented. In this, they can only be applied to a start-up if one can forecast the future cash flows with a reasonable degree of precision. This task can be particularly difficult for the case of high-tech start-ups, which by definition operate in new markets.

It is particularly difficult to adequately estimate the intangible assets of a young company, which are in most cases the most important component of a start-up's assets. The problem becomes even more severe if the company owns assets which do not generate cash flows, but are nevertheless valuable.

Moreover, according to Achleitner and Nathusius (2004), calculation of beta and in the next step the required rate of return of the investors can be problematic. For the calculation of the beta parameter, the obvious problem is that most start-ups or young companies are not publicly listed. Furthermore, industry averages are normally not plausible, since a young company can hardly be compared to a mature one. Achleitner and Nathisius (2004) suggest using an accounting beta in such situations. This solution is unfortunately also not free of faults. Whereas, one can usually use historical data for mature companies, one needs to rely on mainly subjective judgments for young ones.

An additional important critique of DCF methods for the case of high-tech start-ups has been provided by Steffens and Douglas (2007), who claim that the main problem associated with the DCF discounted with the WACC is that most of the risk in young companies is firm-specific, rather than systematic. The WACC method deals only with the market component of risk. For this technique, the accepted way to adjust discount rates for risk is to find an analogous traded entity (or portfolio of traded entities) – immediately implying a market-related risk. Moreover, if the CAPM, is used to determine the appropriate discount rate, no penalty is applied for specific risks, because in this approach the risk can be fully diversified. Authors argue that the high levels of risk associated with technology ventures are largely due to firm-specific risk, and that these should attract a risk penalty. However, if the firm specific risk can be considered low, the CAPM and the WACC can be used in practice. This is usually the case for companies which already exist for a given time, but for instance develop a new entrepreneurial project.

Although, the Cash Flow based methods are widely criticized, not only for the case of young companies, their main advantage is that they are still fully accepted and used in practice. Within the different concepts of cash flow based valuation methods the widest used is the FCFF.

Summarizing, if all challenges can be mastered, the DCF methods can be an appropriate way of valuating start-up companies. Despite some drawbacks, the fact that the methodology is easily explainable to everyone and widely accepted is in favor of this approach.

2.5.3 Venture Capital Method

The venture capital method (also known as the First Chicago method) is, as the name suggests, used for valuation of start-ups. It can be seen as a combination of scenario analysis applied to DCF and valuation by multiples.

This method is often used by investors to value growth companies, since these often cannot be credibly valued solely on the base of multiples, as they lack historic data. On the other hand, it eases the above mentioned problems with DCF applied to high-tech start-ups.

This valuation method pays special attention to the practical fact crucial for the venture capital industry: the exit. Typically, venture capital funds aim to be able to exit the position within 5 years. The method assumes that after this pre-specified timeframe the company behaves like a mature one and can also be valued with traditional valuation methods.

In particular, the method specifies several alternative exit scenarios for the venture. Typically, three scenarios are used: the ‘best guess’ (most likely, median case); the ‘best case’ (optimistic) and the ‘worst case’ (pessimistic). For each of the three exit scenarios, management must estimate the (subjective) probability that the scenario will occur, and the cash flows for each scenario are estimated exactly as in the FCFF method. The final valuation is then the weighted probability of each scenario (Steffens and Douglas, 2007) and discounted with a pre-determined required rate of return. Comparing the discounted value with the investment needed leads to the stake sold for the amount needed.

The advantage of this approach is that some of the risks associated with the venture are explicitly identified and different types of risk are separated and explicitly assessed. An important consequence of dealing with many sources of risk explicitly is a reduction in the sensitivity of the valuation to the discount rate which makes the approach more realistic for young companies. On the other hand, as noticed by Steffens and Douglas (2007) it does not allow for future managerial flexibility. The Venture Capital method is most appropriate when an investment decision of a start-up is dominated by an initial investment, with no or little subsequent investment discretion, since this approach, similarly to standard DCF does not allow for any flexibility. This is not the type of investment regime usually facing technology investments, which typically commence with relatively small outlays, followed by increasingly large successive investment decisions. Thus, the approach is suitable for some incremental innovations, involving a single initial technology investment (such as a web site development for a new market opportunity) that subsequently faces primarily market risks.

2.5.4 Patent Valuation Methods

Since most young companies are not based on significant amounts of tangible assets, evaluating their intangible assets is a crucial point within the overall valuation process.

In valuing a patent, the fundamental issue is by how much the returns from all possible modes of exploitation of the patented invention are greater than those that would be obtained in the absence of the patent. Moreover, in the early life of the patent, many uncertainties are involved. There are uncertainties regarding the technological or commercial success in markets as well as legal aspects that may arise during the life of the patent.

When valuing patents it can clearly be seen that the system of valuation is the same as for companies. As patents are associated with a clear goal, which is to protect intellectual property, the requirements for valuation methods need to answer this goal, and the chosen valuation method must fulfill it in the best possible way.

With regard to order of sophistication, patent valuation methods may be ordered and briefly described as follows (Pitkehly, 1997):

1.) Cost based methods: Knowledge of at least the future costs of creating intellectual property rights (IPR) is needed as part of almost all valuation methods. The most serious shortcoming of cost based methods is that they make no allowance for the future benefits which might accrue from the patent. They are of no help other than in historical cost based accounting systems.
2.) Market based methods: The aim of market based methods is to value assets by studying the prices of comparable assets which have been traded in an active market. The main problem associated with these methods is that unless the cost considered reflects a very similar IPR in a recent transaction, the prices are not comparable. A patent, by definition specifies a product which is by its nature unique; comparison of prices even within the same market is difficult.
3.) DCF based methods: Discounted Cash Flow methods, as already introduced, are widely used in diverse applications. The advantages and limitations of DCF methods in general have already been described. In particular, for the case of patents, one advantage is that since patents have limited lifetimes one is not faced with the problem of estimating scrap values for the cash flows beyond the forecasting horizon. The limitations of DCF include the problem with estimating correct discount rates. Firstly the discount rate used should always be the one which reflects the risk of the cash flow concerned. For example if the project is not an average project for the company this will not be the same as the company's cost of capital. Secondly, with a multi-stage cash flow such as with a patent or patent application the risk associated with the cash flow will vary considerably over the lifetime of the investment in a patent.
4.) DTA (Decision Tree Analysis) based methods: These methods to some extent account for the possibility for flexibility of the management in decision-making at different stages of the life of the patent. In practice, one prepares a decision tree and applies DCF to every

branch of it. Therefore, the big advantage of the DTA method over simple DCF analysis is that it builds on the value of flexibility encountered in a project or patent. This allows at least some account to be taken of the ability to abandon the patent though it does not solve the discount rate problem. The rates used ought to be appropriate to the risk involved at each stage and following each type of decision, whilst in practice a constant rate is usually used (Pitkehly, 1997).

5.) Real options based methods: Since real options method constitutes the core of this work, the aspects of real options valuation of patents are discussed in the following chapter.

3 Real Options Approach

In the previous chapters various methods of corporate valuation have been presented. As the aim of this work is to highlight a specific one, this part is dedicated solely to the Real Options approach. This part of the thesis starts by introducing the idea of a real option and give an overview of the current literature. Subsequently, different kinds of real options are shown and it is described how to value them.

3.1 Introduction

Based on Black and Scholes (1973) and Merton (1973), Myers (1987) came up with the idea of a "real option", as the right but not the obligation to purchase a real asset. The underlying idea is that the model allows substantial upside potential while the potential loss is limited. Obviously, this idea was a breakthrough in bridging the gap between finance and strategy.

An option is a contract which gives the owner the right, but not the obligation to buy or sell a specific asset or financial instrument at a specific price in the future. That is, the long holder pays the premium to the seller (the short holder) to exercise this right. An option which conveys the right to buy is called a call, whereas if it allows the long holder to sell the asset it is a called a put. Additionally one needs to distinguish between different styles of options, as far as the time at which the right can be exercised is concerned. The two most common styles of options are European and American options. The former may be exercised only at the pre-specified expiration date of the contract, whereas the latter can be exercised at any time before the expiration date. However, there exist many other styles of options. The two described are not only the most commonly used, but also the most often encountered in real options analysis.

Markets nowadays require important strategic investment decisions to be made in uncertain environments, in which market growth, competitor moves or costs of development may be unknown or difficult to assess. As already mentioned, the classical methods of valuation require tools relying on forecasts of future cash flows, which often do not reflect the immanent uncertainty. The second already mentioned problem is that the decisions about undertaking a particular project are taken once and for all - DCF does not allow for recapitulation at a later stage.

The real options approach allows us to explicitly include uncertainty in the decision-making process. Unlike the traditional view, in which increasing uncertainty reduces the value of the project, the real options approach considers uncertainty as increasing managerial flexibility, and thus creating value.

Moreover, as already mentioned the traditional discounted cash flow approach assumes a single decision pathway with fixed outcomes, and that all decisions are made in the beginning, thus not allowing for any managerial flexibility. The real options approach considers multiple decision pathways as a consequence of uncertainty in choosing optimal strategies or options along the way when new information becomes available (Mun, 2006). This flexibility can be summarized by considering several examples of real options:

- Option to abandon,
- Option to wait and see,
- Option to expand,
- Option to switch resources,
- Option for sequential investments.

Each of these examples reflects a decision that a manager may take during the course of the project, and which can alter its value. The value of each of these options can subsequently be calculated in a way that is similar to that which is used to value financial options.

3.2 Literature about Real Options

In recent years, R&D and intellectual property have been a major focus in the real options literature (Childs and Triantis (1999), Huchzermeier and Loch (2011) and others). Even more recently, several authors have adopted the real options approach in an attempt to analyze and evaluate intellectual capital of firms (see Kossovsky (2002), Bose and Oh (2003)). Kossovsky (2002) valued nearly 8000 intellectual property assets using the real-options model. He showed how R&D real options could be studied with respect to financial reporting and how they could be incorporated in intellectual capital analysis. In his analysis, however, all options were European options, all model parameters were constant over the life of the option and the analysis did not incorporate the effect of market competition into the real-options valuation of the intellectual property assets.

Myers (1987) was the first to point out that adopting DCF is no help at all for pure research and development. The value of R&D is almost entirely option value. Numerous academics and practicing managers now recognize that traditional financial analysis tools for capital budgeting are inadequate, such as the NPV rule and the DCF approaches (see Ming-Cheng and Tseng (2006) for a more detailed discussion).

The real-options approach gains attention for evaluation of R&D projects and intangible assets both for business academics and practitioners. For example, Merck's Finance Group used the Black Scholes option pricing model to determine the R&D value of an investment project which required an up-front investment of $2 million for researching a bio-technological drug. The Chief Financial Officer (CFO) of Merck, Judy Lewent, once said, 'Option analysis, like the kind used to value stock options, provides a more flexible approach to valuing our research investments than traditional financial analysis' (Nichols, 1994).

A prominent case study showing the strength of ROV is provided by Leslie and Michaels (1997) who analyze investment decisions of British Petroleum. The authors analyze the discovery of Andrew oilfield in 1974, which was not developed until the mid 1990s when BP developed innovative drilling methods and sharing of costs and benefits with other companies in the industry. In effect, BP bought an out-of-the-money option to develop the Andrew field, deferred exercising the option until the company had proactively driven down the exercise price, and then exercised an option that it had turned into an in-the-money one (Leslie and Michaels, 1997).

Another practical example of the option approach in R&D project valuation is given by Herath and Park (1999). The authors develop a valuation model based on a binomial option pricing model and apply it to Gillete's MACH3 project to illustrate how one can use the options approach rather than the traditional DCF model to value an R&D investment. They show the advantages of the option approach over the traditional NPV valuations for evaluating projects involving high degrees of uncertainty. Moreover, they demonstrate how valuations can be linked to a company's stock price.

More recently, advantages of the ROV have been analyzed in the context of IT investments case studies. Benaroch and Kaufmann (1999) analyze investment decision of Yankee 24 – a company operating automatic teller machines. Taudes *et al.* (2000) describe a real—life case study where option pricing models were used to decide whether to continue employing SAP R/2 or to switch to SAP R/3.

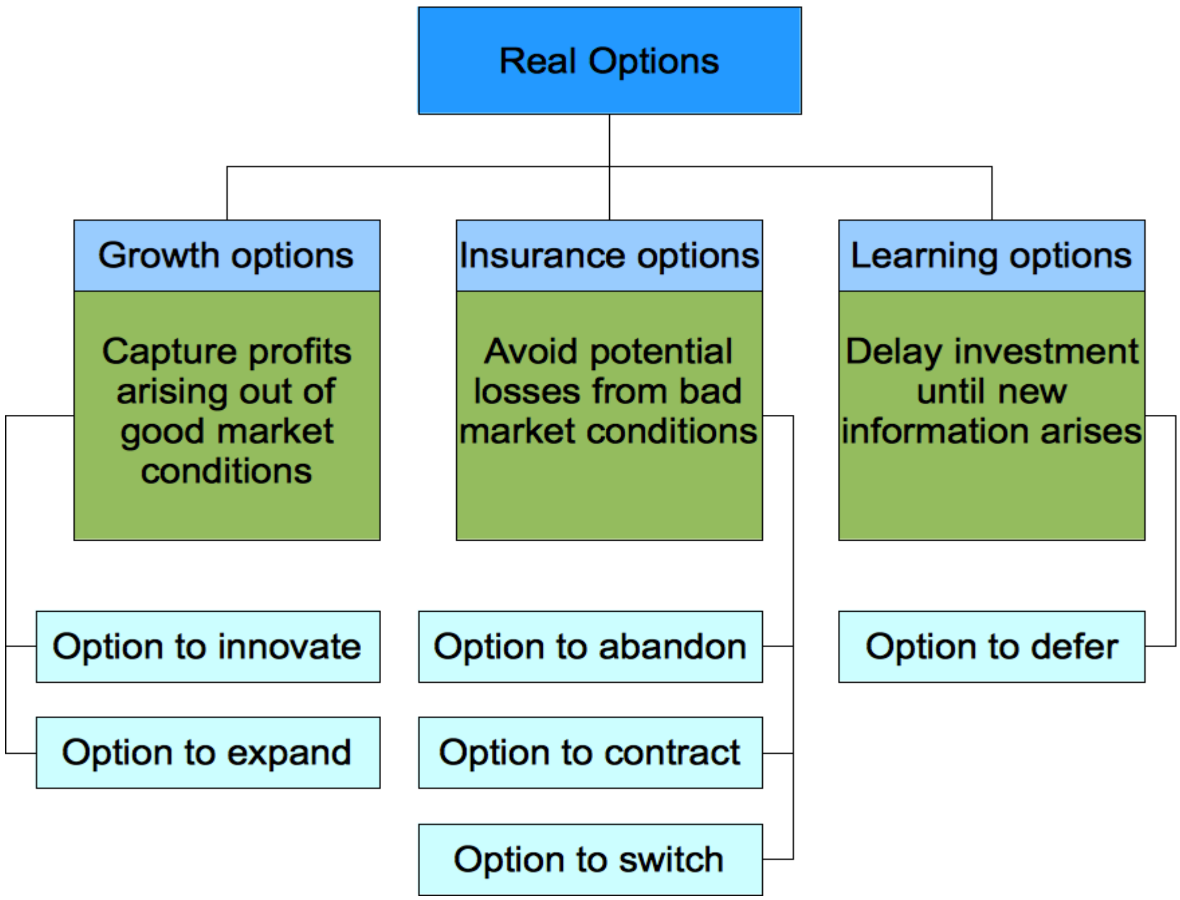
In the particular context of patents, recent studies demonstrate that patent value can be evaluated through a real option approach. Bloom and Van Reenen (2002) analyze 200 British firms since 1968 and show that patents have a significant impact on firm-level productivity and market value. Most importantly, they find that patenting affects the market value immediately whereas it appears to have a lagged effect on productivity, which leads to a conclusion that a patent creates a valuable real option, while providing exclusive rights to develop innovations, enabling firms to delay investments.

Laxman and Aggarwal (2003) value a real 3G-telecom patent of Sasken Communication Technologies. Sasken has come out with a 3G protocol, that allows 3G transmission/reception. However, this technology will be used in practice, only if it gets included in the comprehensive 3G standard by the world body 3GPP, which is a low chance because of the many contestants in the market. If it does get included in the standard, Sasken will get royalties for each 3G handset sold anywhere in the world for the next few years, until someone comes up with an improvement and the standard is upgraded to better technology. Applying the real option framework to value this patent application, the authors recommend the filing of the provisional patent since the expected value of Sasken`s provisional patent far outweighs the cost (Laxman and Aggarwal, 2003).

Ming-Cheng and Tseng (2006) develop a model of patent valuation with ROV and present a sensitivity analysis showing the relationships that exist between the patent value and the underlying asset, time to maturity, volatility and risk-free rate. Furthermore, panel data involving 101 Taiwanese listed firms in electronic industry for 1993–2002 was presented to examine the above relationships. The empirical results indicated that the patent value increases in the underlying asset, time to maturity and the risk-free rate (Ming-Chen and Tseng (2006), pp. 317).

3.3 Types of Options

Copeland and Keenan (1998) present a comprehensive overview of the types of real options and suggest classifying them into three categories from the managerial point of view. The classification is presented in Figure 2.



Source: Own work

Figure 2: Categories of real options according to Copeland and Keenan (1998)

According to this classification 'a growth option' allows a company to secure profits if the market conditions happen to be better than expected. This can be accomplished by reinvesting the capital, expanding the scale of production or entering new market sectors. Additional sources of the growth options comprise R&D and innovation, intellectual property and change in the market position.

'Insurance options' allow management to scale down or abandon certain investments in order to avoid potential losses (Stellmaszek, 2009). Therefore, it is mainly seen as risk-reducing option. The value of the option stems from the opportunity to postpone or abandon unprofitable investments.

Finally, 'learning options' allow the company to 'wait and see'. In other words, they allow the management to defer decisions regarding investments. The value of the options stems from the opportunity to wait for the resolution of uncertainties before committing resources to investment.

In order to fully present the concept of real options, several examples of market situations which correspond to above described types of real options are referred to below.

3.3.1 Option to defer

The deferral option, or option of waiting to invest, derives its value from reducing uncertainty by delaying an investment until more information has arrived (Brach, 2003). Delaying investment may be beneficial, if management predicts that some additional information that alters the value of the project will be available in the future. For example, a pharmaceutical company may delay the decision to build a new production facility for a new drug until a better understanding of the market uncertainties such as pricing, market penetration and entry. In such a case a deferrable investment opportunity can be viewed as a call option that has as underlying asset the present value of expected cash inflows from the completed and operating project. This kind of option is important among others in natural resource extraction industries, real estate development and agriculture.

3.3.2 Option to abandon

This type of model can be used whenever a company faces a problem of investment, for which the management may decide to abandon the development at a certain stage of the project in the future. This situation is fairly common whenever a firm is developing a new technology, for which at the start of the project it is not sure whether it will become profitable, or arise some obstacles, which make a further development impossible. Consider an example of a pharmaceutical company, which is developing a new drug. Due to the uncertain nature of the drug's development progress, market demand, success in testing, approval of drug administration authorities etc., management might decide to abandon the project at some point in the future. That is, at any time with the years of development, management can review the progress of the R&D effort and decide whether to terminate the program (Mun, 2006). If the program is terminated, the intellectual property rights can be sold to another company, at any time within the period of contract. In real options terms, the company should value this abandonment option. Options to abandon are more frequently encountered in capital-intensive industries, such as airlines and railroads, financial services and new product introductions in uncertain markets.

3.3.3 Option to expand or contract

This kind of option can be used whenever a firm decides to expand its operations. Once a project is undertaken, management may have the flexibility to alter it in various ways at different times during its life. The flexibility to expand or contract a project's scale can be quite valuable. When a firm buys vacant, undeveloped land, or when it builds a small plant in a new geographic location to position itself to develop a large market, it essentially acquires an expansion option (Smit and Trigeorgis, 2004). An option to expand the scale of production by *e%* is analogous to a call option on a fraction *e%* of a project. If demand is high, management can expand capacity. Analogously, 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. The option to contract can thus be seen as a put option on the part of the project that can be contracted, with an exercise price equal to the part of planned expenditures that can be canceled. These option are often in natural resources extraction industries such as mining, fashion industries, consumer goods and commercial real estate.

3.3.4 Compound options

In compound option analysis, the value of the option depends on the value of another option. These can be divided into two categories: simultaneous compound options and sequential compound options. The latter kind is often used in analyzing R&D investments in high-tech companies, at which technology development strategy to pursue. R&D programs involve multiple contingent stages and thus should not be treated as isolated projects. The value of potential profits from the commercial projects that may follow from the research stage must be properly incorporated in determining the value of the underlying research program. Hence, the analysis requires explicit consideration of the project's various stages, from research and product development to future commercialization (Smit and Trigeorgis, 2004). The scope of compound options covers also many other kinds of staged investments such as such as investment in new technologies, pharmaceutical drug development programs, investments into technology platforms and so on.

3.4 Real Option Valuation Methods

The real option valuation methods can be divided into two main strands:

1.) Analytical methods, which include closed-form solutions as well as approximate analytical solutions, which are derived in a manner similar to the standard Black-Scholes equation.
2.) Numerical methods, which either approximate the stochastic differential equation that describes the option or approximate the underlying diffusion process. This part concentrates on the binomial tree method and Monte Carlo simulation.

3.4.1 The Black Scholes Method

To fully present the real options approach, this section starts with explaining the fundamentals of the Black-Scholes-Merton model, which serves as a base for options valuation. A value of a call option can be calculated as

$$Call = S_t \Phi(d_1) - X e^{-rf(T)} \Phi(d_2), \tag{18}$$

where

$$d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(rf + \frac{1}{2}\sigma^2\right)(T)}{\sigma\sqrt{T}}, \tag{19}$$

and

$$d_2 = d_1 - \sigma\sqrt{T}, \tag{20}$$

where the variables respectively are (note in parentheses the real options counterparts of the financial options interpretation):

- Φ is the cumulative standard normal distribution function,
- S is the price of share or current value of the underlying asset (gross present value of discounted cash flows),

- X is the exercise price or the cost of executing the option (investment cost),
- rf is the nominal risk free rate,
- σ is the annualized volatility of the asset, and
- T is the time to expiration or the economic life of the option (time left until the opportunity to invest expires).

Similarly, one can define the value of the European put option as

$$Put = Xe^{-rf(T)}\Phi(-d_2) - S_t\Phi(-d_1), \tag{21}$$

The main assumption of the Black-Scholes-Merton model is that the asset price follows a Geometric Brownian Motion with static drift and volatility parameters and that this motion follows a Markov-Wiener stochastic process. That is, the price of the asset is given by

$$\frac{dS}{S} = \mu dt + \sigma dW, \tag{22}$$

where W is a Wiener process. This assumption will be relatively often violated in reality. However, this does not preclude using the option model for most purposes. Additionally one can use derivations of this benchmark case, which assume different underlying motions resulting in asymmetric (e.g. lognormal) probability distributions. The latter case may often come in hand, while deriving the value of options which by their nature are characterized by asymmetric distributions of risk.

The formula above specifies the following relationships between the right-hand-side variables and the value of the option (in this case for a European call option): the execution cost is negatively related to the value of the option, whereas time to expiration, risk-free rate and volatility affect positively the value of the option. Volatility is of a particular interest for the case of real options: uncertainty of the manager's choice, in real options approach should positively affect the value of a project.

3.4.2 The Binomial method

The binomial method is a method for approximating the underlying continuous stochastic process. Instead of a stochastic differential equation, the process is approximated with the use of lattices e.g. by using binomial (or sometimes trinomial) trees that start with the current underlying value of the asset as the start value. Therefore, instead of the continuous Wiener process, in each step the price of the asset can move up or down by a specific factor (*u* or *d*) in discrete steps, where by definition $u \geq 1$ and $0 < d \leq 1$. So if the current price of the asset equals *S*, it shall equal $S_{up}=S*u$ or $S_{down}=S*d$ respectively in the next period. The *u* and *d* factors are calculated using the underlying volatility of the asset σ and duration of the step *t*. Thus,

$$u = e^{\sigma\sqrt{t}}, \tag{23}$$

and

$$d = e^{-\sigma\sqrt{t}} = \frac{1}{u}., \tag{24}$$

A great advantage of this approach as opposed to analytical solutions is that it accommodates American style options, often encountered in real option analysis. The approach was introduced by Cox *et al*. (1979) for the pricing of financial options.

3.4.3 Monte Carlo Simulation

Monte Carlo simulation can be applied to find the value of an option. Instead of a closed-form solution as given by the Black-Scholes equation, simulation allows finding an approximate value, by simulating the underlying stochastic process. In the simulation approach, a series of forecast asset values are created using the Geometric Brownian Motion, and the maximization calculation is applied to the end of point of the series, and discounted back to time zero, at the risk-free rate. That is, starting with an initial seed value, the process simulates multiple pathways using the Wiener Process, where

$$\delta S_t = S_{t-1}\left(rf(\delta t) + \sigma\varepsilon\sqrt{\delta t}\right). \tag{25}$$

That is, the asset value in step *t* is equal to the value in *t-1* multiplied by the Brownian Motion component, where ε is the simulated value from the standard Normal distribution with mean 0 and variance 1.

This approach can be easily applied to European style options, however it is difficult to apply it to American style options, for which one needs to additionally optimize the exercise date. As a matter of fact, American-style options are very common in the real option valuation; therefore one needs to concentrate on this issue in more detail. There is basically one way to value American-style options, instead of determining the exercise boundary before simulation, this approach focuses on the conditional expectation function. Longstaff and Schwartz (2001) proposed the Least-Squares Monte Carlo (LSM) method, a relatively easy way to implement this approach. The basic idea of this approach is that at each exercise time point, option holders compare the payoff for immediate exercise with the expected payoff for continuation. If the payoff for immediate exercise is higher, then they exercise the options. Otherwise, they will leave the options alive. The expected payoff for continuation is conditional on the information available at that time point. The key insight underlying this approach is that this conditional expectation can be estimated from the cross-sectional information in the simulation by using least squares.

3.5 Limitations of the analogy to financial options

Whilst Black and Scholes pointed out that many kinds of assets could be valued using the option based methods and other authors identified wide applicability of the option approach financial assets, application of the model to the case of non-financial assets raises relevant questions. Emery, Perr *et al.* (1978) point out differences between traditional capital budgeting methods and option pricing methods in the way the latter treats the probability distribution of returns, the relationship to interest rates and time to exercise date of the option and concluded that using option pricing for real investment decisions risked illogical decisions (Emery, Parr *et al*., 1978). Triegoris (1996) and Kester (1993) mention several ways in which real options may differ from standard financial options. This distinction is particularly important for the case of valuation of intangible assets and in particular intellectual property.

Additionally, Pritsch (2000) [original in German] identifies further problems which arise when one applies the option theory to real assets. These are: market inefficiencies, inaccuracy, complexity and endogenous character of option parameters as well as the fact that real options do not satisfy some of the basic assumptions of the option theory.

The fact that the asset in real option theory is not actually traded gives rise to the problem of market inefficiency. There is no straightforward parallelism between the real asset and the financial asset, and therefore it is not easy to specify the actual market 'price' of the real asset. Moreover, the agency problem also falls into the category of market inefficiency. The assumption of the option pricing theory is that the option is exercised when it is optimal to do so. However, in reality management might not wish or be able to exercise the option at the optimal time because of information asymmetry or lack of quality of the manager in charge.

Real options are in most market situations by far more complicated then the corresponding financial options. Investment strategies involve complex, multiple decisions, determined sequentially during the life of the asset. This problem becomes even more severe for the case of compound options, for which the value of the compound option is different from the sum of values of the separate options (Trigeorgis, 1996).

The endogeneity problem is of particular importance for real options in R&D investments and high-tech. Normally, the uncertainty of investments should diminish over time. However, as noticed by Pindyck (1993) in certain projects, e.g. stage investments (i.e. sequential real options) the uncertainty is only resolved by investing. This means that the uncertainty is endogenous with respect to management decisions. Moreover, the uncertainty resolution is continuous for financial options, whereas it is discrete for real options. Finally, as noticed by Trigeorgis (1996), real options do not always satisfy certain other assumptions of the option pricing theory. For example, real options may not be exclusive i.e. more than one agent has the right to exercise it.

3.6 Real Options in Patent Valuation

The features of real options in general case have already been described above together with specification of the models as well as differences between financial and real options that need to be kept in mind. For the case of real options in patent valuation several aspects are still open. First of all, it is not clear what option model should be used for valuing patents. Pitkethly (1997) claims following Scherer (1997) that the returns to patents are highly skewed even in the case of just patents renewed to their full term as well as common experience which shows that distribution of returns from patented inventions must be highly skewed at the end of their life with a few highly valuable patents and a lot of worthless ones. Therefore it is not obvious if the standard Brownian motion is the correct diffusion process in this case.

Second, there is a major difference between valuing a situation after the invention has been made and it is not clear what the market value of it will be and a situation in which the invention is yet to be – it is not clear whether anything will be invented at all. In such a case it is difficult to model the patent development in a standard way and one might need to refer to e.g. jump process instead of the standard diffusion.

The third aspect concerns the volatility of returns to the underlying asset (Pitkethly, 1997). In the case of a patent, it is likely that the standard deviation of the returns is not constant, but decreasing over time. Such a situation has been pictured by Koller *et al.* (2010) for the case of staged pharmaceutical R&D. As such a project survives longer, continuing with the project becomes less and less risky, and the spread of potential outcomes narrower and more certain. Moreover, the distribution of the returns might change from the likely lognormal at the beginning of the life of the project, towards one highly skewed at the upper values for the patents that survive.

Taking into account the theoretical discussion of traditional valuation methods and real options presented in previous chapters, it can be concluded that the real options approach constitutes a reasonable method of valuing young companies. In order to discuss the practical relevance and applicability of the real options method, the remainder part of this work is dedicated to showing an example of employment of both approaches to a case of a start-up company.

4 Case Study: Introduction

4.1 Description of the company

Phoenics creative studio OG was founded in 2008 by David, Thomas and Gregor Lechner. Phoenics' main operations comprise 3D-Animation, web development, sound design/studio recording, photography and video production.

It is worth mentioning, that the three brothers can be considered artists. David Lechner graduated in media composition and audio engineering at the University of Music and Performing Arts in Vienna. Thomas Lechner graduated in media information systems at the Technical University of Vienna and jazz guitar at the Conservatoire Vienna. Gregor Lechner has a higher technical degree in graphics and design. Together they also form a music band “Phoenics”.

In 2009 the company developed an innovative 360° video display: Phoenics RD7. Until that point it was not possible to present 360° videos, therefore the product can be considered groundbreaking and has been awarded an international patent. Phoenics RD7 displays are multifunctional multimedia columns to inform, entertain and advertise. It is expected that, with the use of this product, every audio-visual presentation will absorb significantly more viewers than any flat screen. Additionally, according to the product brochure “RD7’s timeless design combines monolithic simplicity with sophisticated multimedia items”.

For all tasks not related to the core business of Phoenics, the brothers use their broad networks to receive every necessary service of the best quality. Their network therefore includes a finance specialist, a tax advisor and several “well-networked” people in the advertising industry.

As a matter of fact, the company offers two different yet complementary products. On the one hand, the design studio offers advertisement contents to agencies as well as directly to customers. One the other hand, Phoenics RD7 multimedia display allows presentation of the advertisement content in a breathtaking way.

4.2 Key Financial Data

As Phoenics’ legal entity is an “OG” *(Offene Gesselschaft,* which is equivalent to common law’s *general partnership)* and its sales have remained below € 400.000 in the last years (§ 4 Abs.3

EstG[2]) it is not obliged to use a double book entry accounting system. In fact, the company is only obliged to declare their revenues and expenses for tax purposes. Moreover, it is not allowed to capitalize tangible assets and depreciate them.

As this method of book keeping is not widely used and does not have a counterpart in international accounting standards, slight changes to the balance sheets of the company have been introduced. The purpose of these alterations is to allow easy international comparison, especially for a reader who is not familiar with the particularities of the Austrian accounting law. All of the changes are explained in further detail in the following section.

4.2.1 Balance Sheet

It is common to assume that assets of a start-up consist mainly of intangible components. As Phoenics OG has received a government subsidy to develop the product, the value of this subsidy should appear as a major item in the fixed assets part of the balance sheet. However, as the company's revenues and expenses statement does not provide information about the exact size of investment in the intangible assets following from this subsidy, this figure does not appear in the balance sheet presented. Moreover, although according to IAS 38 expenses in R&D have to be capitalized and depreciated, it is not allowed to capitalize these expenses within the Austrian §4 Abs. 3 EStG framework.

The result of the described analysis is presented in Table 1, which exhibits total assets in Euro for the period 1.1.2010 until 1.10.2012.

[2] The paragraph of the Austrian tax code that regulates this specific accounting system.

Table 1: Balance Sheet Phoenics OG: Assets: 2010 - October 2012

Assets	2010	2011	2012 (- Oct.)
Fixed Assets	**22.877,25**	**58.442,80**	**68.908,24**
Equipment	22.877,25	58.442,80	68.908,24
Current Assets	**32.050,00**	**72.367,00**	**102.807,00**
Cash and equivalents	7.535,00	18.180,00	36.774,00
Receivables	2.064,00	6.952,00	6.188,00
Accruals	22.451,00	47.235,00	59.845,00
Total Assets	**54.927,25**	**130.809,80**	**171.715,24**

This balance sheet was summarized and translated by the author. The idea of summarizing it is to present the major features of the financial situation of Phoenics without going into details of the Austrian tax law.

Summarizing, the assets side of the balance sheet shows that the company was growing constantly year by year without significant deviations from this trend.

As the legal entity in question is a general partnership, it is strongly related to the individual financial situation of the shareholders. Therefore, there exists an account which is called “private” and shows the accumulated financial relation of the shareholders to the company. If the amount in the private account is positive, it means that the shareholders owe this amount to the company. In our case, the amount on the private account it is negative for all years except for one, for which it is equal to zero, which means that this amount has to be paid out to the shareholders.

Table 2: Balance Sheets Phoenics OG: Liabilities & Owners Equity: 2010 - October 2012

Liabilities & Owners Equity	2010	2011	2012 (- Oct.)
Equity	**15.455,69**	**40.768,85**	**55.678,93**
Retained earnings	15.455,69	85.547,85	114.806,93
Privat	0,00	-44.779,00	-59.128,00
Liabilities	**39.471,56**	**90.040,95**	**116.036,31**
Current liabilities	*36.578,56*	*87.147,95*	*93.143,31*
Payables	9.022,00	11.391,00	2.369,00
State and other public entities	27.556,56	75.756,95	90.774,31
Long-term liabilities	*2.893,00*	*2.893,00*	*22.893,00*
Total liabilities and owners Equity	**54.927,25**	**130.809,80**	**171.715,24**

4.2.2 Income Statement

Analysis of the income statement reveals the typical development of a young company on the one hand, yet some more mature figures on the other. The statement is analyzed in more detail below.

Sales equal €35.310 in 2010 and rose to €77.738 in 2011. In the year 2012 a result similar to that of 2010 can be expected - until the end of the end of the 3rd quarter sales have equaled €48.194. Please note that the shown figures do not distinguish between sales stemming from the content business and the rent of RD7.

Table 3: Income Statement Phoenics OG: 2010 - October 2012

	2010	2011	2012 (- Oct.)
Domestic Sales	35.310,00	77.738,00	48.194,00
International Sales (Fee's)	0,00	0,00	4.696,00
Subsidies	100.000,00	126.096,00	40.000,00
Other	0,00	0,00	20.000,00
Net sales	**135.310,00**	**203.834,00**	**112.890,00**
OPEX	-107.068,00	-105.391,00	-64.098,00
Depreciation	-7.625,75	-4.575,45	-11.688,56
EBIT	20.616,25	93.867,55	37.103,44
Interest expenses	-200,00	0,00	0,00
Interest and other income	170,00	158,00	42,00
EBT	20.586,25	94.025,55	37.145,44
Taxes	-5.146,56	-23.506,39	-9.286,36
Net profit	**15.439,69**	**70.519,16**	**27.859,08**

At the same time, each year Phoenics has managed to receive government subsidies for the development of RD7. The company plans to apply for additional subsidies for a further development, however according to official information, after 2012 no subsidies can be guaranteed.

In order to avoid confusion of the reader not familiar with the nuances of the Austrian accounting regime, the method of reporting subsidies shall be addressed in more detail. In certain regimes (e.g. in Portugal for the subsidy instrument QREN when granted for fixed assets investment purposes) subsidies are reported as liabilities which, under certain conditions, will be waived in the future. This is not the case, however for the governmental subsidies in the Austrian tax regime. Therefore, these are reported as presented in Table 3.

Operational expenses reveal a clear picture of the cost structure. They are equally distributed within the whole analyzed time frame, which suggests that these costs are not easy to alter and could therefore be considered fixed costs. They consist mainly of overheads such as salaries and the rent of the office as well as diverse media. For the analysis of future development of the company it is important to note that these costs will most probably remain constant if the business model remains the same. In other words, as long as Phoenics OG rents (not sells) RD7, the above mentioned overheads will remain the same. If the company decides to produce RD7 serially, additional variable costs will appear. The assumptions about the costs of particular development scenarios will be explained in more detail in Section 5.1.1.2.

4.3 Market size and market potential

The market for advertisement in Austria has been constantly growing since 2000 (see Figure 3). Especially, the out-of-home segment is getting more and more attention throughout the last 12 years. This segment attracts the viewer's attention during his daily routine, thus the time not spent at home.

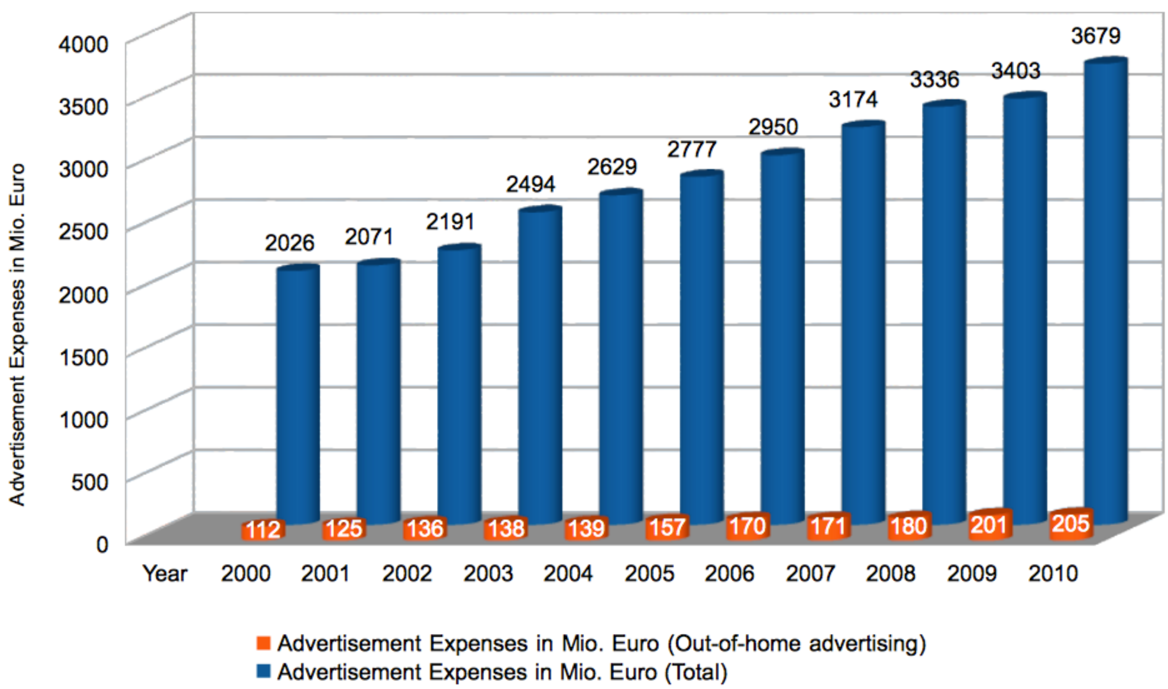


Figure 3: Advertisement expenses in Austria 2000-2010

Source: own work based on data provided by Gewista

Phoenics RD7 is a highly competitive advertisement medium in the Ambient Media Segment – a part of the Out-of-Home segment.

Table 4: Gewista - Advertising revenues in Austria

	2009		2010		2011	
	in '000 €	%	in '000 €	%	in '000 €	%
total	**2.658.080**	**1417,7%**	**2.869.983**	**1481,3%**	**3.021.072**	**1505,6%**
cinema	**11.500**	**6,1%**	**14.299**	**7,4%**	**13.848**	**6,9%**
out-of-home	**201.693**	**107,6%**	**204.691**	**105,7%**	**211.217**	**105,3%**
out-of-home d	187.493	100,0%	193.742	100,0%	200.656	100,0%
ambient media	14.200	7,6%	10.949	5,7%	10.561	5,3%
radio total	**172.039**	**91,8%**	**181.223**	**93,5%**	**181.052**	**90,2%**
ORF	107.725	**57,5%**	113.065	**58,4%**		**0,0%**
others	64.314	**34,3%**	68.158	**35,2%**		**0,0%**
TV total	**628.024**	**335,0%**	**671.624**	**346,7%**	**728.103**	**362,9%**
ORF	295.281	**157,5%**	273.562	**141,2%**		**0,0%**
others	332.743	**177,5%**	398.062	**205,5%**		**0,0%**
Online	**115.836**	**61,8%**	**134.165**	**69,2%**	**118.648**	**59,1%**
press	**1.528.988**	**815,5%**	**1.663.981**	**858,9%**	**1.768.204**	**881,2%**

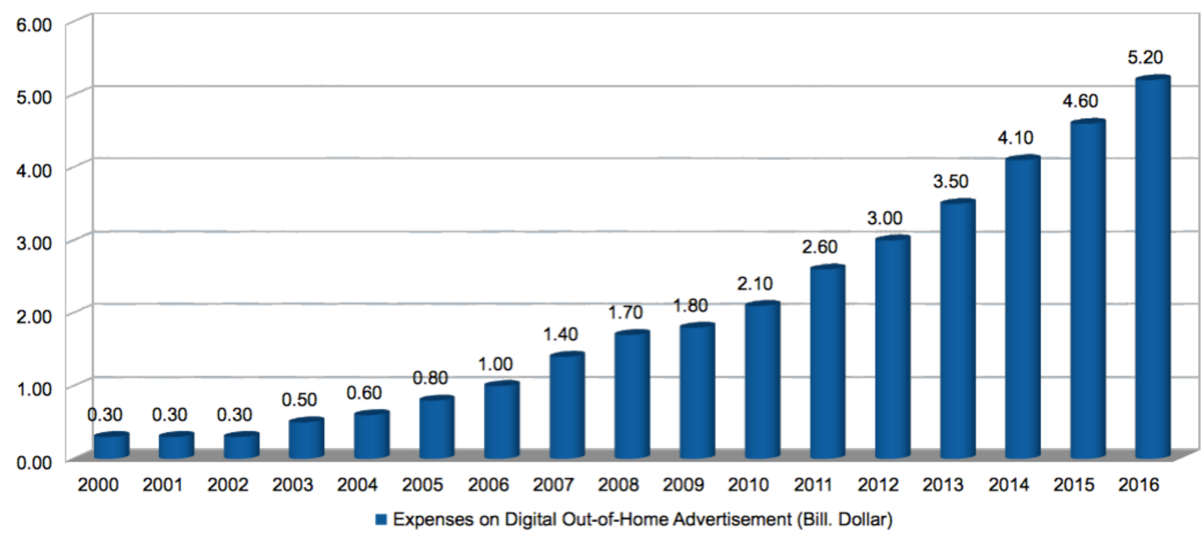


Figure 4: Worldwide expenses on digital out-of-home advertisement - forecast

Source: own work based on data provided by Magnaglobal

This advertisement segment allows placing advertisements in the direct environment of the potential viewer. Therefore, it is possible to reach customers in places where they otherwise would not expect advertising. The main advantages of ambient media hereby are, that they can directly interact with the consumers and that they create attention of masses if placed in central locations.

Although the ambient media segment is growing in general, there was a downturn in the last two years in Austria, mostly due to the crisis in Europe. According to Gewista[3], the biggest

3 3 http://www.gewista.at/DE/Home.aspx

Austrian advertisement market research institute and market leader in outdoor advertisement, the ambient media segment will grow again in 2012 and 2013, in particular the creative segment.

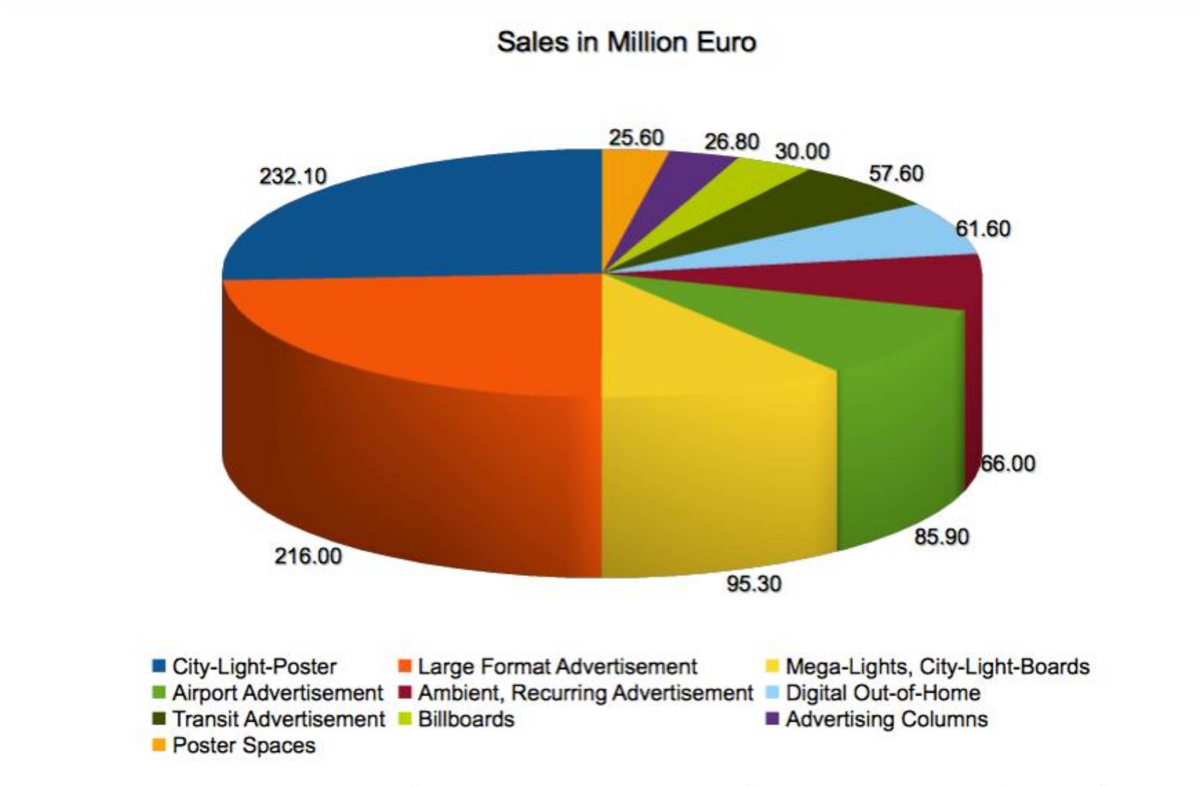


Figure 5: Sales in the advertising market in Austria

Source: own work based on data provided by Gewista

4.4 SWOT Analysis

The SWOT Analysis is a widely used strategic tool to develop corporate strategies. The analysis below is mainly based on a SWOT analysis carried out in 2009 by an Austrian consulting company for Phoenics (original in German).

There are two important issues in which the SWOT-analysis can be helpful. Firstly, it will serve as the basis for computing the basic financial prognosis. As the following SWOT analysis has been performed in 2009, it has been renewed as some important factors have changed during the period 2009 to 2012. Secondly, it helps to develop strategic choices / options for Phoenics.

In the following paragraphs, the major strengths and weaknesses of the product are discussed as well as what opportunities and threats are arising because of them.

The product has three major sources of strength. The first one is its design. Because of its impressive design it has a very high chance of contact with the target group and it is highly recognizable as a medium. The second and the most important one, is the innovative technical solution. It offers the user a fast and simple application and highly focused advertisement. Additionally, the 360° presentation increases the advertence of the target group immensely. Thirdly, it is a highly flexible product. It can be placed everywhere, and at the same time because of its compact size is very mobile.

Phoenics' weaknesses are similar to the most small and medium sized companies' and startups' weaknesses. First of all, the product is not widely recognized, which results in very few channels of sale. Competitors simply have much more power in promoting their product. Additionally, there is not enough financial capacity for a fast internationalization process. Besides these weaknesses on the business side, there are also two technical weaknesses. Firstly, at the moment it is not possible to use Phoenics RD7 outdoors, which is an obvious limitation of its usage. Secondly, due to its current stage of development it is also not possible to sell the technology; it can only be rented.

Having found the most important strengths and weaknesses, various opportunities and threats can be identified.

The first big opportunity is to rent Phoenics RD7, together with the other services offered by the firm, namely the advertisement content. Such a package, would give the potential customer cost effectiveness and guarantee a high level of service. The second one is to develop RD7 up to the point where it is possible to sell it afterwards. This would open a huge market and would make the market entry in other countries much easier. Market entry without a sellable solution is possible, however, much more difficult. This specific opportunity is of particular importance for the real options analysis, which is performed later on.

As in every startup major threats are various. The most important threat is that the customers prefer traditional media during the crisis. This is also visible in the market analysis which is presented above, as the market share of ambient media in the overall advertising market went down from 7,6% in 2009 to 5,3% in 2011. Using creative solutions requires courage on the side of the customers, during the crisis the firms tend to act risk-averse. Additionally, it is possible that the market in Austria is too small to accommodate such a product. Finally, although the product is protected by a patent, one should consider the possibility that one of the competitors creates a similar product. These competitors[4] operate on a much bigger scale and would, therefore have all the resources necessary for a quick expansion.

Since the SWOT analysis serves as a link between finance and strategy, the mentioned opportunities (real options) will serve as a basis for the real options valuation, in the next chapter.

[4] Examples: Gewista (AUT), Stroehr (DE), JC Decaux (FR)

5 Case Study: Valuation

Valuation will be done in some steps. First of all a base case in which the overall company is valuated with the FCFF method is created and analyzed. After the value of the options has been identified it will be determined and added to the base scenario.

The FCFF method has been chosen, although for some cases which are similar to the case of Phoenics, the APV is recommended. This is because the final result is the same for both methods and a standard FCFF is much easier to be understood by the management of the company. Furthermore, from now on throughout this work, the acronym DCF will refer to specifically to the FCFF method:

5.1 Core Assumptions

5.1.1 Projections and Budgets

The projections of future budgets are a crucial for the overall valuation process. All prognoses and budgets presented here are based either on the forecast of sales or, on assumptions about costs based on the input provided by the management of the company. Furthermore, it is important to mention that all presented revenues and associated costs are valid for the whole company, not just for the RD7 product.

In order to forecast the revenues and the costs mentioned here, it is assumed that Phoenics OG maintains the current structure and operations in its core business for the forecasting period. This means that the management team will not change significantly, the main customers will order approximately the same services as up to now and the economic circumstances will not change significantly in the forecasting period (e.g. interest rate /tax rate remains constant).

5.1.1.1 Revenues

The forecast of the data on sales has been prepared with the use of econometric methods. It uses the data on sales obtained from the balance sheets of Phoenics as well as data on the size of the global market for ambient media until the end of 2016. The data on sales are collected on a monthly basis, so in total comprises 31 observations between January 2010 and August 2012. On the other hand, the data on the size of the global market are available until 2015, however only on a yearly basis. In the first step of the analysis, the global data has been interpolated, assuming constant monthly growth rates within each year.

Having created a monthly dataset, several methods of forecasting have been tested. Two methods which do not require formal modeling have been used: simple exponential smoothing as well as Holt-Winters (HW) method for non-seasonal data. The results of these analyses however have not been satisfying. Single exponential smoothing, by construction, predicts constant out-of-sample sales, does not accord to the observed global trend in the ambient media market. The non-seasonal HW prediction predicts a growth of sales, however only on a slow pace (slower than the global market) as well as is does not account for the observed in-sample variation. That is why a formal econometric model to analyze the change in sales is used.

Several ARIMA models without seasonality have been specified. Inspection of the data revealed that there is no straightforward pattern of sales within each year, which would require using a seasonal model. As an additional independent variable, the size of the global market has been added to the model. Out of the several specifications that have been tested for, the ARIMA(6,0,0) model was characterized by the highest values of the Akaike and Schwartz information criteria. An ARIMA(12,0,0) has offered slightly higher fit in terms of the adjusted R^2, but the loss of degrees of freedom in this case is substantial, particularly since the time series is short.

With the use of the ARIMA model and the out-of-sample observations about the global market size, it was possible to perform an out-of-sample forecast of the future sales of Phoenics. This forecast is the basic scenario of development of sales, and predicts a growth rate of sales of 13% per month for the next three years. In order to take into account the standard error of the forecast, which in case of such a long out-of-sample forecast cannot be neglected, an empirical interval forecast by estimating the quantiles of the residuals of the forecast equation has been prepared. Using quantile regression on the predicted residuals the 25th and 75th quantiles of the predicted residual have been estimated. By adding (subtracting) the values of the predicted residuals from the point forecasts, it is possible to obtain the empirical forecast interval. The lower and upper bound of the interval represent the respective “pessimistic” and “optimistic” prediction of sales. In the pessimistic variant of the forecast, sales grow by 8% monthly, whereas in the optimistic variant the monthly growth is 18% on average.

5.1.1.2 Costs

As mentioned above, the operating expenses (OPEX) consist mainly of wages, office rent and other overheads. Because of the nature of the company's business, operational expenses relative to sales are approximately constant. Up from a predetermined value of sales of 1 million Euro, the relative OPEX would jump to a higher level because of a major increase in the administrative costs. This is because of the fact that Phoenics is currently not working at full capacity. If sales rose above 1 million EUR, Phoenics OG would have to rent a bigger office and hire additional staff. However, this is not the case in the forecast shown below.

5.1.2 Income statement forecast

As has already been explained above, the forecasted revenues in the income statement have been created using econometric forecasting techniques. OPEX and depreciation have been, however fixed. As already mentioned, depreciation is set at 20% of previous year fixed assets. The operational expenses have been fixed at 62.54% of the net sales, which corresponds to the

Table 5: Income Statement Phoenics OG: Forecast 2012 - 2016

	2012	2013	2014	2015	2016
Domestic Sales	98.695,75	183.247,10	253.084,52	269.844,73	360.011,40
Subsidies	60.000,00	0,00	0,00	0,00	0,00
Net sales	**158.695,75**	**183.247,10**	**253.084,52**	**269.844,73**	**360.011,40**
OPEX	-99.243,78	-114.597,49	-158.271,82	-168.753,18	-225.140,84
Depreciation	-11.688,56	-12.272,99	-11.545,50	-11.161,90	-10.337,43
EBIT	47.763,40	56.376,61	83.267,19	89.929,65	124.533,14
Interest & other income	42,00	1.193,85	2.310,44	3.930,82	5.633,74
EBT	47.805,40	57.570,46	85.577,63	93.860,47	130.166,88
Taxes	-11.951,35	-14.392,61	-21.394,41	-23.465,12	-32.541,72
Net profit	**35.854,05**	**43.177,84**	**64.183,23**	**70.395,35**	**97.625,16**

average operational expenses over years 2010-2012.

In addition to that, the current interest rate on deposits in Austria equals 1%[5] and corporate tax rate equals 25%[6], which are the values used in further calculations.

[5] www.ecb.int; Please note that the interest rate was set at 1% by the time this work has been prepared; currently (beginning of 2013) it is set at 0.75%

[6] §22(1)KStG (Austrian corporate tax code)

5.1.3 Balance Sheet Forecast

All forecasts within the balance sheet are made automatically, and in this sense the rates of changes are constant. In other words, the key figures such as the capital structure or the ratio of fixed to total assets are not influenced manually, but the changes follow the assumptions about the market development.

As in probably all start-ups there are no clear budgeting rules or investment plans. In accordance with the company's management, therefore some simple assumptions have been made.

One of the most important assumptions is clearly the investment rate as a percentage of the last year's net profit. The assumptions about the investment rate have been developed together with the company's management and are based on prior experience. it will be assumed that the investment rate equals 25% in 2012 and 20%, 15%, 10%,10% in the following years. The assumed development of investment rates arises from the fact that the company's main assets are already accumulated and there is no need for major investments within the foreseeable future. Depreciation of equipment was fixed at 20% (thus, corresponding to a usage duration of approximately 5 years) based on the last year's assets.

Furthermore, management has decided on a dividend payment of 10% (2012) and 15%, 15%, 20%, 20% in the upcoming years, in case the company shows profits. As these payments are made after the revision of the accounting data (which usually takes place in spring), dividend payments are always based on last-year results. The amount of profits remaining after the dividend payments is than added to the retained earnings.

In any case, the taxes are added to the "liabilities (state and other public entities)" and not paid (not deducted from cash). The effect of this alteration is that the balance sum is larger than usually, however this change does not have an effect on the debt to equity ratio.

As a result it is possible to obtain the following balance sheets:

Table 6: Balance Sheets Phoenics OG: Assets: Forecast 2012 – 2016

Assets	2012	2013	2014	2015	2016
Fixed Assets	**61.364,94**	**57.727,52**	**55.809,50**	**51.687,14**	**51.112,22**
Equipment	61.364,94	57.727,52	55.809,50	51.687,14	51.112,22
Current Assets	**113.879,26**	**169.709,03**	**250.728,01**	**335.874,20**	**452.536,93**
Cash and equivalents	59.692,26	115.522,03	196.541,01	281.687,20	398.349,93
Receivables	6.952,00	6.952,00	6.952,00	6.952,00	6.952,00
Accruals	47.235,00	47.235,00	47.235,00	47.235,00	47.235,00
Total Assets	**175.244,20**	**227.436,56**	**306.537,51**	**387.561,34**	**503.649,15**

Table 7: Balance Sheets Phoenics OG: Liabilities and Equity: Forecast 2012 - 2016

Liabilities & Equity	2012	2013	2014	2015	2016
Equity	**62.273,90**	**100.073,64**	**157.780,19**	**215.338,90**	**298.884,99**
retained earnings	121.401,90	159.201,64	216.908,19	274.466,90	358.012,99
privat	-59.128,00	-59.128,00	-59.128,00	-59.128,00	-59.128,00
Liabilities	**112.970,30**	**127.362,92**	**148.757,32**	**172.222,44**	**204.764,16**
Current liabilities	90.077,30	104.469,92	125.864,32	149.329,44	181.871,16
Payables	2.369,00	2.369,00	2.369,00	2.369,00	2.369,00
State and other public entities	87.708,30	102.100,92	123.495,32	146.960,44	179.502,16
Long-term liabilities	22.893,00	22.893,00	22.893,00	22.893,00	22.893,00

5.2 DCF – Valuation

As all the forecasts are established, the DCF valuation is presented. Here the most traditional version of the FCFF is calculated.

5.2.1 Calculation of the Weighted Average Cost of Capital

As explained before, using WACC as the discount rate is the most suitable one for our purposes. This section presents all the subsequent assumptions of the calculation and justification of them.

At first the WACC has been calculated as suggested by the standard theory. Since calculating the required rate of return in this way, does not lead to a plausible result, an alternative way of calculation is presented.

5.2.1.1 CAPM

5.2.1.1.1 Beta

As Phoenics is an unlisted company, the standard definition of the Beta coefficient cannot be used in our case. A possible strategy in such a case has been proposed by Stone and Hill (1980).

Instead of a standard market beta, it is possible to calculate the "risk-composed equity beta" using the following formula[7]:

$$\beta_i = \frac{d(ROE_i)}{d(ROE_m)}, \quad (26)$$

where d is the first moment change with respect to time, ROE_i indicates return on equity of the considered company, and ROE_m is the respective market ROE. Such an "accounting beta" is an accounting analogue to the market beta. Implicit in the analogy is the assumption that accounting returns are generated by a statistical process structurally similar to that generating stock market returns. Hill and Stone (1980) show that such a measure is strongly related to the market beta, significant at α=0.05 level. Despite existence of various critiques of the performance of this approach in the literature, at first this strategy is followed, mostly because there is no reasonable alternative.

The first question that arises is how to determine the relevant market. Two possibilities have been identified. First, using a database provided by Stern-University[8],[9], 48 publicly traded European companies in the advertising industry in 2010 have been selected and 60 with the same characteristics for 2011 and calculated their average Return on Equity. This approach is referred to as the "Industry Beta". An advantage of that method is that there is a substantial amount of data available. The biggest disadvantage is the limited potential for comparison, as most of the selected companies operate in different segments than Phoenics (though in the same industry).

In the second approach, a focus group consisting of two listed companies: Stroehr (GER) and JCD (FR), which work in the same segment as Phoenics has been selected. This method will afterwards be referred to as "Focus group". The advantage of comparing Phoenics to these two close competitors is that they are active in the out-of-home advertising segment. On the other hand, these companies are large multinational entities, with a completely different organizational structure, and therefore resources.

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[7] An equivalent formula which uses return on assets (ROA) instead of ROE can be found in Stone and Hill (1980)

[8] http://pages.stern.nyu.edu/~adamodar/New_Home_Page/data.html?pagewanted=all

[9] An alternative to the chosen dataset would be the Bloomberg data. However, since the dataset of Stern University is fully reliable and easily accessible it has been decided in favor of the Stern University data.

Table 8: RoE Calculation, Stroehr, JCD and Phoenics

RoE - Calculation				
	2008	2009	2010	2011
Stroehr				
RoE	33,96%	-2,39%	19,74%	-1,32%
JCD				
RoE	5,49%	1,22%	7,02%	8,61%
Phoenics				
ROE			99,90%	172,97%

As one can see in Table 8 Phoenics' book return on equity was equal to 99,90% in 2010 and 172,97% in 2011. Furthermore, it is known that the industry average was equal to -9,6% in 2010 and -23,25% in 2011. Return on equity for the focus group is computed by their average RoE which was equal to 13,38% in 2010 and 3,65% in 2011.

Knowing that, it is possible to compute the betas, which are then

ß = (172,97-99,90)/(-23,23-9,6) = -5,35 for the focus group and

ß = (172,97-99,90)/(3,65-13,38) = -7,51 for the industry

A highly negative value of the beta coefficient indicates that the return on equity of Phoenics develops contrary to the market. As this is a very nonstandard result, the meaning of it is discussed in more detail in Section 5.2.1.2.

5.2.1.1.2 The Risk-Free Rate

As the recent financial crisis has shown, there is no such thing as a risk-free rate. The closest approximation is, however still a government bond. As the market for government bonds is currently very volatile, there is no clear answer to the question of which bond to choose. Based on the government bonds ratings, the German 10-year government bond has been chosen as likely having the minimal risk of defaulting.

The risk-free interest rate is therefore given by 1,01%[10].

[10] http://www.bloomberg.com/quote/GDBR10:IND

5.2.1.1.3 The Market Risk Premium

The market risk premium is determined by the difference between the market rate of return and the risk-free interest rate. As the beta coefficient was calculated using returns on equity, consequently the market rate of return is also expressed in terms of RoE.

The RoE of the market is computed by taking the average of years 2010 and 2011. The results are:

-16,42%- 0,81% = -17,23% for the industry and

8,51%-0,81% = 7,70% for the focus group

5.2.1.2 Results

Given the above results it is possible to find the required return on equity by applying the CAPM formula which yields:

-17,23%* -7,51 = 129,40% for the industry group and

7,7%* -5,35= -41,20% for the focus group

These results cannot be considered valid for several reasons. For the industry group the discount rate is obviously very high. Furthermore, the calculated discount rate is positive, but this is just a technical consequence of the fact that both variables: beta and the market risk premium are negative. This is the case, as the value of the respective market was decreasing and at the same time Phoenics has shown very good financial results, one has to conclude a negative value of the beta parameter.

The discount rate found for the focus group contradicts the idea of any discounted cash flow calculation. Obviously, the idea of incorporating risk by discounting can only be reasonable when the discount rates are positive.

The above results are a perfect exemplification of an already described major problem associated with valuation of young companies with the discounted cash flow approach. The value of the industry required rate of return is extremely high but only because of the two negative components of calculation. The focus group rate of return is negative and therefore it cannot be used for further calculations, as in this case, the idea of a discount rate would be not be meaningful.

Given that the above results are not satisfying, further calculation requires employing a different approach. In the next section the alternative calculation of the discount rate, which employs the required return on equity is presented.

5.2.1.3 The Alternative Approach

The alternative is a more intuitive and suitable way of expressing the required return on equity. Calculating market risk premiums and betas can be considered an indirect way of asking investors how much return they require in order to invest in a company. For publicly traded companies this is usually the only feasible solution. However, since Phoenics is a small company, the obvious alternative is simply to ask the investors, which in this case are also the managers of the firm. Although this approach is not free of various critiques and can be considered unorthodox, for the case of this study it seems to be more accurate than the more standard solutions.

In order to avoid the influence of bounded rationality of the founders on the results, the question was asked in a very specific way.

The managers had to answer the following question:

"How much interest would you ask for if you had €100.000 on your bank account and the company asked you a for an equity investment characterized by the same risk as your project?"

The three managers answered with 10/30/30 % which yields on average 23%.

The idea of such a formulation of the question reflects the basic concept of the discount rate as the opportunity cost of investment. By asking the question in such an indirect way, it was possible to avoid the need for clarifying the concept of the cost of capital to the managers (who are, as explained, not trained in finance) and at the same time was able to receive information about their subjective required rate of return. Furthermore, this idea is supported by the venture capital method, which uses a predetermined required rate of return as a discount rate.

The result seems low, but it accurately reflects what a required return on equity should reflect. Moreover, since Phoenics OG cannot be considered a start-up in the classical sense as it has a constant income, the answer should be considered reasonable.

5.2.1.3.1 The Cost of Debt

The cost of debt is determined according to the market requirements. I have been informed by the management of Phoenics, that the company requested a long-term loan in December 2012. The bank offered an interest rate of 8% p.a., which should be then considered the cost of debt. This figure should serve for further computations. It has been decided to follow the market approach, since the computation of the cost of debt solely based on the accounting data would lead to an artificially low value, as all debt has so far been provided by the stakeholders.

5.2.1.3.2 Calculating WACC

The calculation of the WACC according to the standard approach would yield the following:

WACC = 54,1%*-57,01%+45,9%*(1-25%)*8% = -28,10%

Since, as has already been explained, this result cannot be considered valid, the alternative method for WACC calculation has been exercised and the result is:

WACC = 64%*23%+36%*(1-25%)*8% = 14,62%

The alternative approach leads to a value of WACC of 14,62%. Consideration of empirical investment behavior for technology ventures reveals that discount rates used by venture capitalists are reportedly very high, in the range 20% - 100% according to Timmons and Spinelli (2004) or 40% - 75% (Westland, 2002), thus well beyond the empirically observed range of market-risk-adjusted discount rates for traded companies (Steffens and Douglas, 2007).

Given that, 14,62% seems a very low discount rate. However, taking into account the fact that Phoenics OG does not rely solely on the high-tech business but also operates in a much more stable and therefore risk-averse business, it is reasonable. There are additional aspects that make this result reliable. First of all, the fact that the company is highly subsidized results in a low risk of failure. Second of all, market entry has already taken place (although in a small market) and therefore customers are already available. Finally, the management has several years of experience in the industry and is well networked.

Because of the above observations, it seems that the calculated WACC as a discount rate for further computations is a correct choice.

5.2.1.4 Discounted Cash Flow Results

With the use of the forecast of the income statements and balance sheets, it is possible to create the cash flows for the years 2012 to 2016.

Since the terminal value of the operation is not a fixed endless rate, there is a need to calculate it differently. In order to find the meaningful terminal value a two-period Gordon

Table 10: DCF Valuation, Cash Flow Statement - forecast

Cash Flow Statement					
	2012	**2013**	**2014**	**2015**	**2016**
Cash Flow from Operations	**50.471,96**	**69.843,45**	**97.123,14**	**105.022,37**	**140.504,31**
Net profit	35.854,05	43.177,84	64.183,23	70.395,35	97.625,16
Additions to Cash					
Depreciation	11.688,56	12.272,99	11.545,50	11.161,90	10.337,43
Increase in Accounts payable	-9.022,00	0,00	0,00	0,00	0,00
Increase in Taxes Payable	11.951,35	14.392,61	21.394,41	23.465,12	32.541,72
Cash Flow from Investing	**-14.610,70**	**-8.635,57**	**-9.627,48**	**-7.039,54**	**-9.762,52**
Purchase of common equipment	-14.610,70	-8.635,57	-9.627,48	-7.039,54	-9.762,52
Cash Flow from Financing	**5.651,00**	**-5.378,11**	**-6.476,68**	**-12.836,65**	**-14.079,07**
Dividends paid	-14.349,00	-5.378,11	-6.476,68	-12.836,65	-14.079,07
Increase debts	20.000,00	0,00	0,00	0,00	0,00
Cash Flow sum	**41.512,26**	**55.829,77**	**81.018,98**	**85.146,19**	**116.662,72**

growth model has been employed. The use of two periods is necessary, as it is expected that the sales will grow at different rates before and after the termination of the patent. It has been assumed that the free cash flows will grow on the rate equal to the average growth rate within the first five years of the rest of the duration of the patent, thus at 26,05% per year. After the patent expires an endless growth rate of 3% per year is assumed. The result of the calculation is shown

Table 9:DCF Valuation: Final result

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
FCF	**35.861**	**61.208**	**87.496**	**97.983**	**130.742**	**164.799**	**207.728**	**261.839**	**330.047**	**416.021**
										2.845.638
Total	35.861	61.208	87.496	97.983	130.742	164.799	207.728	261.839	330.047	3.261.659
DCF	**1.429.387**									

in Table 10.

Table 10 shows a discounted cash flow of €1.429.387. This value ignores all the available strategic choices within the company in general and for the patent in particular. This as well as the fact that the value is relatively low, reflects the practical importance of the critique of the DCF methods applied to a case of companies with substantial intangible assets. DCF methods, takes into account only the current state of the world, and not the options for the use of the patent available to the company. As identified in the SWOT analysis, Phoenics encounters many opportunities which should somehow be included in the valuation of the firm. The next chapter presents how the use of real options allows me to incorporate the opportunities available into the valuation, which will result in a higher and more realistic value of the firm.

5.3 Real Options valuation

In order to perform a real option valuation of Phoenics, certain steps are necessary and some key figures have to be computed. The major steps include:

1. Description of the available options,
2. Calculation of the NPVs of each option,
3. Simulation of the implied volatility of each option,
4. Specification of the relevant risk-free rate.

Three scenarios of development corresponding to three available options have been prepared.

1. The option to expand to Germany. This option involves an initial investment for setting up the branch, but no investment for making RD7 available for sale.
2. The option to make the product available for sale without expanding to the German market.
3. The (sequential compound) option to make the product available for sale and expand to the German market in the second phase of development.

The NPV of each scenario consists of the base case (without any option taken) plus the performance of the option. For each of the scenarios the forecasted balance sheets, income statements and cash flow statements are presented further on.

The following simulations have been prepared using the Risk Simulator[11] software. Risk Simulator is an Excel add-in used for applying simulation, forecasting and statistical analysis in Excel spreadsheet models developed by Real Options Valuation Inc. This powerful tool, developed by an established consulting company in the area of real options, allows for a comprehensive quantitative analysis of real options including valuation of the options, simulation

[11] http://www.realoptionsvaluation.com/risk-simulator-software.php

of volatilities and more. The base for the analysis is the prediction of the market shares, which will be obtained if the company expanded with the Phoenics RD7 product to the German and Austrian markets or sold the product, respectively. The market shares serve then to forecast sales in each of these markets, which are calculated as a fraction of the value of sales in the whole out-of-home segment. Data about the value of sales in the out-of-home segments in Austria and Germany have been obtained from Fachverband Aussenwerbung e.V. (FAW)[12] (a German professional association of advertising companies) and Gewista. Therefore, the final forecasted values stem from the values of sales in the whole market multiplied by the simulated market shares of Phoenics in these markets. The simulated sales are then used to find the cash flows from expansion for the years 2013 to 2016, which are in turn discounted with relevant discount rates to find the NPV of each scenario.

The implied volatility of each scenario has been computed using Monte Carlo simulation performed by the software Risk Simulator. The strategy of measurement of the volatility of the project introduced by Copeland and Antikarov (2003) and Mun (2006) is followed. The volatility of the project is then found as the standard deviation of the rate of return distribution. The annual rate of return of the project is defined natural logarithm of the ratio between the present values of cash flows discounted at year 1 and the present values of cash flows discounted to the base year, whereas the latter is assumed to be constant (thus, it represents the expected value of the cash flows). In other words, it is the difference between the natural logarithms of the given present values. Therefore, the volatility of the project is calculated as the standard deviation of the expression:

$$x = \ln\left[\frac{PV_1}{E(PV_0)}\right]. \tag{27}$$

It can be shown (Han, 2007) that this method of volatility calculation is not free of faults, and in particular that it tends to overestimate the volatility if the option life is longer than one year. However, since this method is standard in the option literature, calculation continues as described, keeping in mind the potential critique.

[12] http://www.faw-ev.de/

5.3.1 NPV

5.3.1.1 Expansion

The option to expand to Germany is defined by the action of continuing with the same business model (content + renting of RD7) in Germany and Austria.

For this scenario, starting with 2013, the management of Phoenics predicts the following market shares in Austria and Germany:

Table 11: Prediction of market shares - expansion.

	2013	2014	2015	2016
Austria	0,70%	0,80%	0,90%	1,00%
Germany	0,70%	0,80%	0,90%	1,00%

Note also that since the market performance in the two markets is highly related, a 10% correlation between the market shares is assumed in the simulation (which does not influence the DCF calculations of this scenario, however increases the volatility). The above figures result in the following income statement:

Table 12: Income Statement forecast - expansion.

Income Statement

	2012	2013	2014	2015	2016
Domestic Sales	98.695,75	638.515,70	854.829,18	1.078.961,23	1.355.217,00
Subsidies	60.000,00	0,00	0,00	0,00	0,00
Net sales	**158.695,75**	**638.515,70**	**854.829,18**	**1.078.961,23**	**1.355.217,00**
OPEX	-99.243,78	-399.309,46	-534.585,73	-674.751,50	-847.513,96
Depreciation	-11.688,56	-12.272,99	-16.662,20	-20.277,56	-22.138,70
EBIT	47.763,40	226.933,25	303.581,25	383.932,16	485.564,34
Interest and other income	42,00	1.193,85	5.209,90	10.510,90	17.287,28
EBT	47.805,40	228.127,10	308.791,16	394.443,07	502.851,62
Taxes	-11.951,35	-57.031,77	-77.197,79	-98.610,77	-125.712,91
Net profit	**35.854,05**	**171.095,32**	**231.593,37**	**295.832,30**	**377.138,72**

Since the business model remains constant, also the income statement is built in the same way as for the base case. It is furthermore assumed that no subsidies are given after 2012. OPEX are hereby 64,53% of sales. Although the current OPEX consists mainly of fixed costs, this assumption is reasonable also for the described scenario, as the management will pay the increasing sales in the form of bonuses. Depreciation is again equal to 20% of last year´s assets.

Summarizing, the net profit will increase from the expected €35.854 in 2012 to €377.138 in 2016. Although, this is a tenfold increase compared to the beginning, it can be seen as reasonable as start-up companies are usually characterized by high growth. In certain cases much higher than shown here.

From the income statements it is easy to find the balance sheets for the upcoming years.

Table 13: Balance Sheets forecast: Assets - expansion.

Assets	2012	2013	2014	2015	2016
Fixed Assets	**61.364,94**	**83.311,02**	**101.387,82**	**110.693,48**	**126.268,66**
Equipment	61.364,94	83.311,02	101.387,82	110.693,48	126.268,66
Current Assets	**113.879,26**	**314.682,18**	**579.732,23**	**918.550,96**	**1.346.660,94**
Cash and equivalents	59.692,26	260.495,18	525.545,23	864.363,96	1.292.473,94
Receivables	6.952,00	6.952,00	6.952,00	6.952,00	6.952,00
Accruals	47.235,00	47.235,00	47.235,00	47.235,00	47.235,00
Total Assets	**175.244,20**	**397.993,19**	**681.120,05**	**1.029.244,44**	**1.472.929,60**

Since this balance sheet represents the standard business model of renting RD7, the main assumptions for creating it remain the same as in the base case which has been shown and explained before.

Two major assumptions for the further calculation are presented in Table 14:

Table 14: Assumptions of the expansion scenario.

	2012	2013	2014	2015	2016
Investment rate	25%	20%	15%	10%	10%
Dividend rate	10%	15%	15%	20%	20%

Firstly, the investment rate is expected to decrease from 25% in 2012 to 10% in 2016. This is due to the fact that all necessary assets, also for the expansion, have been by then already purchased. Further major investment needs are neither necessary nor planned.

Secondly, the dividend rate (as the percentage of the net profit) will increase from 10% in 2012 to 20% in 2016.

Table 15: Balance Sheets forecast: Liabilities and Equity - expansion.

Liabilities & Owners Equity	2012	2013	2014	2015	2016
Equity	**62.273,90**	**227.991,12**	**433.920,19**	**683.433,81**	**1.001.406,07**
Retained earnings	121.401,90	287.119,12	493.048,19	742.561,81	1.060.534,07
Private	-59.128,00	-59.128,00	-59.128,00	-59.128,00	-59.128,00
Liabilities	**112.970,30**	**170.002,08**	**247.199,86**	**345.810,63**	**471.523,54**
Current liabilities	90.077,30	147.109,08	224.306,86	322.917,63	448.630,54
Payables	2.369,00	2.369,00	2.369,00	2.369,00	2.369,00
State and other public entities	87.708,30	144.740,08	221.937,86	320.548,63	446.261,54
Long-term liabilities	22.893,00	22.893,00	22.893,00	22.893,00	22.893,00
Total liabilities and owners Equity	**175.244,20**	**397.993,19**	**681.120,05**	**1.029.244,44**	**1.472.929,60**

Due to the high growth of the company, the debt to equity ratio decreases from 166% in 2012 to 40% in 2016. It should, however be noted that this ratio could be higher than 40% if the company decides to pay more dividends.

Taking into account the above observations, the following Cash Flow Statement has been reached:

Table 16: Cash Flow Statement forecast - expansion.

Cash Flow Statement					
	2012	**2013**	**2014**	**2015**	**2016**
Cash Flow from Operations	**50.471,96**	**240.400,08**	**325.453,36**	**414.720,63**	**524.990,32**
Net profit	35.854,05	171.095,32	231.593,37	295.832,30	377.138,72
Additions to Cash					
Depreciation	11.688,56	12.272,99	16.662,20	20.277,56	22.138,70
Increase in Accounts payable	-9.022,00	0,00	0,00	0,00	0,00
Increase in Taxes Payable	11.951,35	57.031,77	77.197,79	98.610,77	125.712,91
Cash Flow from Investing	**-14.610,70**	**-34.219,06**	**-34.739,00**	**-29.583,23**	**-37.713,87**
Purchase of common equipment	-14.610,70	-34.219,06	-34.739,00	-29.583,23	-37.713,87
Cash Flow from Financing	**65.651,00**	**-5.378,11**	**-25.664,30**	**-46.318,67**	**-59.166,46**
Subsidies	60.000,00	0,00	0,00	0	0
Dividends paid	-14.349,00	-5.378,11	-25.664,30	-46.318,67	-59.166,46
Increase debts	20.000,00	0,00	0,00	0,00	0,00
Cash Flow sum	**101.512,26**	**200.802,91**	**265.050,06**	**338.818,73**	**428.109,99**

Adding Cash Flow from Operations and Cash Flow from Investing results in the Free Cash Flow forecast presented in Table 17.

Table 17: DCF Valuation - expansion.

	2012	2013	2014	2015	2016
FCF	35.861,26	206.181,02	290.714,35	385.137,40	487.276,45
Total	**35.861,26**	**206.181,02**	**290.714,35**	**385.137,40**	**487.276,45**
	2017	2018	2019	2020	2021
	626.476,59	805.442,01	1.035.532,43	1.331.352,73	1.711.679,95
					2.655.228,74
Total	**626.476,59**	**805.442,01**	**1.035.532,43**	**1.331.352,73**	**4.366.908,69**
DCF	**3.290.230,64**				

Given that, Free Cash Flows increase from €35.861 in 2012 to €487.276 in 2016. From 2017 until the end of the patent in 2021 these are calculated with the average growing rate of FCF of the years before. However, since there is a huge increase in sales from 2012 to 2013 this year is excluded from the average. The result is a growth rate of 28,57% in this timeframe. The terminal value then is calculated with 3% growth.

Comparing the result of €3.290.230 with the result of the basic scenario of €1.429.387 shows that the NPV of that opportunity is €1.860.843. This value is of great importance for the value of the option afterwards. Furthermore, the results show that the strategic decision of whether to expand to Germany or not should be answered with yes, according to the NPV of the project.

5.3.1.2 Sale

This scenario assumes that an engineer is paid in order to fulfill the last steps which are necessary to produce and sell Phoenics RD7 to the public.

As an implication, there will be some differences in the income statement as compared to the previous case, as shown in Table 18.

Table 18: Income Statement forecast - sale.

	2012	2013	2014	2015	2016
Domestic Sales	98.695,75	213.247,93	283.112,02	355.007,03	443.555,70
Costs of goods sold	0,00	-53.311,98	-70.778,00	-88.751,76	-110.888,93
Subsidies	60.000,00	0,00	0,00	0,00	0,00
Net sales	**158.695,75**	**159.935,95**	**212.334,01**	**266.255,28**	**332.666,78**
OPEX	-99.243,78	-75.014,53	-99.590,72	-124.881,33	-156.030,22
Depreciation	-11.688,56	-12.272,99	-12.033,66	-11.951,10	-11.569,65
EBIT	47.763,40	72.648,43	100.709,64	129.422,85	165.066,91
Interest and other income	42,00	1.193,85	2.587,06	4.495,11	6.901,72
EBT	47.805,40	73.842,28	103.296,70	133.917,95	171.968,63
Taxes	-11.951,35	-18.460,57	-25.824,18	-33.479,49	-42.992,16
Net profit	**35.854,05**	**55.381,71**	**77.472,53**	**100.438,46**	**128.976,47**

The first and obvious difference is that sales will increase substantially as the customers can use Phoenics RD7 at a lower price than now. Phoenics will still produce contents if demanded, but the customers will also have the chance not to use the services of the company. Assumed market shares in the following years are presented in the box below:

Table 19: Prediction of market shares - sale.

	2013	2014	2015	2016
Market share Austria	1,50%	1,70%	1,90%	2,10%

Furthermore, it is assumed that the costs of goods sold will be 25% of total sales. OPEX should be 75% of the previously found 62,54% and therefore 46,90%. This alteration happens since the workload associated with the new business model will be lower than before and that the associated costs will shift from the OPEX to the costs of goods.

Taking into account the income statement leads me to the following balance sheets:

Table 20: Balance Sheets forecast: Assets - sale.

Assets	2012	2013	2014	2015	2016
Fixed Assets	**61.364,94**	**60.168,29**	**59.755,51**	**57.848,26**	**59.176,25**
Equipment	61.364,94	60.168,29	59.755,51	57.848,26	59.176,25
Current Assets	**113.879,26**	**183.540,08**	**278.942,31**	**399.273,01**	**549.825,95**
Cash and equivalents	59.692,26	129.353,08	224.755,31	345.086,01	495.638,95
Receivables	6.952,00	6.952,00	6.952,00	6.952,00	6.952,00
Accruals	47.235,00	47.235,00	47.235,00	47.235,00	47.235,00
Total Assets	**175.244,20**	**243.708,38**	**338.697,82**	**457.121,27**	**609.002,20**

This balance sheet is created under the assumption of the same investment and dividend rates as in the example before. Note that the overall equipment is declining from 2012 to 2016. This happens because the profits are not high enough to cover the depreciation of capital. It has to be mentioned that currently, the main part of equipment consists of RD7 parts which should not be classified as fixed assets after the product is developed for sale. Therefore, the figure presented in the balance sheet is not artificially low.

Table 21: Balance Sheets forecast: Liabilities and Equity - sale.

Liabilities & Owners Equity	2012	2013	2014	2015	2016
Equity	**62.273,90**	**112.277,50**	**181.442,77**	**266.386,73**	**375.275,51**
Retained earnings	121.401,90	171.405,50	240.570,77	325.514,73	434.403,51
Private	-59.128,00	-59.128,00	-59.128,00	-59.128,00	-59.128,00
Liabilities	**112.970,30**	**131.430,87**	**157.255,05**	**190.734,53**	**233.726,69**
Current liabilities	90.077,30	108.537,87	134.362,05	167.841,53	210.833,69
Payables	2.369,00	2.369,00	2.369,00	2.369,00	2.369,00
State and other public entities	87.708,30	106.168,87	131.993,05	165.472,53	208.464,69
Long-term liabilities	22.893,00	22.893,00	22.893,00	22.893,00	22.893,00
Total liabilities and owners Equity	**175.244,20**	**243.708,38**	**338.697,82**	**457.121,27**	**609.002,20**

Since the long-term liabilities will not change and the equity will rise at a faster rate than the current liabilities, the debt to equity ratio will decrease from 180% in 2012 to 62% in 2016.

Summing up the presented figures leads me to the Cash Flow Statement out of which the FCFF can be computed.

Table 22: Cash Flow Statement forecast - sale.

Cash Flow Statement					
	2012	2013	2014	2015	2016
Cash Flow from Operations	**50.471,96**	**86.115,27**	**115.330,36**	**145.869,05**	**183.538,28**
Net profit	35.854,05	55.381,71	77.472,53	100.438,46	128.976,47
Additions to Cash					
Depreciation	11.688,56	12.272,99	12.033,66	11.951,10	11.569,65
Increase in Accounts payable	-9.022,00	0,00	0,00	0,00	0,00
Increase in Taxes Payable	11.951,35	18.460,57	25.824,18	33.479,49	42.992,16
Cash Flow from Investing	**-14.610,70**	**-11.076,34**	**-11.620,88**	**-10.043,85**	**-12.897,65**
Purchase of common equipment	-14.610,70	-11.076,34	-11.620,88	-10.043,85	-12.897,65
Cash Flow from Financing	**65.651,00**	**-5.378,11**	**-8.307,26**	**-15.494,51**	**-20.087,69**
Subsidies	60.000,00	0,00	0,00	0	0
Dividends paid	-14.349,00	-5.378,11	-8.307,26	-15.494,51	-20.087,69
Increase debts	20.000,00	0,00	0,00	0,00	0,00
Cash Flow sum	**101.512,26**	**69.660,82**	**95.402,22**	**120.330,70**	**150.552,94**

Similarly to the calculation of the scenario before, Free Cash Flows are predicted to grow with the average growth rate of the years between 2013 and 2016, again excluding growth from 2012 to 2013. On average the growth rate is 27,70%.

Table 23: DCF Valuation - sale.

	2012	2013	2014	2015	2016
FCF	35.861,26	75.038,93	103.709,48	135.825,21	170.640,63
TOTAL	**35.861,26**	**75.038,93**	**103.709,48**	**135.825,21**	**170.640,63**
	2017	2018	2019	2020	2021
	217.907,66	278.267,53	355.346,93	453.777,14	579.472,26
					898.901,35
TOTAL	**217.907,66**	**278.267,53**	**355.346,93**	**453.777,14**	**1.478.373,61**
DCF	**1.155.312,55 €**				

Taking into account the above figures results in the DCF of €1.155.312. Subtracting this value from the NPV of the basic scenario results in a negative Cash Flow of -274.074,46 €.

According to the discounted Cash Flow Analysis, RD7 should therefore not be sold to the public, but just rented. Given that result, it is possible to conclude that the market share captured in the small Austrian market is too insignificant for a successful business model. Of course an additional expansion or a higher market share could solve that problem; therefore the value of sale and expansion are computed in the next step.

5.3.1.3 Expansion + Sale

Since the impact of either an expansion to Germany or the development for serial production has already been described, the next section turns to analyzing what happens if Phoenics does both.

The impact of a serial production on the cost structure has been already explained above. Most important for the overall value of this scenario are the market shares obtained in both countries given RD7 is serially produced and sold. Having consulted the management regarding their predictions of the market shares, the following market shares for Austria and Germany from 2013 to 2016 have been assumed.

Table 24: Prediction of market shares - expansion + sale.

	2013	2014	2015	2016
AUT	1,70%	1,90%	2,10%	2,30%
GER	1,00%	1,20%	1,40%	1,60%

Multiplying the presented market shares with the overall market value, results in the following income statement.

Table 25: : Income Statement forecast - expansion + sale.

Income Statement	2012	2013	2014	2015	2016
Domestic Sales	98.695,75	983.247,93	1.365.512,02	1.771.807,03	2.273.955,70
Costs of goods sold	0,00	-245.811,98	-341.378,00	-442.951,76	-568.488,93
Subsidies	60.000,00	0,00	0,00	0,00	0,00
Net sales	**158.695,75**	**737.435,95**	**1.024.134,01**	**1.328.855,28**	**1.705.466,78**
OPEX	-99.243,78	-345.878,52	-480.348,10	-623.271,07	-799.912,62
Depreciation	-11.688,56	-12.272,99	-21.232,74	-28.919,13	-33.537,02
EBIT	47.763,40	379.284,44	522.553,18	676.665,07	872.017,14
Interest and other income	42,00	1.193,85	7.799,87	16.782,22	28.598,32
EBT	47.805,40	380.478,29	530.353,05	693.447,29	900.615,46
Taxes	-11.951,35	-95.119,57	-132.588,26	-173.361,82	-225.153,86
Net profit	**35.854,05**	**285.358,72**	**397.764,79**	**520.085,47**	**675.461,59**

According to the income statement presented in Table 25, sales will rise from €98.695 in 2012 to €2.273.955 in 2016 and profit from € 35.854 to €675.461. Given this result and assuming the same rules for balance sheets as in the above cases, the balance sheet can be presented, as follows.

Table 26: Balance Sheets forecast: Assets - expansion + sale

Assets	2012	2013	2014	2015	2016
Fixed Assets	**61.364,94**	**106.163,70**	**144.595,67**	**167.685,09**	**201.694,23**
Equipment	61.364,94	106.163,70	144.595,67	167.685,09	201.694,23
Current Assets	**113.879,26**	**444.180,69**	**893.297,95**	**1.484.102,87**	**2.246.692,10**
Cash and equivalents	59.692,26	389.993,69	839.110,95	1.429.915,87	2.192.505,10
Receivables	6.952,00	6.952,00	6.952,00	6.952,00	6.952,00
Accruals	47.235,00	47.235,00	47.235,00	47.235,00	47.235,00
Total Assets	**175.244,20**	**550.344,38**	**1.037.893,63**	**1.651.787,96**	**2.448.386,33**

First inspection of the table reveals that the value of equipment increases, which was not the case in the last scenario. This result shows that the profits are high enough to cover financing of the old equipment easily if necessary. It should be mentioned here that the cash basis is increasing substantially in this scenario. Obviously, the remaining cash might be paid out. Since this change would not matter for the Free Cash Flows it does not alter the results if this position remains in the balance sheets or not. It has been decided to leave it for clarity reasons; however, it would not be wrong to assume that the outstanding cash is used for dividend payments.

Table 27: Balance Sheets forecast: Liabilities and Equity - expansion + sale.

Liabilities & Owners Equity	2012	2013	2014	2015	2016
Equity	**62.273,90**	**342.254,51**	**697.215,49**	**1.137.748,00**	**1.709.192,50**
Retained earnings	121.401,90	401.382,51	756.343,49	1.196.876,00	1.768.320,50
Private	-59.128,00	-59.128,00	-59.128,00	-59.128,00	-59.128,00
Liabilities	**112.970,30**	**208.089,87**	**340.678,14**	**514.039,96**	**739.193,82**
Current liabilities	90.077,30	185.196,87	317.785,14	491.146,96	716.300,82
Payables	2.369,00	2.369,00	2.369,00	2.369,00	2.369,00
State and other public entities	87.708,30	182.827,87	315.416,14	488.777,96	713.931,82
Long-term liabilities	22.893,00	22.893,00	22.893,00	22.893,00	22.893,00
Total liabilities and owners Equity	**175.244,20**	**550.344,38**	**1.037.893,63**	**1.651.787,96**	**2.448.386,33**

Due to high profits, Phoenics OG will be able to lower their debt to equity ratio from 180% to 43% in 2016.

Given all the above results, the Cash Flow Statement reveals the following picture:

Table 28: Cash Flow Statement forecast - expansion + sale

Cash Flow Statement	2012	2013	2014	2015	2016
Cash Flow from Operations	**50.471,96**	**392.751,28**	**551.585,79**	**722.366,42**	**934.152,48**
Net profit	35.854,05	285.358,72	397.764,79	520.085,47	675.461,59
Additions to Cash					
Depreciation	11.688,56	12.272,99	21.232,74	28.919,13	33.537,02
Increase in Accounts payable	-9.022,00	0,00	0,00	0,00	0,00
Increase in Taxes Payable	11.951,35	95.119,57	132.588,26	173.361,82	225.153,86
Cash Flow from Investing	**-14.610,70**	**-57.071,74**	**-59.664,72**	**-52.008,55**	**-67.546,16**
Purchase of common equipment	-14.610,70	-57.071,74	-59.664,72	-52.008,55	-67.546,16
Cash Flow from Financing	**65.651,00**	**-5.378,11**	**-42.803,81**	**-79.552,96**	**-104.017,09**
Subsidies	60.000,00	0,00	0,00	0	0
Dividends paid	-14.349,00	-5.378,11	-42.803,81	-79.552,96	-104.017,09
Increase debts	20.000,00	0,00	0,00	0,00	0,00
Cash Flow sum	**101.512,26**	**330.301,43**	**449.117,26**	**590.804,92**	**762.589,22**

Summing up the Cash Flow from Operations and the Cash Flow from Investing, forecasting them with the average growth rate of 32% and a terminal value of 3% will result in a DCF of €6.273.431 if discounted with the WACC of 14,62%

Table 29: DCF Valuation - expansion + sale.

	2012	**2013**	**2014**	**2015**	**2016**
FCF	35.861,26	335.679,53	491.921,07	670.357,88	866.606,32
Total	**35.861,26**	**335.679,53**	**491.921,07**	**670.357,88**	**866.606,32**
	2017	**2018**	**2019**	**2020**	**2021**
	1.146.730,39	1.517.402,50	2.007.891,63	2.656.927,73	3.515.759,95
					5.453.792,26
Total	**1.146.730,39**	**1.517.402,50**	**2.007.891,63**	**2.656.927,73**	**8.969.552,21**
DCF	**6.273.431,93 €**				

Subtracting the NPV of the last scenario from the base case results in a value added of €4.844.044. This result clearly suggests that this scenario should be undertaken.

5.3.1.4 Analysis of the results

The in-depth analysis of the results is necessary for two reasons. First of all, it serves as a basic DCF analysis and second of all it serves a basis for the further Real Options analysis.

The result of the DCF analysis leads me to two main conclusions. On the one hand, a theoretical value of the entity if a certain scenario is undertaken has been obtained. On the other hand, the analysis helps to determine the value of strategic decisions.

DCF results show that Phoenics OG should expand to Germany. This is true, since this option opens a huge market in which taking over even a small stake results a substantial increase in sales.

In the last few months the management of Phoenics has been considering whether to produce RD7 serially or not. Given the results of the DCF analysis, they should not follow this strategy, as it would result in a lower DCF than in the current situation. Increase in the market share in this case does not cover the resulting increase in the cost of sales. Therefore, the company can be advised not to produce and sell RD7 serially, if the product is only sold in Austria.

The last part of the previous sentence is crucial for the following analysis, since the scenario resulting in the highest NPV is the scenario where Phoenics expands to Germany and produces RD7 serially. This result seems somehow ambiguous: Phoenics should not develop the product to sell it, but it should do it if it plans to expand to Germany.

The next step will use the obtained results as an input to the real option valuation. As a starting point of the further analysis, the volatility of the DCF forecasts, which will be needed to find the values of the real options, is calculated.

5.3.2 Volatility

The volatility of the underlying asset (the static DCF of each scenario) is the primary value driver for the real option value. However, given the innovative nature of Phoenics RD7, it is difficult to refer to market data about comparable traded options with similar risk parameters. Given that, it was necessary to refer solely to the estimates of the management and data about the development of the out-of-home media market.

The most important step is to determine the major sources of uncertainty in the development of future cash flows. two main drivers of the uncertainty of the cash flows are assumed:

- the uncertainty about the value of out-of-home markets in Germany and Austria,
- the uncertainty about the market shares intercepted by Phoenics when entering these two markets with their product.

The volatility simulation is performed, by changing the value of the independent variables in each Monte Carlo simulation round and than finding the standard deviation of the intermediate variable introduced above in (27). The calculation has been prepared with Risk Simulator software.

The first source of uncertainty is the value of out-of-home media markets in Austria and Germany in the upcoming years. As already noted, the forecasts of the market values obtained from Gewista and FAV are in a static form, thus no forecast errors are provided. Moreover, it is difficult to find comparable markets, for which data about the uncertainty of the future payoffs would be available. On the other hand, it would unreasonable to assume that the market develops exactly as described by the data providers. This lack of data has forced me to make an ad hoc assumption about the uncertainty of the market values. The best guess in this case is to refer to the forecast error of the sales of Phoenics, as described in sales forecasts section. The forecast error of the sales prognoses for Phoenics is equal to 25% of the predicted value. Additionally, there is no information about the models behind the forecasts of market development prepared by Gewista and FAV. Most commonly, it would be assumed that the market values are normally distributed, which is also assumed here. Summarizing, for the purpose of the uncertainty simulations, the market values are assumed to be normally distributed with a 25% coefficient of variation for each year, which corresponds to a respective standard deviation.

The second main driver of uncertainty in the future cash flow levels is the uncertainty about what share of each market can be overtaken by Phoenics if the options are exercised. The estimates of the uncertainty have been prepared after consultations with the management about their predictions of the development of sales, who have named the values of the most likely market shares in each scenario and their estimates of the uncertainty. The formulation of the problem in this way implies that the market shares will be assumed to follow a triangular distribution. For each scenario the respective assumptions are presented below:

Expansion: The market shares in both German and Austrian markets are predicted to equal 0.7% in 2013 ± 0.6% and then rise by 0.1% each year with the constant 0.6% uncertainty.

Sale: The market share in Austria equals 1.5% ± 0.5% in 2013 and rises by 0.2% afterwards.

Expansion and Sale: The market share in Austria is assumed as in the above scenario, whereas the market share in Germany equals 1% ± 0.5% in 2013 and rises by 0.2% each year.

In other words, e.g. the market share in Austria in the expansion scenario in 2014 will follow a triangular distribution with the mean 0.8% and support [0.2%,1.4%], and so on.

Moreover, it is important to mention that in each scenario that involves presence in both Austrian and German markets, the market shares are assumed to be correlated. This assumption stems from the fact, that the customers of Phoenics often operate in both markets at the same time, and recognition of the Phoenics RD7 in one market is followed by increased market presence in the other one. This effect could be described as a network effect. It is difficult to estimate the actual value of the correlation. Consultation with the management of Phoenics revealed that the company believes that about 10% of their customers operate in both markets, and therefore 10% correlation between market shares is assumed in the simulations. Positive correlation between the markets necessarily drives the volatility of the cash flows up.

Given the assumption, the calculations are performed. Each independent variable changes the values of the future cash flows in each scenario. These changes are then reflected in the volatility calculated according to the Copeland and Antikarov (2003) formula. The results of the calculations are presented in Figures 6-8.

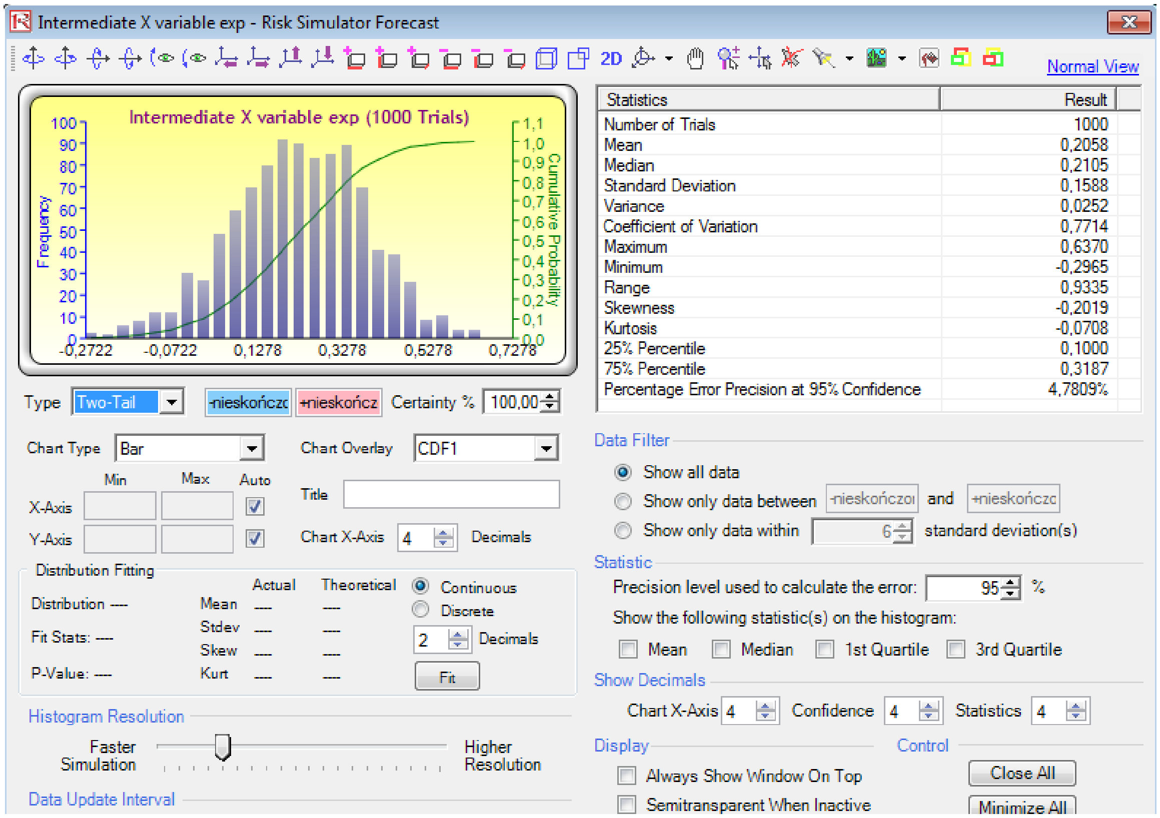

Figure 6: Simulated distribution of the intermediate variable - expansion.

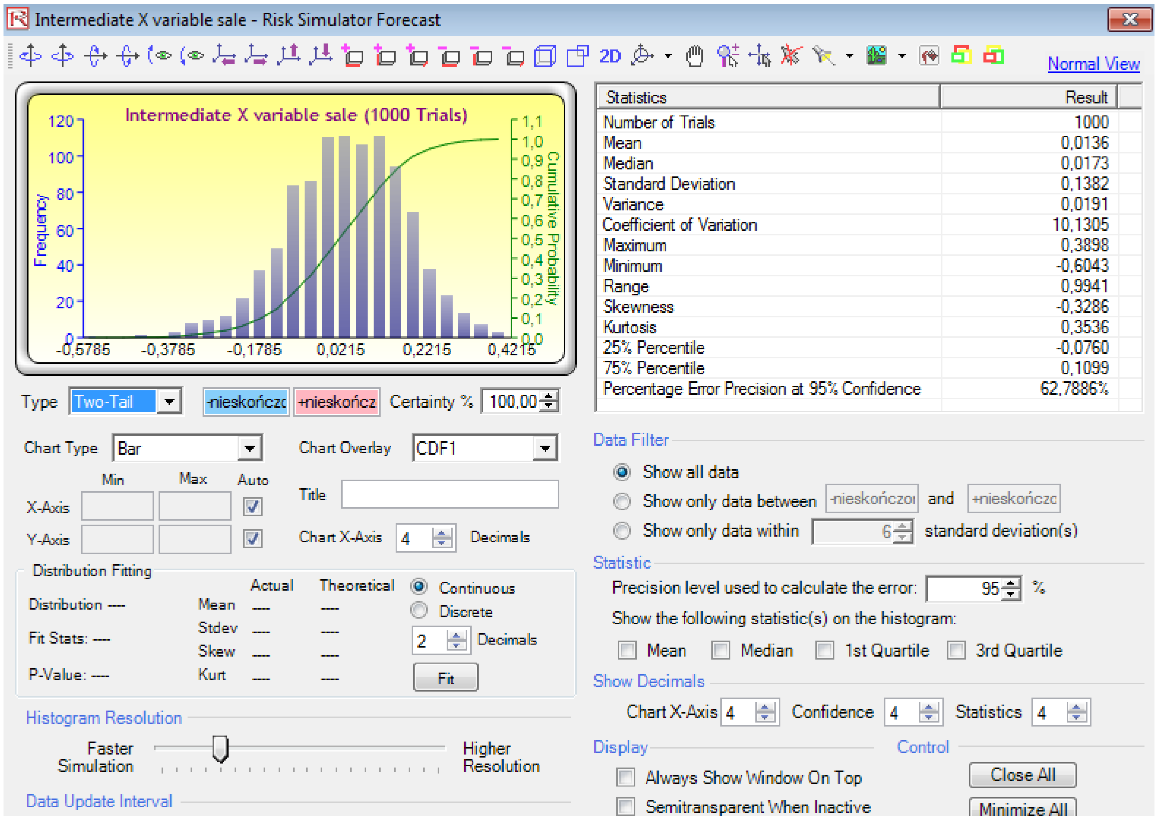

Figure 7: Simulated distribution of the intermediate variable - sale.

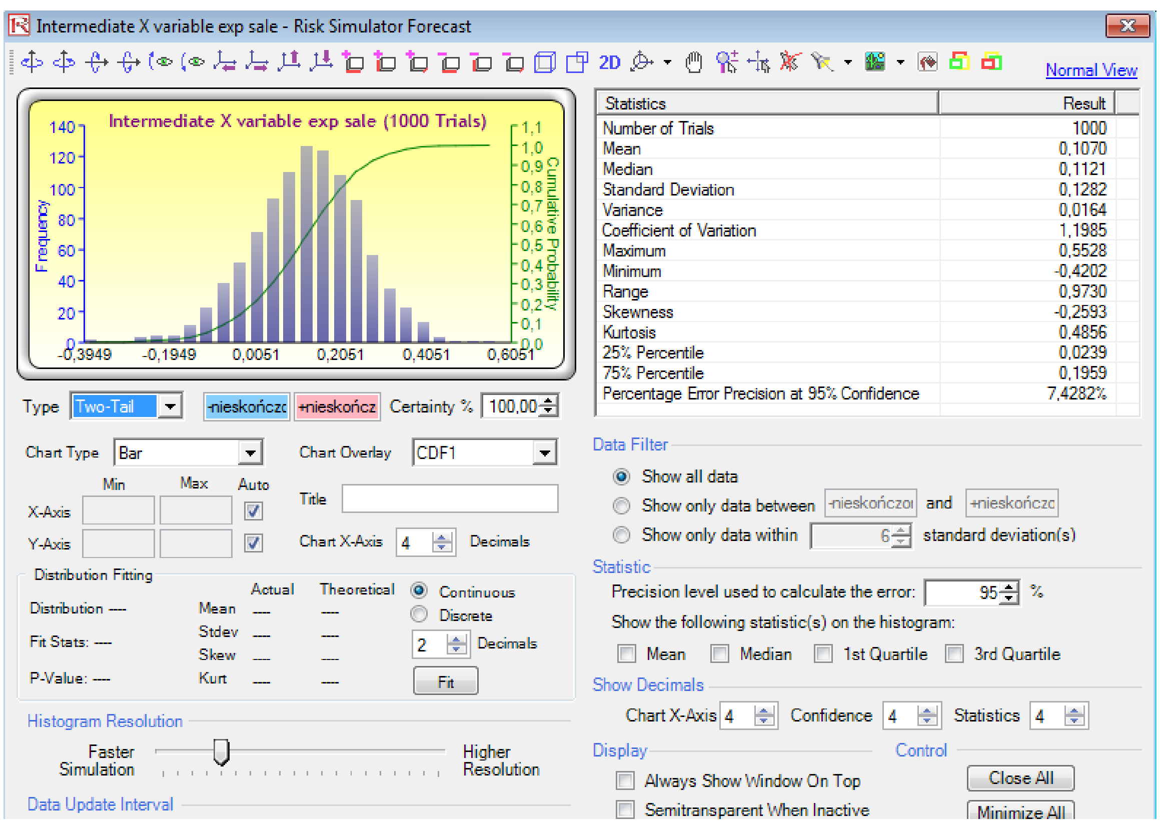

Figure 8: Simulated distribution of the intermediate variable - expansion + sale.

The expansion scenario is characterized by the highest volatility which equals 15.88%. For the sale option the volatility equals 13.82%, and for the expansion and sale scenario the estimated volatility equals 12.82%. The values of the volatilities reflect the fact that the German market has been assumed to have the same coefficient of variation as the Austrian market, but since its value in absolute terms is much higher, this is necessarily reflected in the estimated volatility. The second driver, thus the variation of the market shares is also visible in the estimates. For the sales scenario the supports of the distribution have been assumed narrower than in the base-case renting scenario. It lies in the nature of the real option analysis that the volatility estimates, which in turn determine the value of the options, rely heavily on the assumptions. This is a characteristic rather than a shortcoming of this method, but it is indeed a reason why practitioners are sometimes reluctant to adapt ROV (Shockley, 2007) and must always be kept in mind.

5.3.3 The Value of the Real Options

The value of Phoenics OG consists of the value of the base case plus the sum of the real options available. Since the base case value has already been calculated, this part concentrates on the real options.

5.3.3.1 ROV: The value of renting the Product in Austria & Germany

The value of the option to expand is given by the following inputs, as presented in Figure 9.

Assumptions		*Intermediate Computations*	
PV Asset Value ($)	1.860.843,63 €	*Stepping Time (dt)*	0,0090
Implementation Cost ($)	250.000,00 €	*Up Step Size (up)*	1,0152
Maturity (Years)	9,00	*Down Step Size (down)*	0,9850
Risk-free Rate (%)	0,81%	*Risk-neutral Probability*	0,4987
Dividends (%)	0,00%		
Volatility (%)	15,88%	***Results***	
Lattice Steps	1000	*Auditing Lattice Result (10 steps)*	1628420,18
Option Type	American	*Super Lattice Results*	0,00
Terminal Equation	Max(Asset-Cost,0)		
Intermediate Equation			

Figure 9: ROV: Assumptions of the expansion scenario.

In each scenario the real option is an American call option as the scenario can be followed at any time in the future before the end of patent protection. The present value of the asset is the NPV of the scenario minus the NPV of the base case. Estimated implementation costs of each option have been provided by the management. The maturity of the option is specified by the length of the patent. Dividends are equal to zero which stems from the fact that the present values have already been calculated with FCFF, therefore considering for all the future costs of each scenario. If it is necessary to discount e.g. future operational costs, one could insert them here as dividends. As a matter of fact, since there are no future dividends, the value of the American option will be the same as that of a corresponding European option. The calculations are performed with both the Black-Scholes equation and the binomial method, for which there are 1000 lattice steps performed by the software. Here, only the last 10 are shown.

The first lattice tree shows the evolution of the value of the underlying asset which results in a value of €1.860.843,63.

Underlying Asset Lattice

										2163399,57
									2131052,03	
								2099188,15		2099188,15
							2067800,71		2067800,71	
						2036882,58		2036882,58		2036882,58
					2006426,75		2006426,75		2006426,75	
				1976426,30		1976426,30		1976426,30		1976426,30
			1946874,41		1946874,41		1946874,41		1946874,41	
		1917764,40		1917764,40		1917764,40		1917764,40		1917764,40
	1889089,64		1889089,64		1889089,64		1889089,64		1889089,64	
1860843,63		1860843,63		1860843,63		1860843,63		1860843,63		1860843,63
	1833019,96		1833019,96		1833019,96		1833019,96		1833019,96	
		1805612,32		1805612,32		1805612,32		1805612,32		1805612,32
			1778614,48		1778614,48		1778614,48		1778614,48	
				1752020,31		1752020,31		1752020,31		1752020,31
					1725823,79		1725823,79		1725823,79	
						1700018,96		1700018,96		1700018,96
							1674599,97		1674599,97	
								1649561,05		1649561,05
									1624896,52	
										1600600,77

Figure 10: ROV: Lattice evaluation - expansion.

This value should be interpreted as the value of the asset in T=0. The next lattice shows the corresponding option value to the underlying asset which results in a value of €1.628.420,58.

Since the value of the option is influenced by many independent variables, a sensitivity analysis has been performed. The results of it are shown in Figure 11.

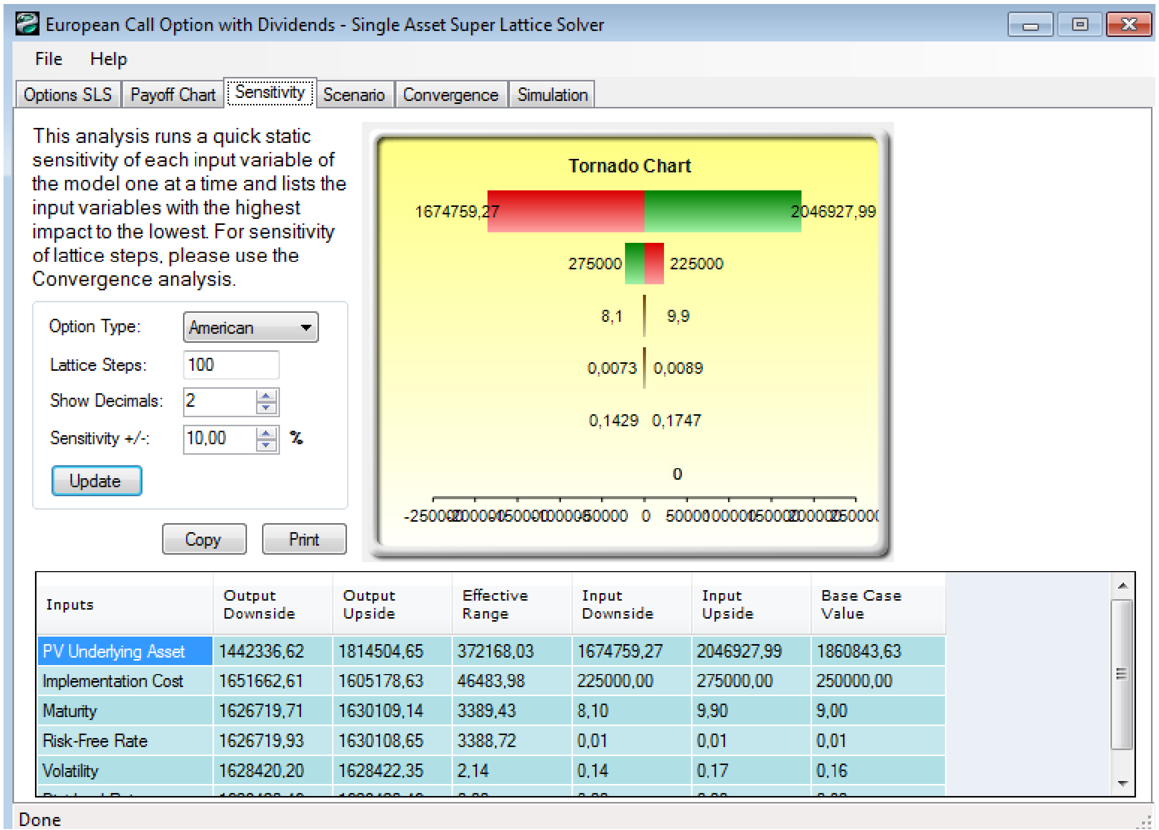

Figure 11: ROV: Sensitivity analysis - expansion.

The tornado chart shows all the input parameters and their influence on the final value of the option. Obviously, the main driver of the value is the present value of the underlying asset, followed by the implementation cost. Surprisingly, the influence of volatility is very low - it seems less important than the time to maturity or the risk-free rate.

The value of the option obtained with the binomial method is very close to the value resulting from the standard Black-Scholes equation, which can be verified by inspecting the figure below. This is true since the number of steps in the lattice is relatively high.

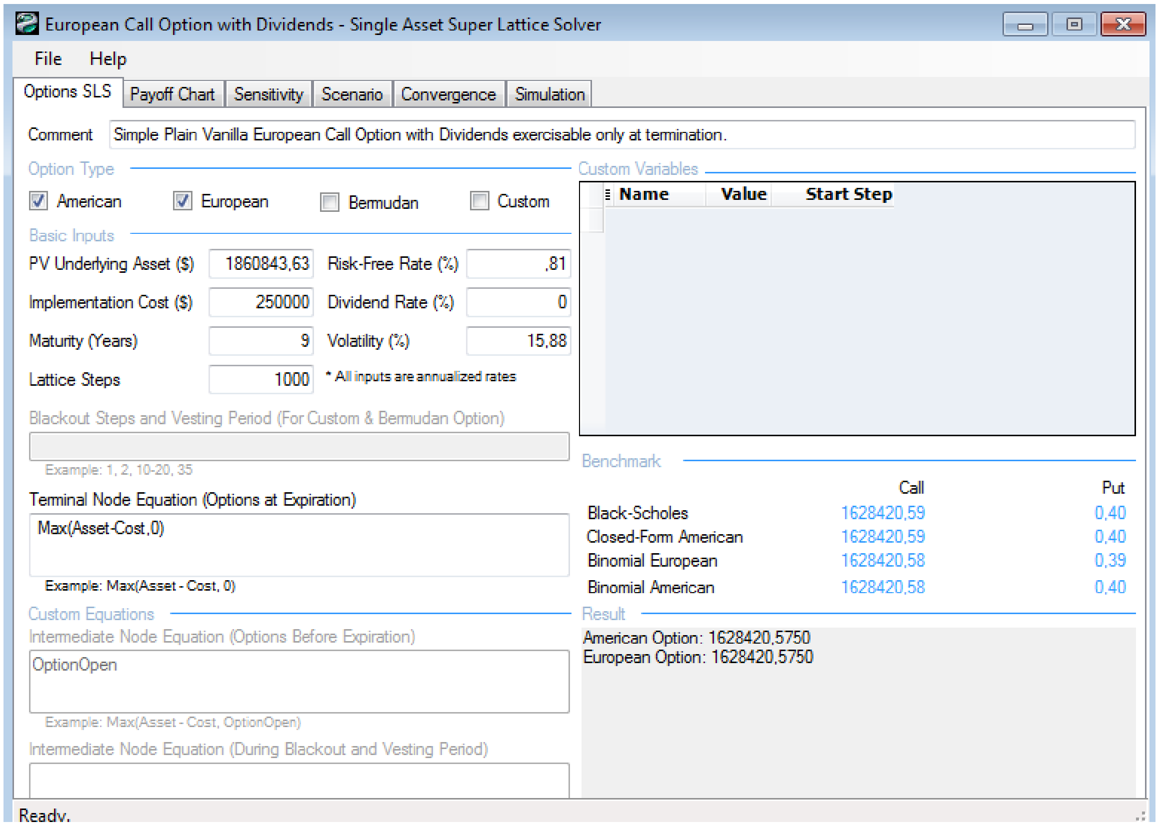

Figure 12: ROV: Black-Scholes value - expansion.

5.3.3.2 ROV: The Value of selling the product in Austria & Germany

Since the NPV of producing and selling RD7 in Austria is negative an option value cannot be calculated directly here. Therefore it will be calculated by finding the value of the option of producing and selling RD7 in Austria and Germany first and then calculating indirectly the value of just producing it, without expanding to Germany.

In this two stage sequential compound option the calculations have been carried out with the following data.

Underlying Asset Lattices *Maturity: 9,00 Years*

Underlying	
PV Asset	4.844.044,92 €
Volatility	12,82%
Notes	

Option Valuation Lattices

Phase2			
Cost	250.000,00 €	*Dividend*	0,00%
Riskfree	0,81%	*Steps*	100
Terminal Equation		Max(Underlying-Cost,0)	
Intermediate Equation		Max(Underlying-Cost,OptionOpen)	
Intermediate Equation (Blackout)			

Phase1			
Cost	424.074,46 €	*Dividend*	0,00%
Riskfree	0,81%	*Steps*	50
Terminal Equation		Max(Phase2-Cost,0)	
Intermediate Equation		Max(Phase2-Cost,OptionOpen)	
Intermediate Equation (Blackout)			

Figure 13: ROV: Assumptions of the expansion + sale scenario.

Phase 1 of the option is defined as the phase in which Phoenics starts to produce and sell serially RD7 in Austria. The implementation cost of this first stage is defined by the initial investment of €150.000 and the opportunity cost of implementation, which involves the decrease in the cash flows resulting from this scenario as compared to the base case.

Phase 2 is defined as the expansion to the German market, the cost of which is estimated to be €250.000.

The value of the sequential compound option is presented in Figures 14 and 15.

PHASE1

										6470019,79
									6202004,11	
								5944118,02		5943176,82
							5695979,33		5695038,82	
						5457220,26		5456280,43		5455339,24
					5227486,90		5226547,76		5225607,25	
				5006438,71		5005500,25		5004560,43		5003619,23
			4793747,98		4792810,20		4791871,06		4790930,55	
		4589099,37		4588162,28		4587223,82		4586283,99		4585342,80
	4392189,44		4391253,03		4390315,26		4389376,12		4388435,61	
4202726,20		4201790,48		4200853,39		4199914,93		4198975,11		4198033,91
	4019493,64		4018557,23		4017619,46		4016680,32		4015739,81	
		3843156,42		3842219,33		3841280,87		3840341,05		3839399,85
			3673454,37		3672516,59		3671577,45		3670636,94	
				3510137,13		3509198,67		3508258,84		3507317,65
					3352963,79		3352024,65		3351084,13	
						3201702,53		3200762,70		3199821,51
							3056130,28		3055189,76	
								2916032,37		2915091,17
									2781202,25	
										2651441,15

Figure 14: ROV: Lattice evaluation - expansion + sale - phase 1.

Summarizing, the value of Phase 1 is €4.202.726,20. Phase 2 is then calculated as follows

PHASE2

										6881906,80
									6613590,96	
								6355404,93		6355063,83
							6106966,53		6106625,67	
						5867907,95		5867567,35		5867226,24
					5637875,31		5637534,96		5637194,10	
				5416528,06		5416187,95		5415847,34		5415506,23
			5203538,48		5203198,61		5202858,26		5202517,40	
		4998591,24		4998251,62		4997911,51		4997570,91		4997229,80
	4801382,90		4801043,53		4800703,67		4800363,31		4800022,46	
4611621,47		4611282,35		4610942,74		4610602,62		4610262,02		4609920,91
	4428687,10		4428347,73		4428007,87		4427667,51		4427326,66	
		4252648,29		4252308,68		4251968,56		4251627,96		4251286,85
			4083244,87		4082905,00		4082564,65		4082223,79	
				3920226,47		3919886,36		3919545,76		3919204,65
					3763352,20		3763011,84		3762670,98	
						3612390,22		3612049,61		3611708,51
							3467117,47		3466776,61	
								3327319,28		3326978,18
									3192789,10	
										3063328,16

Figure 15: ROV: Lattice evaluation - expansion + sale - phase 2.

One can observe that, although the NPV of the serial production of RD7 is negative, if it is followed by the second phase of expansion as specified in the sequential compound option, it is found find that the compound option has a highly positive value for Phoenics, as given by:

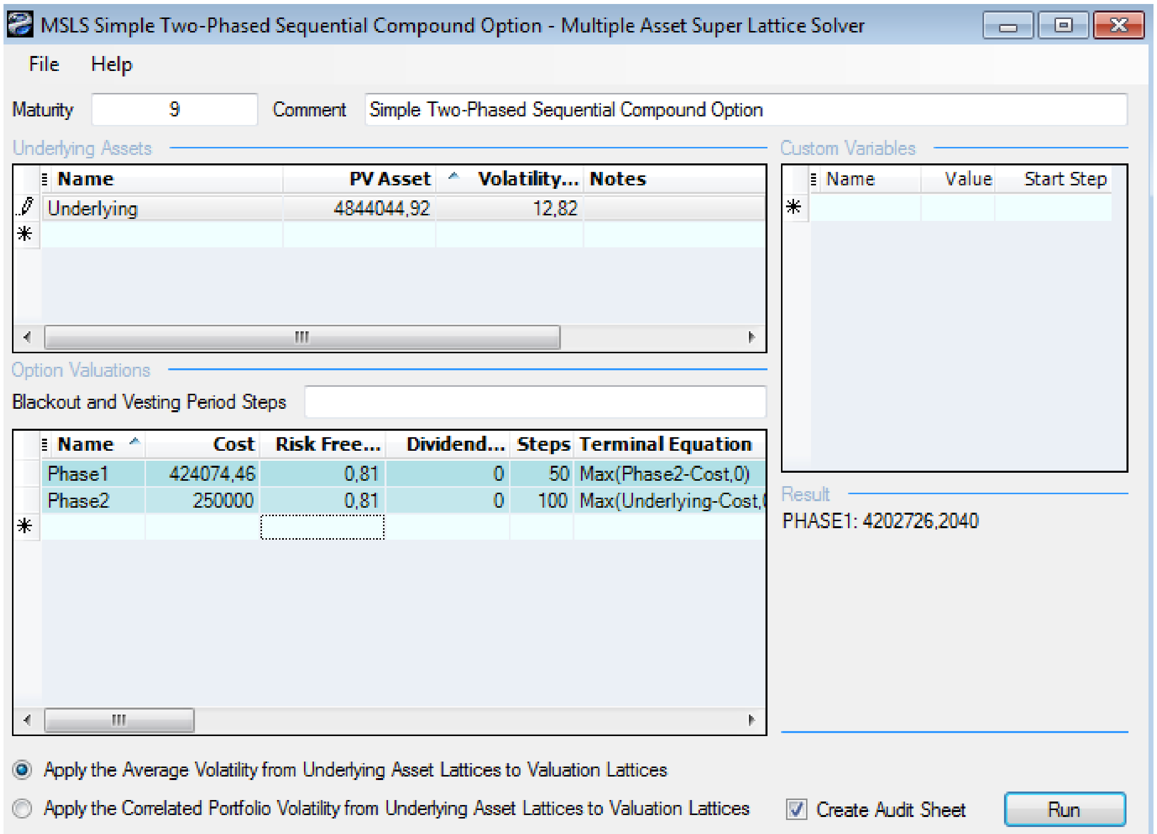

Figure 16: ROV: The value of sale scenario.

5.3.3.3 ROV: The value of selling the product in Austria

The value of the option of selling RD7 has already been determined before. Since the option of selling constitutes a part of the sequential compound option, its value can be calculated indirectly. The result is presented in Figure 16.

The overall value of the option is €4.202.726. This result is surprising as the DCF analysis suggested that the value of selling is negative.

5.4 Valuation of Phoenics with the Real Options method

The valuation of the company consists of the base case DCF scenario and the sum of the real options which can be exercised. Since the option of expansion to Germany without producing RD7 is mutually exclusive with the option of expanding and producing, the option with the higher value should be included in the valuation. Therefore, the option of expansion to the German market without serial production has been excluded from the following analysis.

The remaining two options of

- Serially producing and selling RD7 with a value of €4.202.726,20 and
- Expanding to Germany with a value of € 4.611.621,47

have to be added to the base case FCFF value of €1.429.387,01. The overall value of Phoenics is, therefore estimated at €10.675.191.

The interpretation and implications of this result will be discussed in the following sections.

5.5 Comparison of Real Option Approach and the FCFF method

According to the theory, the DCF valuation should lead to a lower value of the company than a valuation performed with the real options approach. This is true as future risks having negative impact on the DCF valuation, whereas they have a positive impact on the value of the real options.

The base case scenario is equivalent to the standard DCF valuation and yields the value of the firm equal €1.429.387. This result would be the value of the company not taking into account any strategic option that occurs. However, calculation of the three possible scenarios leads to the following result:

Table 30: Summary of the NPV valuations.

	Sales	Expansion	Expansion + Sales
NPV	EUR -274.074	EUR 1.860.843	EUR 4.844.044

These values can be seen as direct values of the options to follow the specific scenario. Analysis of these values shows a huge strategic impact of these options. One can clearly see that expansion of the company to the German market would result in a substantial increase in the value of the firm. One can further notice that expanding and selling the product in the German market creates even higher value. It also shows that the company should not sell the product in the Austrian market alone. Assuming that the company analyzed only this strategic option it would clearly have to reject it.

Comparing the value of Phoenics found with DCF and Real options approach if RD7 is produced serially leads to a result of € 1.155.312 for the former and of €5.632.113 if the value of the option is added to the base case. The final valuation when comparing the result of the scenario where Phoenics expands and produces the product yields a valuation of € 10.675.191 with the real options approach and of €6.273.431 with DCF.

Further investigation of the real option valuation shows an even more interesting picture. Through the calculation of the compound option of selling and expanding it is possible to recalculate the value of the option to expand which is € 4.611.621, rather than €1.628.420 without the compound effect. Furthermore, it is possible to calculate the value of the option the sell which is € 4.202.726, whereas the NPV suggested a negative value of this scenario.

These results clearly reflect what has been expected: the real options valuation always leads to a higher result than DCF valuation if WACC and uncertainty are high. This fact is obviously advantageous for uncertain projects or startup companies who seek financing. It is worth to mention that according to the DCF valuation it is not advisable for Phoenics to produce the product serially. On the other hand, keeping in mind the underlying assumption of the ROV, the real option approach clearly recommends them to do so. The latter result shows that the valuation of projects or startups can be very subtle or even lead to wrong decisions.

However, the above mentioned strategic impact of different valuation methods is of main interest here. Whereas DCF would lead to the strategic decision of not producing RD7 serially, ROA suggest the opposite. The difference in the valuation itself is immense. Assuming that Phoenics is a risk averse company, having calculated solely the value of producing the product serially the firm would clearly have to reject it. In practice, they would not even consider expanding to Germany and producing RD7 serially because the single value of producing serially is readily negative. Most probably the company would therefore remain with its current business which results in a corporate value of € 1.429.387 instead of taking the opportunity to expand and produce serially, reaching a value of € 10.675.191.

6 Conclusions and Prospects

In the beginning of this work it has been described in an exhaustive way, what valuation methods are used in practice with a particular emphasis on the different discounted cash flow valuations and their main value drivers, which mainly consist of the predicted cash flows and the discount rate.

The limitations of the traditional valuation methods for valuing high technology start-ups can be determined through various factors. Practical problems associated with DCF include undervaluing intangible assets which currently produce little or no cash flows. Furthermore, DCF normally runs into difficulties with the estimation of asset's economic life, suffers from forecast errors of the future cash flows and exhibits non-constant nature of the weighted average cost of capital discount rate over time. Additionally, the method assumes that all risk related to the project is fully incorporated in the discount rate, for which risk decreases the value of the firm, whereas the real options method sees it as chance. Taking into account all the drawbacks, leads to a conclusion that DCF is usually undervaluing high tech projects. On the other hand, real options create higher values of projects. The higher the chance (in DCF words it would be risk) - the higher the value.

Having analyzed the theory behind both valuation methods, they have been used them in a practical case study of a company: Phoenics OG. Phoenics OG has a patent for their innovative product RD7 and three strategic opportunities: to expand, to produce it serially or to do both. For the case of Phoenics OG, valuation performed with the real options approach yields higher results than one done with the traditional DCF method. As it is a well-known critique of the real options that the method tends to lead to artificially high valuations, this result is not surprising.

The results are shown in the table below:

Table 31: Summary of the ROA valuations.

	ROA
Sales	EUR 4.202.726
Expansion	EUR 4.611.621
Expansion + Sales	EUR 8.814.347

The value of the patent itself can be determined as the value of the real options, since the patent allows the company to exercise these options. Without the patent, Phoenics would just be one of many similar advertising companies in Germany. The patent allows the expansion to new markets as well as the commercialized production and sale of the patented product. It is possible, therefore to determine the value of the patent being €8.814.347,67.

It is however worth mentioning what the strategic impact of the real option valuation is. According to the DCF valuation it it is not reasonable to serially produce and sell RD7 in Austria, as the NPV of the project turned out negative. The real option valuation, on the other hand, predicts a positive value.

Although, as shown by the sensitivity analysis, the uncertainty seemed to be of low importance for the results of the model, it is obvious that high volatility influences the results in the real options approach. Since it has been assumed the Phoenics OG does not have the capacity to expand all over Europe quickly, the assumed volatility was relatively low. On the other hand, if one considers an internet start-up for which the size of the worldwide market is of high significance, shows what influence uncertainty might have on the value of the projects.

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