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*V*ALUING INFORMATION

- *As an extension on the option to defer*

Master's thesis within Business Administration

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Abstract

Our purpose with this study is to show how information can be valued, as an extension on the option to defer. By using EVPI (Expected Value of Perfect Information) when valuing information, we have developed a framework that can be used when performing valuation on different investment situations. The study will be performed containing the qualitative method, although the study contains mathematical formulas, a bigger weight of the study for reaching its goal lies in the detailed explanaition on how the two methods can interact and what it means.

Our results indicates that the use of the framework presented is more suitible than the use of only the traditional DCF-method (Discounted Cash Flow-method), though, readers must be aware of different hurdles that can arise, e.g., that the user of the invesment method does not fully understand the concept of the situation contra method used. By using the framework, financial experts and decision makers receive more foundations to make efficient decisions concerning different investment situations. Though, they have to be aware of that the probabilities calculated are no garanties that future events really are going to occur.

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1 Introduction

Galileo Galilei once said (Gaarder, 1991, pp. 210)[1]; "measure what can be measured and make those things that can not be measured measurable." The reality for many managers and financial experts is that they do not know how to value (or measure) intangible assets. This is clearly a problem in the decision making process that takes place when deciding whether to invest in a project or not. We provide a study where we show how a project can be valued, including the intangible assets, options and information. The project is taken from Volvo Powertrain AB and we use the valuation model Real Options Analysis (ROA), and more specifically, the option to defer, which means that managers and financial experts are exercising the right to wait for additional information before deciding which actions to take. Information can be gathered about different possibilities and outcomes the company can take and have, by pursuing active management. They can also value information, to see if it is preferable to proceed with the project or not. To calculate the value of information, we use the term Expected Value of Perfect Information (EVPI), which means that all uncertain events that can affect our choosen company´s (in this case Volvo Powertrain ABs) final asset position still occur with the given probabilities but that the information gathered can be used to determine the company´s optimal strategy.

We want to show that intangible assets are not just something bad that is here to make life hard on managers and financial experts, but that it contains alot of value that they can play on. By mapping out as much value as possible from an investment situation, they can gain a more representative value and be prevented from making to hasty decisions.

The competitative business of today does not always alow managers to make the optimal (or qualitiative) decisions they would want to make beacuse the lack of time and knowledge. We provide a work that shows how real option analysis and information valuation can be calculated and how they can interact. By mapping out both tangible and intangible assets, managers can get a bigger understanding and insight of the investment situations they face and thereby make better or optimal decisions for the company.

Both option valuation (ROA) and information valuation (EVPI) are fairly new models in the financial economics. Since ROA will lie as a base in our study, we found it important to give a brief introduction to the model and a more detailed explanation in the theory chapter. The work on information valuation is rather limited, mainly consiting of presentations of high complex mathematical formulas. We will not join this unit since we know that many pracitioners only would open it up, to through it away about a second later and never look at it again. Though, our study consists of some statistics, it is not something that can not be overcomed.

Our ambition in this initial chapter is to give our readers an insight in the subject and problem area. We describe why we have chosen the subject and which goals we want to fulfil with this study.

1.1 Background

A REVOLUTION IS HERE. This could infact be the headline of several business papers in the 1970´s when Black, Scholes, and Merton in 1973 devised rigorous "arbitrage-free" solutions that options began to be properly understood (Copeland & Keenan, 1998). The beginning of a new economic era was here to stay. Myers made the real options framework somewhat proper and understandable in 1977, while he introduced the expression "Real Options" in 1984 (Alessi, 2003).

Despite the fact that the option framework was introduced as late as the 1970´s, people have always dealt with options. In fact, the first known real option account was made, according to the writings of Aristoteles by the first known pre-socratic philosopher, Thales from Miletos. According to the writings, Thales had predicted a bountiful olive harvest that would occur in 6

[1] The translation (from swedish to english) is made by the authors.

months. He did not have much money, so instead of renting the olive presses immediately, he bought the right to rent them at the usual rate. So, when the record harvest occured, the growers were clamoring for pressing capacity, Thales rented the presses to the growers at above the market price. That is, he paid the normal rate to the owners of the olive presses and kept the difference for himself. We do not belive that Thales had made any calculations about what that move was worth, so they did not have to face the complexity about the intangible assets that we face today. Intangible assets like the option to defer, to expand, to contract, to abandon, to switch, and so forth, can all be valued using real options (Copeland & Keenen, 1998).

Though, real options has been known for a long time, they have not been much used in the evaluation process of corporate investments. Many authors have pointed this problem out along with reasons for why this is so. Copeland and Keenan (1998) stated that some reasons are that the mathematics are to comlex and thereby making the results hard to grasp intuitively, although, it has then been more adjusted for use when evaluating investments (Davis, 1998), and the original techniques required the source of uncertainty to be a traded world commodity such as oil, natural gas, or gold (Copeland and Keenan, 1998). Another problem we believe exists, is the basic fact to recognize the options in real life. Despite which industry that is being evaluated, managers make their investment moves according to the information base they have.

Whenever a company considers a decision concerning resource allocation, there lies some calculations that shows what that move is worth. It needs to be stated that a critical determinant of how a company allocates it´s resources is based on how it estimates value (Luehrman, 1997). Investments in strategic projects, such as R&D and investments in information technology are not expected to bring immediate payoff, instead, these project payoffs may occur in many different forms and at unknown times in the future. But still, these strategic moves have some value and Real Option Analysis (ROA) can be used to properly evaluate these kind of projects (Miller & Park, 2002).

The three prerequisites for real options are flexilibity, uncertainty, and the arrival of further information (Copeland & Keenan, 1998, and Copeland & Antikarov, 2001, briefly mentions this in their work), although we sometimes feel that the arrival of new information does not get as much space in the spotlight as it deserves. We believe that the possibility of the arrival of new information will be the guideline through the choice of possibilities and outcomes that the managers and financial experts have identified for the company.

We want to outlight the importance of information in this study. We know for a fact that many managers are only interested in the numbers presented by the financial experts. If the numbers are positive, invest, if negative, do not invest (more or less). We do not believe in these kind of black or white ways to look at things of life. The complexity is much higher, so also for various investment situations. We have already briefly mentioned why financial experts neglect some intangible assets, due to the complexity they add to the calculations, but still the complexity is not an excuse not to attack a problem. For example, the basic element to define the value of an intangible asset can make managers and financial experts shudder (as we will discuss below). Another reason we believe for why experts neglect some intangible assets, and why they still have not got the impact that we believe they deserve, is that (as we have mentioned above reagarding ROA) they are fairly new in the calculations and still somewhat complex. Therefore, we want to extend the analysis on real options to include information valuation as well. By turning the abstract term information to something concrete, by transforming it into numbers, we believe that the intangible asset information can get a stronger hold in the calculations of investment situations and be a better guideline that will, hopefully, in the end lead to more optimal decision being made.

1.2 Problem discussion

Both ROA and the valuation process for EVPI are dependent on that assumptions are made. These assumptions are subjective and will be highly influenced by the financial expert that performs the calculations. Assumptions made on the probabilities, volatility and the time to maturity will always have some marginal error.

The problem with intangible assets is to quantify the proper value for the respective asset, and the term value can be difficult to interpret. There exists several appellations of the word, e.g., relative value, absolute value, market value, equity value, and so forth.

Different objects have different values. Take a wedding ring for example. This ring has a much higher value than the gold that sorrounds the ring for the owner, it also has a symbolic value that can not be estimated, partly because this value is non-existent for an outsider and partly because the owner of the ring can not make an objective valuation of it´s value, due to the symbolic value. The same thing holds for an entrepreneur that has spent all his life building a company. A multinational enterprise that considers buying this company, only sees the value on the company based on it´s assets and future cash flows, while the entrepreneur also sees the unvaluable social aspects.

These abstract values (that can not be valued properly), makes the intrepretation process much more difficult of the term value. Even concrete objects like the wedding ring can have different values for different people. Some people trade daily with gold without any greater consideration (except, of course, to make a profit) while others make a lifelong commitment with the exchange of a tiny piece of gold. We will not extend the discussion about defining value in this study, but as we have mentioned above, this is a more basic elemental problem for defining intangible asset value, why it is important to be aware of the complexity involved.

An important thing to keep in mind when it comes to informational value, is that if managers are exercising an option to defer to e.g. collect additional money for a project and they are planning to make the same decisions regardless of the arrival of new information, this new information has no value. But, when they are exercising the right to wait for new information before making a decision, and this information will lie as a base for the next moves managers will make, it will also have an expected value.

Our purpose with this paper is not to higlight real options as an excellent method to use when calculating investment opportunities. Even though we consider it to be a step in the right direction towards a more representative value of an investment, it still has some drawbacks and limitations, as any other method. We believe that real options are going to get a bigger hold in the economy.

The economic heroes of the 70´s have made it possible to quantify the intangible asset options, and we want to extend the framework to information. We believe that information is the key parameter to every investment decision, though it is not included in the calculations of any investment method. Therefore, we want to perform an analysis on real options to also include another intangible asset; information. We ask: *How* c*an information be valued properly, as an extension on the option to defer?*

1.3 Purpose

We want to provide a study that investigates how the option to defer and valuing information can interact.

1.4 Disposition

To receive an overview of the study, we can categorize the disposition into two parts. Firstly, where we provide an brief describtion of the content of each chapter, and secondly, by illustrating the process we have used throughout the study.

In chapter 1, we start by giving an introduction to our background, problem and purpose. Chapter 2 contains relevant information concerning the subject-area. We then move on to present the methods used through the study in chapter 3 We show our empiricial study in chapter 4 and present our analysis on the empiricial study and problems with it along with conlcluding results/discussion and proposals for future research in chapter 5.

Our process of the study can be illustrated using figure 1-1, below:

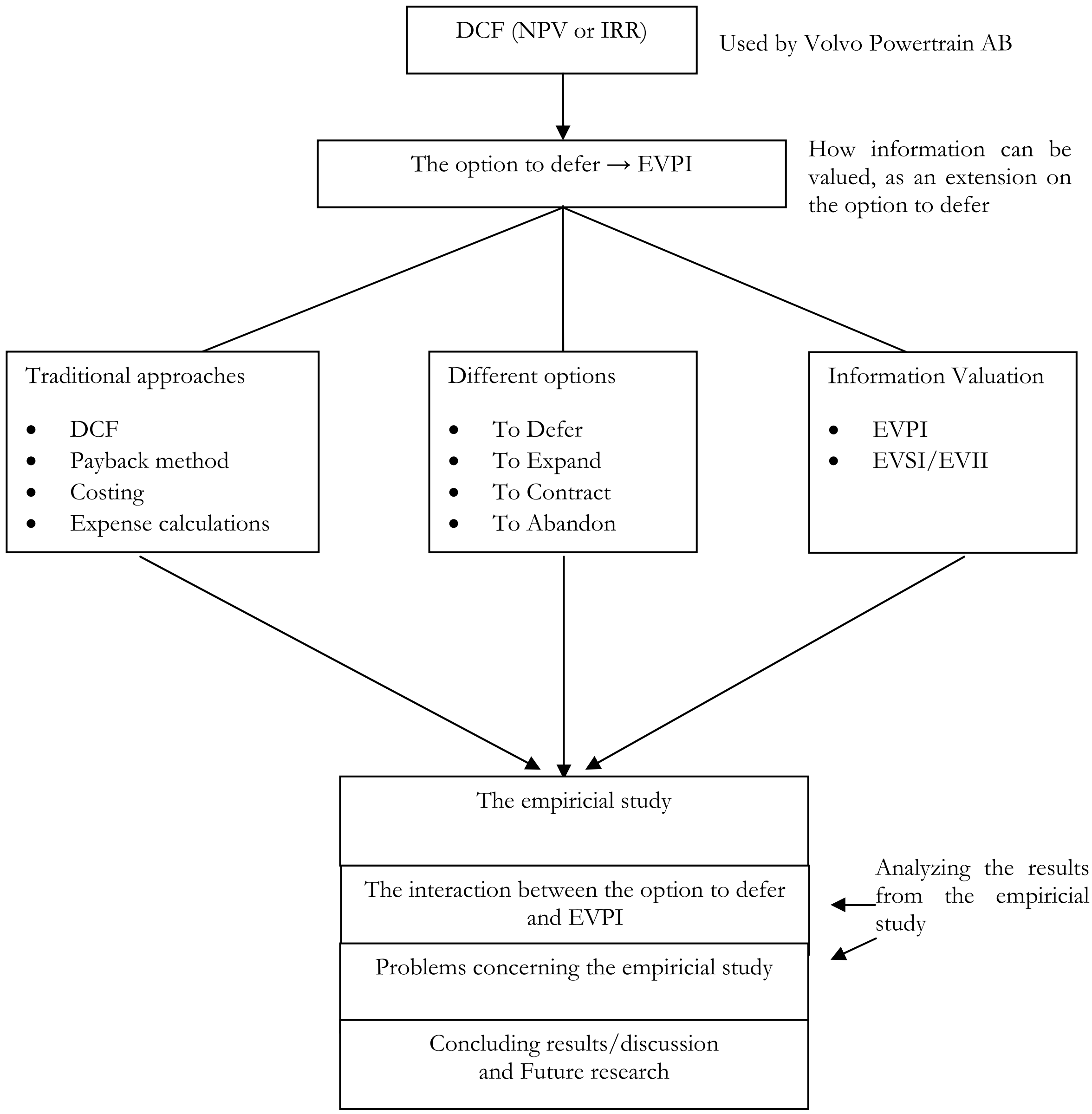

Figure 1-1 Summary and overview of the process of the study.

Figure 1-1 above starts by showing our problem area (chapter 1) and how we use Volvo Powertrain ABs investment situation as a base when we later on in the study show how the option to defer and EVPI can interact. The project collected from the company will constitute as the base for the calculations to come on the option to defer and EVPI and in the end, for solving our problem. The literature (chapter 2) consists first of several traditional approaches, which are used today in various companies and investment situations. Since Volvo Powertrain AB already use NPV, to reach our goal, we will identify the appropriate option for the project, which in this case is the option to defer (among the several options that exists in ROA, see later chapters for a more detailed explanation for why this is so). To be fully prepared for the calculations, we also have to identify which of the to two information valuation methods serves best for calculating the information value in our study. We find that EVPI is most appropriate, which we will discuss later on in the study. We begin our empiricial study (chapter 4) by giving a brief introduction about our company (Volvo) and also about the investment situation. We then present our calculations and assumptions about the option to defer and EVPI carefully in the same chapter, which serves as a base for our analyzing study (chapter 5), were we evaluate the study and provide foundations for future research. We provide a framework and show how the option to defer and EVPI (along with the DCF-method) can interact and explain why we consider our framework to be appropriate in investment situations. We also bring forward problems that are associated when performing such calculations and summerize our concluding results/discussion and provide foundations for future research.

As can be seen, the theory chapter lies before the method chapter, which may seem somewhat unorthodox in this context, but not in any way wrong. The main reason for why we choose to put the theory chapter before the method chapter is because of figure 1-1, that we have presented above and which serves as a base for how we will reach the goal of the study from our starting-point. To be able to get an overview and understand the concept of the figure, we find it important for the reader to go through the theory chapter before reading the method chapter (if the reader is not already highly familiar with the subject areas, ROA and EVPI).

Another reason for choosing this structure is that we find that the method chapter and empiricial study chapter are related in the sense that we in the method chapter present the methods used and describe why we have choosen those methods. The empiricial study chapter does not only contain the calculations made, but we also describe how we have made those calculations (the process for bringing forward the results of the study). It can also be discussed whether the process should lie in the method chapter or not, and that we only should present our calculations made in the empiricial study chapter. We have come to the conlcusion that to receive a smother transition between the chapters and, more importantly, to get a more understandable overview of the calculations, we found it necessary to seperate the contents in this way.

2 Theory

We begin this chapter with giving a brief introduction to options and then move on to mention traditional approaches used in investment valuation processes. We describe the term ROA and finally, we present the theory on valuing information.

2.1 Options

To start the theory section, we want to give a brief introduction to the term options. There exists two basic types of options; call options that gives the holder the right to buy the underlying asset at a certain date for a certain price and put options that gives the holder the right to sell the underlying asset at a certain date for a certain price (Hull, 1993). The important thing to notice is that the holder of the option has the right but not the obligation to buy or sell an option. The price, for which the optionholder can buy or sell his option is called the strike price or exercise price. We have illustrated the two payoff diagrams below, which represents the cash payoff on an option at expiration (which is the last date for which the option can be exercised). Starting with the call option, the diagram illustrates that the net payoff is negative (and equal to the price paid for the call option) if the value of the underlying asset is less than the strike price, i.e., the gross payoff is the difference between the value of the underlying asset and the strike price, if the price of the underlying asset exceeds the strike price. The net payoff is the difference between the gross payoff and the price of the call. The opposite thing holds for the put option. The put option has a gross payoff equal the difference between the strike price and the value of the underlying asset if the asset value is less than the strike price. It also has a negative net payoff if the value of the underlying asset exceeds the strike price, as can be seen below in figure 2-1 and 2-2. (www.damodaran.com, 040226).

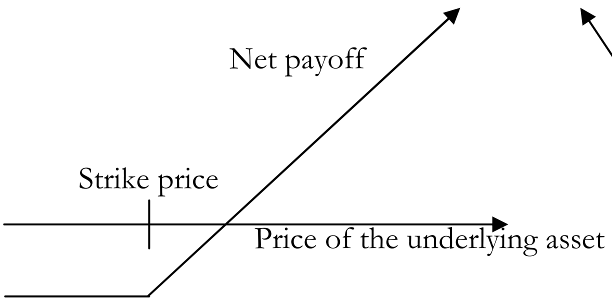

Figure 2-1 Payoff on Call Option.

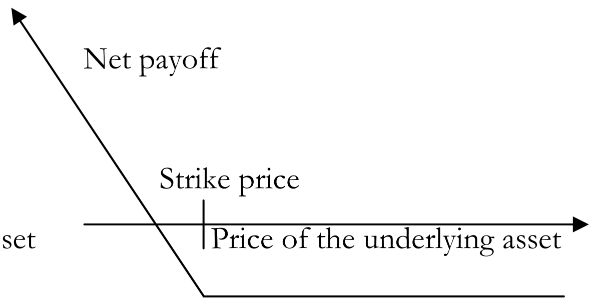

Figure 2-2 Payoff on Put Option.

There also exists two kinds of option types; Amercian option and European option. The Amercian option can be exercised at any time up to the expiration date while the European option can only be exercised on the expirition date itself (Hull, 1993). The Amercian option is therefore more valuable, due to the possibility of early exercise, but they are also more difficult to value (www.damodaran.com, 040226).

2.2 Tradition approaches

There exists several approaches to value an investment, e.g., payback method, net present value (NPV), expense calculation, costing, and, internal rate of return (IRR) (Sandahl & Sjögren, 2002). However, the NPV method is the most used method among these traditional approaches (Luehrman, 1998b). It is included in the traditional DCF-method family (along with IRR) (Sandahl & Sjögren, 2002) and it is the method used in this study. This is due to the fact that the DCF-method (NPV and IRR) is a prerequisite when performing ROA. In other terms; ROA is an extension to the traditional DCF, not a substitute for it (Mun, 2002).

The net present value is an accept-or-reject kind of investment method, i.e., if the benefits outweights the costs, you should invest, otherwise, do not do it. The NPV method can briefly be presented as a method that involves four steps of calculation. The first thing is to choose an appropriate discount rate and then to compute the present value of the cash proceeds expected from the investment. The third thing involves computing the present value of the cash outlays required by the investment, and finally, to sum the present values of the proceeds minus the present value of the outlays. The sum is the net present value of the invesment (Bierman & Smidt, 1993).

2.3 Differences between DCF-method and ROA

Mun (2002) describes some differences between DCF and ROA.

DCF Assumptions	**Realities**
Decisions are made now, and cash flow streams are fixed for the future.	Uncertainty and variability in future outcomes. Not all decisions are made today, as some may be deferred to the future, when uncertainty becomes resolved.
Future free cash flow streams are highly predictable and deterministic.	It may be difficult to estimate future cash flows as they are usually stochastic and risky in nature.
All risks are completely accounted for by the discount rate.	Firm and project risk can change during the course of a project.
Unknown, intangible, or immeasurable factors are valued at zero.	Many of the important benefits are intangible assets or qualitative strategic positions.

Table 2-1 Differences between DCF and Realities (Mun, 2002; page 59).

According to Miller and Park (2002), the DCF-methods have three main limitiations. Firstly, the authors argue the problem of selecting an appropriate discount rate. Second, is that the DCF techniques does not take the flexibility into consideration, i.e., to adjust decisions along the value chain when and if new information arrives. Third, is what Mun (2002) above also states, that decisions are typically viewed as now or never type of decisions. Although it does not seem so, traditional DCF-methods do have some advantages (Mun, 2002):

- They are clear, consistent decision criteria for all projects
- They give the same results regardless of risk preferences of investors
- They have a quantitative, decent level of precision, and are economically rational
- Another thing is that they are not so vulnerable to accounting conventions (depreciation, inventory valuation, etc.)

An alternative way to view the differences between DCF and ROA is provided by Lint and Pennings (2001). They identify four different areas in were the two investment tools act in:

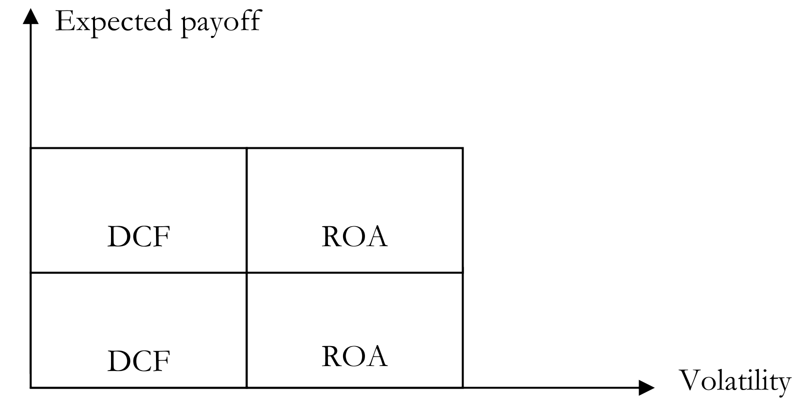

Figure 2-3 DCF and ROA in relations to expected payoff and volatility.

According to their work, the high expected payoff combined with low volatility is the ideal environment for DCF. The DCF techniques should also be used for the combination of low expected payoff and low volatility, but the project should be abandoned. The other two cases are where ROA works best; high expected payoff combined with high volatility and low expected payoff combined with high volatility.

2.4 Why, when and where to use real options

The traditional DCF-methods lie on the assumption that there exists perfectly certain project cash flows, although, in the real world, this can not occur when someone is predicting the future. Miller and Park (2002) writes that the NPV method works best for cost-reduction type problems when future cash flows are relatively certain. We want to underline the word realtively as not absolutely certain. The differences were the traditional DCF-methods and the ROA works best can also be seen in the two figures (figure 2-4 and 2-5) below:

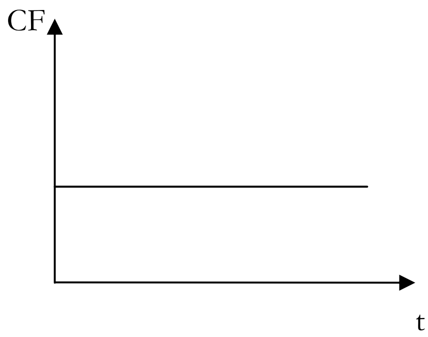

Figure 2-4 Traditional DCF.

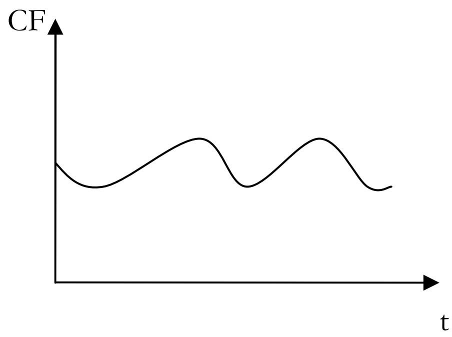

Figure 2-5 ROA.

As can be seen from figure 2-4, DCF assumes that the cash flow stream is constant and predictable while the cash flows in figure 2-5, concerning ROA, are more volatile due to the fact that future cash flow streams can not be predicted with absolute certainty (Leslie & Michaels, 1997).

Due to the high uncertainty, ROA assumes multiple decision pathways while DCF only assumes a single decision pathway with fixed outcomes, which are made at the beginning without the ability to change and develop over time. According to ROA theory, managers has the flexibility to make midcourse strategy corrections when there is uncertainty involved and as the managers get hold of more information and the uncertainty becomes resolved, the management can choose the best strategies to implement. Managers have the right to adapt given the change in the business environment, because ROA assumes a multidimensional dynamic seris of decisions (Mun, 2002). *It can basicly be stated that real options are important in strategic and financial analysis because traditional valuation tools ignore the value of flexibility* (Leslie & Michaels, 1997).

When to use real options can be summarized in three points (Copeland & Keenan, 1998 page 46):

1. When there exists high uncertainty about the future and when it is very likely to receive new information over time.
2. When management can use their flexibility properly and when they can respond appropriately to new information.
3. When the NPV without flexibility is near zero i.e., if a project is neither obviously good nor obviously bad, flexibility can change the course of a project and should therefore be more valuable.

We want to make an extra note on the first point, concerning uncertainty, an the two types of market and private risk (or uncertainty). The part that concerns the *private risk* (or technological uncertainty) is unique to the firm and includes equipment failures and labor difficulties. The other part is *market risk* (or economic uncertainty), which is tied to the economy and concerns demand, competitive pricing schemes, and macroeconomic factors. Private risk (which is also called unsystematic risk in different finance textbooks) can be diversified away by proper handling of the company´s economy. Market risk (which is also called systematic risk) is therefore all that should concern the decision-maker (Miller & Park, 2002).

According to Mun (2002, page 24), there are several areas where ROA are crucial, and those are:

- Helping management navigate by identifying different corporate investment decision pathways or projects, given the highly uncertain business conditions.
- Valuing each strategic decision pathway and what it represents in terms of financial viability and feasibility.
- To based on a series of qualitative and quantitative metrics prioritize these pathways.
- Optimizing the value of your strategic investment decisions by evaluating different decision paths under certain conditions or using a different sequence of pathways to lead to the optimal strategy.
- Finding the optimal trigger values and cost or revenue drivers and timing the effective execution of your investments.
- To manage already existing or developing new optionalities and strategic decision pahways for future opportunities.

2.5 Option value levers

In both financial and real options, there exists six levers that are used when calculating the option value. The signs used for calculating the option value is the same for both financial and real options, though they have a different definition in the respective lever (as can be seen below in table 2-2).[2]

[2] See Appedix 1 for further explanation about the option value levers.

Financial option	**Levers**	**Real option**
Stock price	**S**	Present value of expected cashflows
Exercise price	**X**	Present value of fixed costs
Dividends	**δ**	Value lost over duratin of option
Risk-free interest rate	**r**	Risk-free interest rate
Uncertainty of stock price movements	**σ**	Uncertainty of expected cashflows
Time to expire	**T**	Time to expire

Table 2-2 Option value levers (Leslie and Michaels, 1997, page 9).

2.6 The main options and their characteristics

Trigeorgis (1993) has listed the most common options used today.[3]

- Option to defer
- Time to build option (staged investment)
- Option to alter operating scale (e.g., to expand; to contract; to shut down and restart)
- Option to abandon
- Option to switch (e.g., outputs or inputs)
- Growth options
- Multiple interacting options

Mun (2002) gives additional examples on options:

- Compound options
- Sequential options
- Chooser options
- Barrier options

Copeland and Antikarov (2003) also mention:

- Rainbow options

2.6.1 The option to defer

Since we are focusing on the option to defer to solve our problem, we find it both appropriate and necessary to outlight this option amongst the several options that exists in ROA.

Trigeorgis (1993) argues that the option to defer e.g., is the case where management holds a lease on (or an option to buy) valuable land or resources and that it can wait (x years) to see if output prices justify constructing a building or plant, or developing a field. The most important areas were the option to defer is used are in natural resource extraction industries,

[3] For further information about the different options, see Appendix 2, except for the option to defer, which is presented more detailed in paragraph 2.6.1, since this option will lie as a base for the study.

real estate development, farming, and paper products. The author continues by arguing that since an early investment in a project implies that the option to defer is sacrified, the option value loss is like an additional investment opportunity cost that is only justifying investment if the value of cash benefits actually exceeds the initial outlay by a substantial premium. Copeland and Antikarov (2003) mean that it can be a parable to the American call option and that it is found in most projects where the managers or financial experts has the right to delay the start of a project.

2.7 Drawbacks and limitations with ROA

As good as this investment tool may seem to be, it still has some drawbacks. Before going into details about the drawbacks and limitations of ROA, one thing has to be kept in mind when working with real options and that is that most, if not all, of the real option parameters are estimated. So, there does not exist a single model to use for every investment decision, every example of investment has its one specific critera to work from and a general map for using ROA does therefore not exist. This implies errors to be made, and errors will most certainly be made, because one can not predict the future, but what can be done is to minimize these errors through active management handling of the projects. We will, in this section, bring forward the drawbacks and limitations that we believe are most important to keep in mind before continuing through the study.[4]

2.7.1 The appropriate discount rate

There are those that claim that real options are valued as financial options and should therefore use the risk-free rate for all discounting (Miller & Park, 2002), while others argue that cash inflows and cash outflows should use different discount rates due to the different riskiness in the two parameters. Cash inflows should be discounted using a higher discount rate because it is riskier and more uncertain than cash outflows which are more predictable and should therefore be discounted at a lower discount rate. This could otherwise lead to an over optimistic or to pessimistic estimation of the NPV (Luehrman, 1998a).

2.7.2 Volatility

Estimating the volatility is very important and hard in real options. It means that the uncertainty about the future value of the project´s cashflows (i.e., the riskiness of the project) corresponds to the standard deviation of returns on the expected cashflows. Luehrman (1998a) argues that a necessity to measure uncertainty is by assessing probabilities. He provides his readers with an excellent example. The example concerns a project´s future value and that all its possible future values lies in an urn, weighted according to their likelihood of occuring. This means that if a value of € 50 were twice as likely as € 25 or € 75, there would be twice as many € 50 balls in the urn as € 25 balls or € 75 balls. Luerhman (1998a) continues by arguing that the most common probability-weighted measure of dispersion is variance, which is also often denoted as sigma squared (σ^2). Variance is said to be the summary measure of the likelihood of drawing a value far away from the average value in the urn. It can also be stated that the higher the variance, the more likely it is that the values drawn will be either much higher or much lower than average. High-variance assets are riskier than low-variance assets.[5]

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[4] Interested readers can read Miller & Park (2002) for more information about the limitations and drawbacks with ROA.

[5] We also recommend readers to go through Luerhman (1998a) for more information about the volatility.

There are three ways to estimate the volatility in real options; twin security information, Monte Carlo simulation, and closed-form expression.

The historical return distribution of the twin security can be used as a proxy for the real asset volatility for projects where an appropriate twin security can be identified in the market (Miller & Park, 2002). There will be more information about this way of calculating the volatility, mainly in the subheading 2.9.2, since we use the historical numbers to calculate the volatility. We also mention why we choose this method in the subheading 3.3.1.

As the name suggests, Monte Carlo simulation was named after the attractions of casinos containing games of chance in Monte Carlo, Monaco (Mun, 2002). According to Copeland & Antikarov (2003), we have improved our ability to quantify the risks involved with real options by using the Monte Carlo simulation. Monte Carlo simulation can model the cross correlations among various inputs such as price and quantity, and are fairly simple to use. Although Monte Carlo simulation has been praised (by Copeland & Antikarov and Mun, among other), some critics argue that Monte Carlo simulations can not promise a financially secure retirement precisely because they use random numbers. Questions has been raised whether Monte Carlo simulation can replicate the way markets actually behave (http://planning.yahoo.com/mc3.html, 050802).

The third way to estimate the volatility is the closed-form expression, which can be used to esitmate project volatility as the product of the volatility of the firm´s output price and the price elasticity of the project´s value. An advantage with this form is the ease of which option values can be calculated but on the other hand, the limiting assumptions of the models need to be carefully studied understood, and applied correctly (Miller & Park, 2002).

2.8 Decision lattice

Decision tree analysis (DTA) is a long-standing method for attempting to capture the value of flexiblitiy (Copeland & Antikarov, 2003), and it involves building a tree representing all possible situations and decisions managment can make in response to them (Copeland & Keenan, 1998). Decision trees are a great way of depicting strategic pathways that a firm can take, graphically showing a map of decisions of management´s strategic initiatives and opportunities over time (Mun, 2002).

Decision trees and real option valuation is closely related by the meaning that if you can implement the first, it is not hard to implement the second (Copeland & Keenan, 1998). However, it is important not to replace the analysis with decision trees completely, but to combine DTA with ROA (Mun, 2002). The option approach can be interpreted in the decision tree context as modifying the discount rate to reflect the actual riskiness of the cashflows (Copeland & Keenan, 1998).

Though, Mun (2002) states that binomial lattices (trees) are a much better way to solve real option problems because the binomial lattices can ultimately be converted into decision trees, they are far superior to using decision trees as a stand-alone application of real options.

2.9 Different ways to calculate real options

There exists a number of ways to calculate real options, each with its own characteristics and assumptions. We will mention the two most common methods, the Black-Scholes model and the binomial lattice model

2.9.1 Black-Scholes model

The Black-Scholes closed-form model means, that for a given set of assumptions, the equation can reach an option value in a continuous-time context. There exists four closed-form models in ROA; the Black-Scholes, Margrabe, Geske, and Carr, even though the Black-Schoels model is the most known and the first closed-form equation for valuing financial options (Miller & Park, 2002). The assumptions that needs to be accomplished for the Black-Scholes Model to be functional is (Copeland & Antikarov, 2003, page 106):

- That the option is a European option, i.e., it may be exercised only at the maturity date.
- There is only one source of uncertainty.
- The option is contingent on a single underlying risky asset.
- No dividends are paid by the underlying asset.
- The stochastic process and the current market price followed by the underlying are known.
- All through time, the variance of the return on the underlying is constant.
- The exercise price is known and constant.

The equation for the Black-Scholes Model is (Copeland & Antikarov, 2003, page 106-107):

$C_0 = S_0 N(d_1) – Xe^{-rfT}N(d_2)$

where:

S_0 = The price of the underlying

$N(d_1)$ = The cumulative normal probability of unit normal variable d_1

$N(d_2)$ = The cumulative normal probability of unit normal variable d_2

X = The exercise price

T = The time to maturity

r_f = The risk-free rate

e = The base of natural logarithms, constant = 2,1728

$$d_1 = (\ln(\frac{S}{X}) + r_f \; T / \sigma\sqrt{T}) + \frac{1}{2}\sigma\sqrt{T}$$

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

Benninga and Tolkowsky (2002) argue that the Black-Scholes model is not an appropriate framework for ROA because the assumptions that underlie the model are not really appropriate for ROA. They continue by stating that the model is the most numercially tracable model for valuing options. Though, the Black-Scholes model can give an approximation of the option value in the real option framework.

2.9.2 Binomial lattice model

Perhaps the most common binomial lattice model used to solve real option value is the one developed by Cox, Ross, and Rubenstein in 1979. The binomial lattice follows a discrete, multinomial, multiplicative stochastic process throughout time, in comparison with the Black-Scholes model which follows a continuous process throughout time (Miller & Park, 2002).

The binomial lattices are accepted in the industry because they are easy to explain and therefore accepted by the management because the methodology is much simpler to understand (Mun, 2002). Another advantage of binomial lattices is that they are intuitive in the valuation process (Miller & Park, 2002) and the framework is very flexible and can be used to model many option valuations (Benninga & Tolkowsky, 2002). This approach to real option valuation also describes the uncertainty associated with gross project value of each investment opportunity (Herath & Park, 2002).

A binomial lattice can look like the one brought up in figure 2-6. There are no regelations to how many steps (or time-steps) a binomial lattice can or can not have. The time-steps can be defined as the number of branching events in a lattice. We have two time-steps in figure 2-6, and it is starting from time 0 (S_0). It continous with the first time-step that has two nodes (S_0u and S_0d), the second time-step has three nodes (S_0u^2, S_0ud and S_0d^2), and so forth (Mun, 2002).

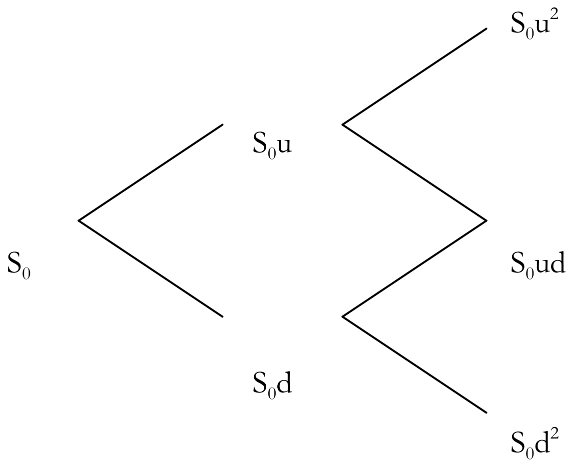


Figure 2-6 The shape of a binomial lattice (Mun, 2002, page 141).

To calculate a problem using binomial lattices is to solve for the up and down movements (Mun, 2002):

$$u = e^{\sigma\sqrt{\delta T}}$$
$$d = e^{-\sigma\sqrt{\delta T}} \qquad \textbf{[1]}$$

The up movement can be explained as the price for one dollar today and the same holds for the down movement (Benninga & Tolkowsky, 2002).

When the movements are solved, we need to know the risk-neutral probabilities (Mun, 2002):

$$p = \frac{e^{rf(\delta t)} - d}{u - d} \qquad \textbf{[2]}$$

Depending on if the option is a call (C) or put (P), the following formulas can be used (Copeland and Antikarov, 2003):

C = MAX(S – X;0) or P = MAX(X – S;0) **[3a]** **[3b]**

To receive the option value (when dealing with European options), we need backward calculation, all the way back to the starting period (Mun, 2002):

[(p)up + (1 – p)down]exp[(-riskfree)(δt)] **[4]**

When dealing with American options, the formula is slightly different, since the American option can be exercised at any date, while the European option can only be exercised at the time to expire. The American option can therefore also have a bigger value (Mun, 2002):

[(p)up + (1 – p)down]exp[(-riskfree)(δt); (S – X;0)] If it is a call option and **[4a]**

[(p)up + (1 – p)down]exp[(-riskfree)(δt); (X – S;0)] If it is a put option **[4b]**

The above calculations are just a few inputs required to calculate the option value. We also have to determine the option value levers, i.e., the present value of expected cashflow (S), present value of fixed costs (X), value lost during options life (δ, see the empricial chapter for more information), risk-free interest rate (r), uncertainty of expected cashflows (σ), and time to expire (T).

To calculate *the present values* of the expected cash inflows and outflows, the net present value formula can be used (Copeland & Antikarov, 2003):

$$PV = \sum_{t=1}^{N} \frac{E(FCF_t)}{(1 + WACC)^t}$$ **[5]**

And to compare the expected cash inflows with the outflows when dealing with the traditional NPV model, the following formula can be used (www.damodaran.com, 040226):

NPV = S – X **[6]**

To determine the *risk-free rate*, you can for example visit the Swedish riskgäldskontoret (depending on which country you operate in) to find an appropriate discount rate that matches the lenght of how long the option to defer can be postponed.

As we mentioned in the subheading 2.7.2, we use historical numbers to calculate *the volaitlity*. We can receive the volatility using the formulas (Mun, 2002):

$$x_i = \ln(\frac{CF_i}{CF_i - 1}) \text{ and Volatility} = \sqrt{\frac{1}{N-1\sum_{t=1}^{N}(xi-\bar{x})2}}$$ **[7]**

where:

n = the number of Xs

$\bar{x}$ = average X values

The tricky thing when calculating the uncertainty of expected cashflows for a company that is not listed, is to collect the appropriate numbers for the volatility. A possible way to overcome this problem is to find a company that is about the same size of our company that we are calculating for and which branch is not to far from our´s. We can then use the company´s historical stocktrade for about 2 years and thereby make the assumption that the chosen company has somewhat the same development as our´s. Other problems that can arise from this way is that the volatility does not fully capture the possible cash flow downside and may produce erroneous results, also, when performing autocorrelated cash flows or cash flows following a static growth rate, it will yield volatility estimates that are erroneous (Mun, 2002).

The time to expire means the time until the option can no longer be postponed i.e., the life of the option. When performing such calculations we also need delta t (δ t), which means the number of steps there exists until the time to expire. The more number of these time intervals, the higher the accurecy of the option value (Copeland and Antikarov, 2003).

In the end, we want to know the value of the option to defer. This is calculated by subtracting the option value (i.e., with flexibility) with the traditional NPV approach (i.e., without flexibility) (Trigeorgis, 1993):

Option to defer = Option value – NPV **[8]**

Or

Option to defer = NPV* - NPV

Where NPV* means with flexibility.

The advantages and disadvantages between the binomial lattice and the Black-Scholes model can look something like table 2-3:

	Binomial lattice	Black-Scholes model
Advantages	• Intuitively appealing • Flexible • Easy implementation	• Simplified calculations • Straightforward
Disadvantages	• Cumbersome • Labor intensive	• Limiting assumptions • Limited applicability

Table 2-3 Advantages and Disadvantages between the binomial lattice and the Black-Scholes model (Miller & Park, 2002, page 117).

We are now done with the theory concerning ROA, and we will continue this chapter by describing the second part of the study that is needed to fulfil the purpose, the value of information.

2.10 Value of information

According to Wall, Thomas and Brady (1999), there are two types of cases to be considered in the context of value of information and those are *the expected value of perfect information* (EVPI) and *the expected value of sample information* (EVSI) *or imperfect information* (EVII). As to our knowledge, different writers use different terms regarding EVSI and EVII, e.g., Goodwin & Wright (1998) use the term EVII while Winston (1994) use the term EVSI, when describing how information can be valued. We will therefore describe these ways to value information, while we use the term EVPI when calculating on the numbers received from Volvo Powertrain AB and to find a solution to the problem of how information can be valued as an extension on the option to defer. Reasons for this choice is discussed in the method chapter, 3.4.1 Validity.

2.10.1 Expected value of perfect information

Wall, Thomas and Brady (1999) defines perfect information as a complete elimination of all uncertainty about the event´s outcome. In other terms it means that all uncertain events that can affect Volvo Powertrain ABs final asset position still occur with the given probabilities and then be used to determine the companies optimal decision strategy. To determine the EVPI, we first have to find *the expected value with perfect information* (EVWPI), which means that the decision maker has perfect information about which state has occured before making a decision by drawing a decision tree. We also have to find *the expected value with original information* (EVWOI), which is the largest expected final asset position that the company would obtain if the test study were not available. The formula for EVPI can be written as follows (Winston, 1994):

EVPI = EVWPI – EVWOI **[9]**

To be able to solve for the information value, we have to construct a decision tree with different possibilities and outcomes that can occur. The decision tree can look like figure 2-7:

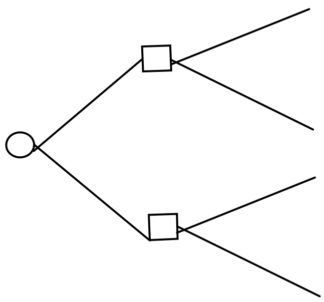
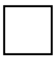
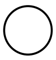


Figure 2-7 The shape of a decision tree that is used to calculate the value of information.



- Decision fork, which means that it represents a point in time when the company has to make a decision (Winston, 1994).



- Event fork, which means when outside forces determine which of several random events will occur (Winston, 1994).

2.10.2 Expected value of sample information or imperfect information

The expected value of sample information (EVSI) means that a company´s expected final asset position is determined based on the assumption that the test study is costless. EVSI shows the highest amount that a company can pay for a test market information and still be at least as well of as without the test market information (Winston, 1994). Wall, Thomas and Brady (1999) argue that when perfect information is not available that it still offers the potential for reducing the uncertainty associated with a decision problem. This holds both for EVSI and *the expected value of imperfect information* (EVII) according to the authors.

To calculate EVSI, we first have to determine *the expected value with sample information* (EVWSI), which is the expected value of the test study information. This is then subtracted with EVWOI or in other terms (Winston, 1994):

EVSI = EVWSI – EVWOI **[10]**

Before entering the method chapter, we still have to describe Bayes´ theorem, which is needed in the calculations of valuing information.[6]

[6] A describtion about how to collect information can be seen in Appendix 3.

2.11 Bayes´ theorem

To perform our analysis on valuing information, we have to use the methods of Bayes´ theorem. This theorem was named after an English clergyman, Thomas Bayes, who got his ideas published posthumously in 1763. We will use Bayes´ theorem as a normative tool, that tells us how we should revise our probability assessments when new information becomes available (Goodwin & Wright, 1998). The normative approach calculates the value of information with the aid of a model of the relation between outcome measures and information (Lord, Jr. 1984).

Before presenting Bayes´ rule, we can give a brief introduction based on Körner & Wahlgren (2000), about different signs, which will make it easier to follow in the process of the theorem and in chapter 4, when presenting our empiricial study:

P(A) means the probability for the event A.

$P(A \mid B)$ means the probability for A given B.

$P(B \cap A)$ means the amount of elements that belongs to both A and B.

Bayes´ theorem can be defined as follows:

$$P(A|B) = \frac{P(B \cap A)}{P(B)}$$

Which means that when A and B are two events defined on a sample space the conditional probability that A occurs given that B has occured, as long as $P(B) \neq 0$ (were $P(B) \neq 0$ means that the probability for B is separated from 0). This expression can also be substituted as (Lancaster, 2004):

$$P(A|B) = P(B|A) * \frac{P(A)}{P(B)}$$

2.11.1 Prior probabilities

Assume that P(A) is the probability assigned to the truth of A before the data has been seen and $P(A \mid B)$ is its probability after the evidence is in. By thinking this way, we can call P(A) the prior probability of A and $P(A \mid B)$ the posterior probability of A. This can then be interpreted as showing how to revise beliefs in the light of the evidence, i.e., how P(A) is changed by the evidence into $P(A \mid B)$ (Lancaster, 2004).

2.11.2 Likelihoods

The expression for the distribution of the data to be observed given the parameter $P(A \mid B)$, or $P(y \mid \theta)$ is called the likelihood function. This holds when y is thought of as the actual data that has been gathered, often denoted by the symbol y^{obs} for clarity. The likelihood is a function of θ with the data values serving as parameters of that function (Lancaster, 2004).

We belive that we now have enough information about ROA and EVPI and that we are ready to move over to the method chapter and begin the process of reaching our goal more concrete.

3 Method

It is important to present the methods and the choice of methods, to receive a reliable study. We want to describe the methods we have choosen to receive the goals of this study in the following chapter. Methods constitute guideling principles for knowledge (Arbnor and Bjerke, 1994).

3.1 Scientific view

Two scientific views that dominates social science are positivism and hermeneutik. Positivismen is about explaining knowledge while hermeneutik is about understanding it (Arbnor and Bjerke, 1994).

Hermeneutik means the theory of interpreting theory and pratice. Positivismen is about generalizing and explaining behavior based on the data that is collected about the social world through application of the theories (May, 2001).

Our base in this paper lies in the hermeneutiska way of thinking, because were are going to try to understand and interpret the theory of information along with the option to defer. We will also receive numbers from Volvo Powertrain AB which will be used as a base for the following interaction between EVPI and the Option to defer (see figure 1-1). Since we have to predict future events when calculating probabilities in estimating information value and calculating on the option value on the option to defer, the objectiveness in the assumptions made is an impossibility (as for any other analyst or author of financial studies). The next best thing is then to focus on bringing forward a representative study made on the valuation process by carefully describing the steps in the empiricial study chapter (as we have mentioned in the initial chapter for why the theory chapter lies ahead of the method chapter and why we believe that chapter 3 and 4 are related).

As we have mentioned, we have to perform forecasts of future events in order to receive the goal of the study, but performing forecasts of future events is just one of many problems that can arise when performing a study such as this one. We therefore highly recommened our readers to carefully go through the section 5.3 concerning problems with the empiricial study and the subheadings 5.3.1 and 5.3.2, so that the reader who wants to perform an analysis on his/her own, can effectively avoid these hurdles.

The reason for why we are focusing on Volvo Powertrain AB is that Volvo is a big company with many employees and a high turnover. As we have mentioned in the earlier chapter, ROA assumes that there exists flexibility, uncertainty and the possibility of the arrival of further information. A one-man company does not always have the possibility to wait for further information before investing in a machine or plant, he or she must act immediately. A big company like Volvo Powertrain AB has the possibilities to act on the three prerequisites in ROA when dealing with investment opportunities.

3.2 Scientific methods

Qualitative and quantitative models are two methods that are separated in social science when collecting and working with information (Andersen, 1998).

Qualitative methods are aiming at describing and explaining the results from examinations (Holme & Solvang, 1997). Methods using mathematical and statistical models when performing measurments and to quantify objects are stated quantitative methods (Backman, 1998).

Our study contains a mix between the qualitative and quantitative method. The first part (the empiricial study) is to receive the required base of calculations performed on EVPI and the option to defer, which the second part (analysis and concluding results/discussion) is aiming to describe how they actually can interact. In the first part, we performe the required calculations, EVPI and the option to defer, independent of eachother, and we describe the course of events, through the chapter. We then move on to provide evidence on how they actually can interact and what the interaction between the two methods mean. The second part is clearly dependent upon the first, and we want to argue that the evidence on how the two methods can interact in combining our goal through the study has more weight. The qualitative method should therefore be the headstone of the two scientific methods.

3.3 Problems in methodology

There are two ways in which problems in methodology can occur. These problems can be that the wrong object is examined (validity) or that it is being measured the wrong way (reliability) (Wiedersheim-Paul & Eriksson, 1991).

3.3.1 Validity

We have been dependent upon receiving representative numbers from Volvo Powertrain AB, to achive the goals of this study. This has affected the validity negatively since we have to trust the numbers we received from the company. We can not conrol if the numbers are valid or not and we therefore have to rely on the fact that the numbers are presented representative.

The reason for why we choose the historical distribution method for calculating the volatility, is that we are somewhat familiar with this method. Since this work is rather limited in time, approximately 10 weeks, we had to rationalize a bit and therefore choose this method among the other two existing methods. Choosing another method would mean that alot more (and valuable) time would be spent on learning different ways of calculating the volatility instead of focusing on the prime target of the study, how information can be valued properly as an extention on the option to defer.

As we have mentioned in the theory chapter, we use the term EVPI because we have made the assumption that (in accordance with EVPI and as we have already mentioned in the introductionary chapter) all uncertain events that can affect, in this case Volvo Powertrain ABs, final asset position still occur with the given probabilities but that the information gathered can be used to determine the company´s optimal strategy (Winston, 1994). We made our assumption based on the fact that we have to believe that the information from Volvo Powertrain AB is representative. We could not get “under the skin” of the investment situation or the company as a whole, while we could not determine whether there was additional information that could indicate that our numbers were not perfect. The other method could therefore require more information and since we were limited to the information about the project, the other method used could affect the validity of the study negatively.

3.3.2 Reliability

We will not be using different methods calculating the same thing in our study, we will use ROA (and more specifically, the option to defer) as a base and then extend the analysis with valuing information (calculating EVPI), so, this will not effect the reliability in our study.

The problem when performing valuation on different investment situations is that most valuation models rely on the fact of subjective assumptions. Every man or woman is unique and will therefore make different assumptions about the same thing, why the final value of an investment will almost always have different results. The best way to receive reliability is to show which logical guesess and resonable imaginations have been used by managers and financial experts (and by us in this study), so that the readers can make their own judgement on the facts and numbers presented.

We will strengthen our reliability by using the process developed in figure 1-1 and also by bringing up problems that can be considered when performing empiricial studies, like the ones in our work, later on in chapter 5.

3.4 Collection of data

Our collection of data and how we use it in the study can be seen in detail in the empiricial study chapter, while we here can provide the reader with a summary with how we have collected infomation. We have met people from the company to receive an overview picture of the investment situation, which is needed in the calculations. We did not send any interview questions in advance, since this was not necessary. We did however preper some workers of our arivial with a simple phonecall that we would arive and what we wanted to know, concerning the prior probabilities we needed about the machines and the occurence of defective and non defective components used in the calulations of EVPI. We also had a discussion with the people who provided us with the initial numbers on the project about the production costs and how long the option could be postponed (all the people we met from Volvo Powertrain AB wants to be anonymous in this study). We also use primary data in terms of meetings with our tutor, who has given us guidlines in how to proceed with the study.

The secondary data is in form of numbers received from Volvo Powertrain AB, books, articles, Internet and other economical reports.

3.5 Critics of the source

It is also important to conduct oneself critical in the examining and interpretation of the sources. Tendency critics and contemporary critics are the two most important critics of sources. Tendency critics means to what extent the person who leaves the information is subjective, while contemporary critics is about that the literature and data collected is of current interest (Wiedersheim-Paul & Eriksson, 1991).

We are aware of that this can be a problem when writing a study. As we have mentioned earlier, neither ROA nor valuing information are old subjects, it is recently discovered, why the problems with old sources can be repudiated. The problem with subjectiveness is harder to get around, since every author has a subjective way of writing and, of course, makes subjective assumptions. This is a problem, why it is important to be aware of it.

We will also be critical concerning this study and provide the reader with problems that can arise, so that these mistakes does not occur if the reader wants to perform an analysis on their own. The problems are provided in chapter 5 (5.3 and the subheadings 5.3.1 and 5.3.2).

3.6 Problems with translation

The literature about the methods used was written in swedish. We are aware of the problems that can occur when theories are translated, that there exists an marginal error. The interpretation of the secondary source will therefore contain a risk, but this risk is limited, since only the literature about the methods used was written in swedish. We did not find any suited translation for the two words positivism and hermeneutik, why we use the swedish term. However, we have briefly explained what they mean and we therefore leave the translation open to the reader.

The literature about the real options and how to estimate information was written in english, except for a small part concerning the statistics of Bayes´s rule by Körner & Wahlgren (2000, chapter 2) and also the quotation from Galileo Galilei by Gaarder (1991, chapter 1) which was written in swedish.

We believe that we have provided the reader with enough information to proced with the empiricial study. As we have mentioned, the following chapter contains the process of how we use the information provided on the methods. We do this because we believe that it becomes easier to understand the process of the calculations.

4 Empiricial study

We begin this chapter by briefly describing the company we have chosen in our calculations and we also mention Alfa Laval AB. We present details about how we have made our calculations on the Option to Defer and EVPI. The calculations are based on the investment situation received from Volvo Powertrain AB, and the volatility is based on the historical stock traded for Alfa Laval AB, since Volvo Powertrain AB is not listed. Further details about the calculations can be found in Appendix 4-6.

4.1 Volvo Powertrain AB

The Volvo Group is one of the world´s leading manufacturers of trucks, buses, and construction equipment, drive systems for marine and industrial applications, aerospace componentes and services. The Group also provides complete solutions for financing and service. Their business areas are Volvo Trucks, Mack, Renault Trucks, Volvo Buses, Volvo Construction Equipment, Volvo Penta, Volvo Aero, and Volvo Financing Services. Several business units provide additional manufacturing development or logistical support. The largest business units are Volvo Powertrain, Volvo 3P, Volvo IT, Volvo Logistics, Volvo Parts and Volvo Technology. Founded in 1927, Volvo AB today has approximately 76 000 employees, production in 25 countries, and operates in more than 130 markets (www.volvo.com, 041210).

Volvo Powertrain AB is a business unit that was created the 2:nd of January, 2001, and is a supplier of powertrain components and systems within the Volvo Group. The Volvo Powertrain scope comprises Powertrain Systems, Components (engines, transmissions and axles) and Parts, including adaptation, installation support and after-market support. The total number of employees is 7,800 and Volvo Powertrain's production facilities are located in Sweden, France, the US and Brazil. Volvo Powertrain has a very strong volume position. Volvo Powertrain are the largest manufacturer in the world in the 9 to18 liter engine segment and they also have large volumes in both heavy duty transmissions and axles, if vendor components are also considered. Their volumes are currently split between different product platforms and manufactured within a fragmented industrial structure (http://violin.powertrain.volvo.se/, 041210).

4.1.1 Alfa Laval AB

Alfa Laval is a leading global provider of specialized products and engineered solutions. Alfa Laval's operations are based on leading global positions in the three key technologies of heat transfer, separation and fluid handling. They help their customers to heat, cool, separate and transport products such as oil, water, chemicals, beverages, foodstuffs, starch and pharmaceuticals. Alfa Laval's worldwide organization works closely with customers in almost 100 countries to help them stay ahead. Alfa Laval currently has about 9,350 employees worldwide. Most of these employees are in Sweden (1,941), Denmark (1,098), India (1,031), the US (742) and France (599) (www.alfalaval.com, 041210).

4.2 The Option to Defer

Before we start with presenting the calculations made, we will present the project received from Volvo Powertrain AB. The information we could receive from the company was that the project concerns a machine that produces gearwheels. This machine will constitute as a part of a bigger production process that passes the gearwheels to other stages, which will in the end lead to the developement of the powerful engines of trucks. Except for the numbers presented in Appendix 4 (that the total sum of the income´s are € 728 226,5 and the expense´s are € 834 666,7, and that they use a discount rate of 12 %), we know that the machine has an economic lifeperiod of 10 years. We have also, along with a manager and some workers, developed different scenarios in form of possibilities and outcomes for the investment project and also costs that are related with these possibilities and outcomes that was needed for the calculations on the value of information. Our uncertainties concerning this projects consits of material costs and incoming payments, for the option to defer, and production costs and probabilities, in EVPI. The company´s flexibility consists of the possibility for managers and financial experts to act on the option aswell as to act on the new information that will be brought up using the EVPI.

Firstly, we had to identify the option that suited Volvo Powertrain AB. Since our purpose with this paper is to investigate how the option to defer and valuing information can interact, we identified the option to defer, because they were still uncertain about if they wanted to proceed with the project or not (since the project currently is showing negative numbers).

From the numbers received from Volvo Powertrain AB, we had to identify the option value levers, presented in the theory (in the subheading 2.5).

Present value of expected cashflows and present value of fixed costs. We calculated the income´s and expense´s seperated from each other and sum them up to the respective option value lever. They were both discounted at the WACC that Volvo Powertrain AB currently uses of 12 %. The income´s have a total sum of € 728 226,5 and the expense´s have a total sum of € 834 666,7. We did this using formula **[5]**.

Risk-free interest rate and time to expire. The next step was to find a suitible risk-free interest rate. We used Riskgäldskontorets 1 year national debt of exchange interest rate as the risk-free rate, because we assume that Volvo Powertrain AB could postpone the decsion and wait for additional information for 1 year. The rate was 2,5 % (www.rgk.se, 041105). The assumption about how long the company can postpone the option was made in accordance with a manager in Volvo Powertrain AB.

Uncertainty of expected cashflows. As we mentioned in the subheading 2.9.2, it can be tricky to calculate the uncertainty of expected cashflows for a company that is not listed and that this problem can be overcomed by finding a company that is similar to our company. We found that Alfa Laval is about Volvo Powertrain AB´s size and has a cyclical stock, just as the whole Volvo business has (www.di.se, 041105). We used numbers 2 years back in time and formula **[7]**, which is presented in the theory chapter, to calculate the volatility. The volatility received by this approach was about 6,1 %.[7]

Value lost over duratin of option. Since we were somewhat limited to the information about the invesment project, we can not make any assumptions about the value lost during the options life, why we assume that this option value lever does not affect the project.

After performing these basic calculations for ROA we received the following numbers for the respective option value lever:

[7] We are aware that this is not the optimal way to calculate the volatility for a company though still a way that holds validity. We discuss problems that can arise when calculating the volatility using this approach in the subheading 5.3.1.

Cash inflow	⇨	**S**	⇨	€ 728 226,5
Cash outflow	⇨	**X**	⇨	€ 834 666,7
Risk-free rate	⇨	$\mathbf{R_f}$	⇨	2,5 %
Volatility	⇨	**σ**	⇨	6,1 %
Time to expire	⇨	**T**	⇨	1 year

We now got all the necessary inputs to perform ROA, but we still need a couple of things before we can receive the option value.

e^{rt} is calculated by simply taking the Exponent and multiply it with the risk-free rate and delta t (δ t, which in this case is 1/12, i.e., it represents one month of the year that the option can be postponed). The Up movement (u) is calculated by taking the Exponent and multiply it with the standard deviation (volatility) and the square root of delta t. The Down movement (d) is calculated in the same way, except for a minus in front of the standard deviation. The Risk-neutral probabilities are calculated by subtracting e^{rt} with the Down movement and divide this with the difference between the Up movement and the Down movement. The formulas used for these calculations are **[1]** and **[2]**.

We are now ready to create the Lattice (or tree) for the Underlying (S_0, which is the present value of expected cashflows) with the help of the Excel program Lattice Maker (which can be downloaded at; www.investmentscience.com/mainResource.htm, 041102). We just open the program and type in the required parameters for the Lattice.

The final step is then to calculate the option value. Since we have identified this option as a call option, we will use the formula **[3a]**.

We then use backwards calculations to calculate the option value, using the formula **[4a]**.

The calculations can be shown as follows:

ROA calculations

Inputs

S	728226,5123	*e^rt*	1,002085505
X	834666,6871	*Up movement*	1,017765011
Standard deviation (σ)	6,09996%	*Down movement*	0,982545076
Risk-free rate	2,50%	*Risk-neutral probabilities*	0,554811614
Time to expire (1 year, 12 months	1	*1-p*	0,445188386
Δ t	1/12		
		NPV*	***741,6381952***

Time	0	1	2	3	4	5	6	7	8	9	10	11	12
Lattice Evaluation of	728226,5123	741163,46	754330,2419	767730,9271	781369,68	795250,72	809378,35	823756,97	838391,02	853285,05	868443,67	883871,58	899573,57
the Underlying		715515,37	728226,5123	741163,4645	754330,24	767730,93	781369,68	795250,72	809378,35	823756,97	838391,02	853285,05	868443,67
			703026,1069	715515,3736	728226,51	741163,46	754330,24	767730,93	781369,68	795250,72	809378,35	823756,97	838391,02
				690754,8394	703026,11	715515,37	728226,51	741163,46	754330,24	767730,93	781369,68	795250,72	809378,35
					678697,77	690754,84	703026,11	715515,37	728226,51	741163,46	754330,24	767730,93	781369,68
						666851,15	678697,77	690754,84	703026,11	715515,37	728226,51	741163,46	754330,24
							655211,31	666851,15	678697,77	690754,84	703026,11	715515,37	728226,51
								643774,65	655211,31	666851,15	678697,77	690754,84	703026,11
									632537,61	643774,65	655211,31	666851,15	678697,77
										621496,71	632537,61	643774,65	655211,31
											610648,54	621496,71	632537,61
												599989,71	610648,54
													589516,94
NPV*	741,6381952	1201,2708	1931,710948	3080,322175	4863,6859	7589,5723	11674,302	17637,781	26036,126	37247,522	50941,97	64906,88	64906,88
		172,29983	296,5944499	509,314777	872,25274	1489,3611	2534,5715	4297,0651	7254,0526	12186,001	20355,44	33776,98	33776,98
			18,20604599	32,88326043	59,392842	107,27372	193,75485	349,95469	632,07855	1141,6429	2062,0041	3724,3352	3724,3352
				0	0	0	0	0	0	0	0	0	0
					0	0	0	0	0	0	0	0	0
						0	0	0	0	0	0	0	0
							0	0	0	0	0	0	0
								0	0	0	0	0	0
									0	0	0	0	0
										0	0	0	0
											0	0	0
												0	0
													0

Figure 4-1 ROA calculations on the investment project.

After performing the backward calculations, we now receive the option value (as shown in figure 4-1 above), which is € 741,64. Our option value can be controled using the B-S model. The results from the B-S model test show that the option value is € 626,7. We are aware of the fact that one of the assumptions that the B-S model rests upon is that the option is of European option character, while we have stated that the option to defer is of American option character. Despite these differences it can be interesting to compare the results. Another explanation to why there is a difference is that our Lattice evaluation requires more steps to match the B-S model and that the American option has a higher value since it can be exercised at any date.

Now we are ready to receive the option to defer value by using the formula **[8]**.

Option to defer = € 741,64 – (€ -106 440,2)

Option to defer = € 107 181,84

We are now done with part one of the calculations, i.e., to calculate the option to defer for the investment situation. The next part is show how we calculated the value of the information that had arrived during the time the managers and financial experts at the company had waited for new information.

4.3 Expected Value of Perfect Information

Let us assume that during the options life (1 year), the managers get hold of information that indicates how the production of gearwheels would look like and that they based on other machines and experience in the company could calculate the prior probabilities for the gearwheels to be good or bad (i.e., that the gearwheels works or does not work). Let us further assume that the managers have three different possibilities when it comes to the production of the components, i.e., *to rework the box immediately* (which is sure to be a good box), *to send the boxes directly to the next stage of production,* or *to test the components to determine whether the box is defective or not.*

The first thing we had to do when calculating the information value was to create a decision tree with possible outcomes. We also had to identify the states of the world that could occur (which was not so hard in these calculations since it could be either good (G) or bad (B)). The gearwheels are produced in boxes, containing 50 gearwheels in every box. Based on the knowledge and experience of some workers, we have made the assumption that 88 % of all the boxes that are produced in 1 year contain defective components of 8 %, while the rest, 12 %, contain defective components of 35 %.

The prior probabilities will be:

$P(G) = 0,88$

$P(B) = 0,12$

The possible outcomes that can occur from our project is that an observed component can be defective or that a non-defective component is observed:

D = Defective component is observed

ND = Non-defective component is observed

According to our statements above, we can now present the following likelihoods:

$P(D | G) = 0,08$

$P(ND | G) = 0,92$

$P(D | B) = 0,35$

$P(ND | B) = 0,65$

and the joint probabilities will be:

$P(D \cap G) = P(G) * P(D | G) = 0,88 * 0,08 = 0,0704$

$P(ND \cap G) = P(G) * P(ND | G) = 0,88 * 0,92 = 0,8096$

$P(D \cap B) = P(B) * P(D | B) = 0,12 * 0,35 = 0,042$

$P(ND \cap B) = P(B) * P(ND | B) = 0,12 * 0,65 = 0,078$

In the next step we had to calculate how big the respective possible outcomes were, i.e., that a component is defective or that a component is non-defective:

$P(D) = P(D \cap G) + P(D \cap B) = 0,0704 + 0,042 = 0,1124$

$P(ND) = P(ND \cap G) + P(ND \cap B) = 0,8096 + 0,078 = 0,8876$

The final step before we could finalize our decision tree was to calculate the probabilities according to Bayes´ rule:

$$P(G|D) = \frac{P(D \cap G)}{P(D)} = \frac{0,0704}{0,1124} \approx 0,626$$

$$P(G|ND) = \frac{P(ND \cap G)}{P(ND)} = \frac{0{,}8096}{0{,}8876} \approx 0{,}912$$

$$P(B|D) = \frac{P(D \cap B)}{P(D)} = \frac{0{,}042}{0{,}1124} \approx 0{,}374$$

$$P(B|ND) = \frac{P(ND \cap B)}{P(ND)} = \frac{0{,}078}{0{,}8876} \approx 0{,}088$$

Further assumptions we have made is the different production costs for each box of components and the test costs for the components. It costs € 1 900 to rework the box, € 1 600 to send a good box to the next stage of production, € 3 600 to send a bad box to the next stage of production, and € 35 to test the components to determine whether they are defective or not. (These numbers were presented as possible costs to us by a representative in the company.)

Before completing the calculations on the EVPI, we have to map out the expected value with perfect information and the various outcomes and possibilities that occur. We do this in a decision tree (all numbers are negative except for the probabilities):

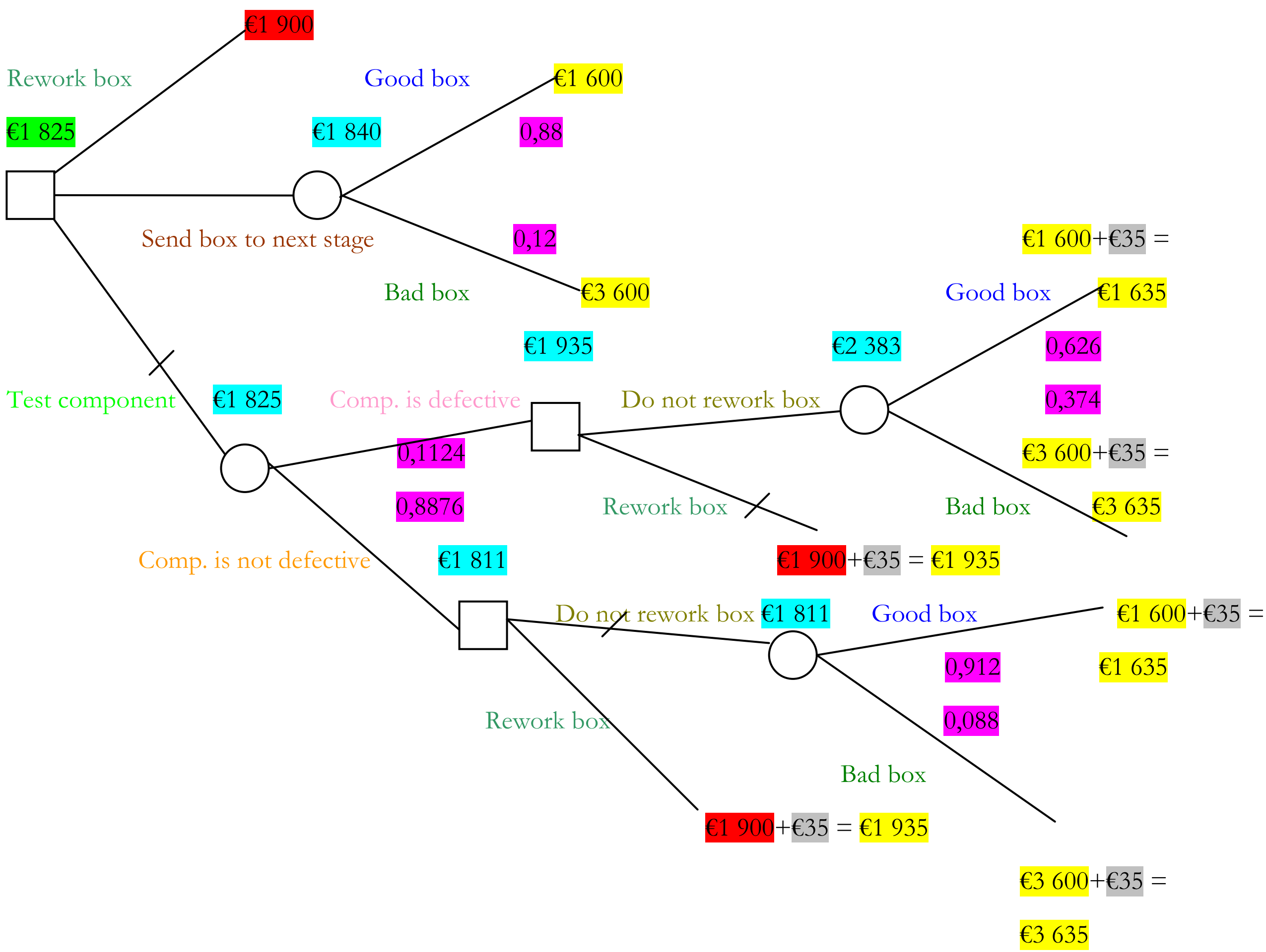


Figure 4-2 Decision tree that will determine which outcome of the three possibilities is most preferable.

Firstly, when constructing the decision tree, we had to draw three branches from the decision fork, representing the three possibilities concerning the gearwheels; *to rework the box immediately, to send the boxes directly to the next stage of production,* or *to test the components to determine whether the box* *is defective or not.* Second, we have to determine which of the three possibilities is most profitable, using backward calculations, just as we did when calculating the option value on the option to defer. Starting with the possibility to rework the box immediately, we find that the cost equals € 1 900. The second possibility we had was to send the boxes directly to the next stage of production. In this possibility the boxes could either be good or bad, representing a total cost of € 1 840. The third and final possibility was to test the components and at an early stage determine whether the box is defective or not. Having this branch as a starting point, we move on to the event fork, where the box could be either defective or not, given the probabilities (calculated above) 11,24 %, that a component is defective and 88,76 % that a component is not defective. Moving on from these branches we have to face a decision, whether to rework the box or not and calculate which of the two possibilities is more profitable. If we choose not to rework a box, we then have to face the event that a box can either be good or bad, while if we choose to rework a box, receive a good box along with a cost of € 35. Facing the possibility that a component is defective, we find that it is more profitable to rework a box, while facing the possibility that a component is not defective, choosing the decision not to rework a box is more profitable. After performing these backward calculations, we find that the possibility of testing the components has a total cost of € 1825, which also is the most profitable branch of the three possibilities.

This decision tree can be used to determine EVSI, i.e. using the formula **[10]**, presented in the theory.

Since EVSI assumes that the test costs are costless we have to subtract -€ 35 from -€ 1 825 (which represents the total cost of testing the components) to receive EVWSI. EVWOI equals the cost of the possibility to send the boxes directly to the next stage of production, which in this case is -€ 1 840. EVSI will therefore be:

EVSI = -€ 1 790 – (-€ 1 840) = € 50.

This means that € 50 is the most that the company can pay for the test information and still be at least as well off as without the test market information. Since the test costs are € 35, the company can perform this test study in accordence with EVSI.

When calculating on EVPI, we also have to create a smaller decision tree which shows the expected value with perfect information (EVWPI, which has to be used in the final calculations of EVPI, again, all numbers are negative except for the probabilities):

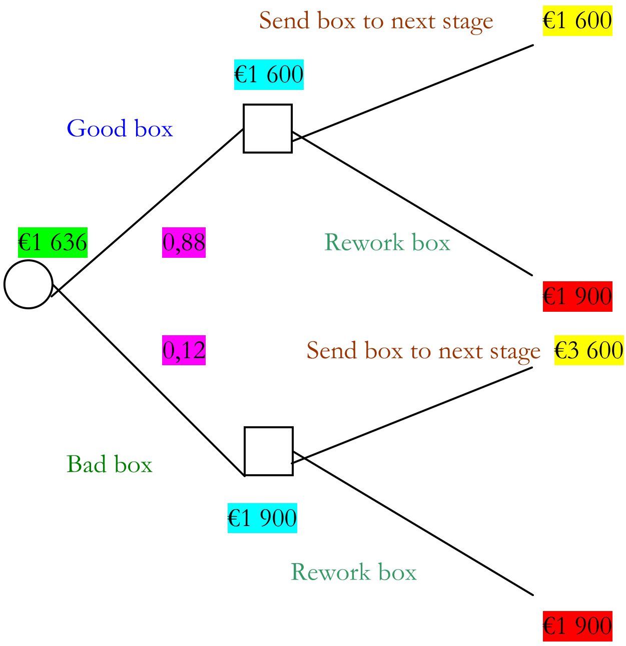


Figure 4-3 Decision tree for calculating the EVWPI.

From the decision tree above, which shows the EVWPI, we can gather the final numbers needed before receiving the EVPI, using the formula **[9]** for the calculations. Then:

EVPI = -€ 1.636 – (-€ 1.840) = € 204

The expected value of perfect information in our calculation equals € 204.

We are now ready for the final chapter of the study, Analysis and Concluding results/discussion.

5 Analysis och Concluding results/discussion

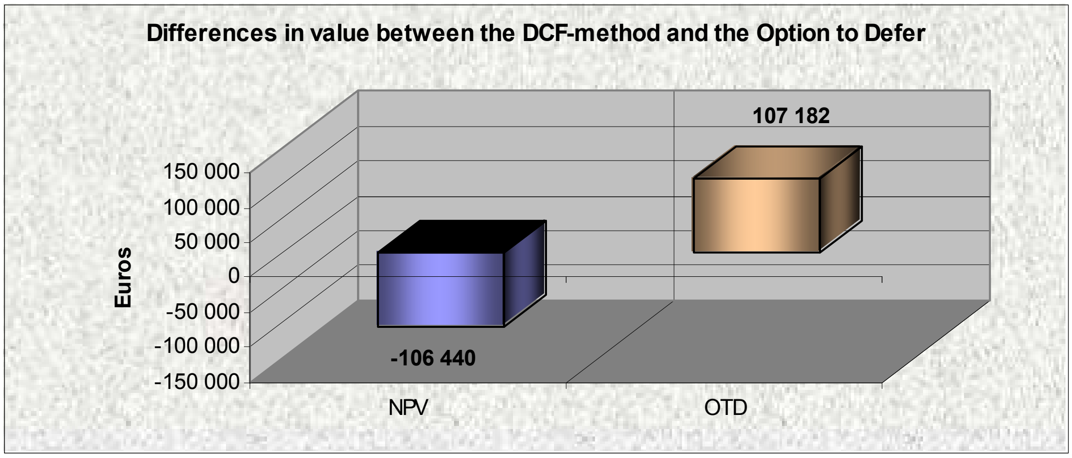
In this final chapter of the study we will present an analysis on the problem stated in the initial chapter:

- *How can information be valued properly, as an extension on the option to defer?*

The chapter begins with a comparison of the results gathered in the empiricial study chapter. We will also discuss problems associated with performing such analysis and present our concluding results/discussion. We end the study by recommending areas that can be used for future research.

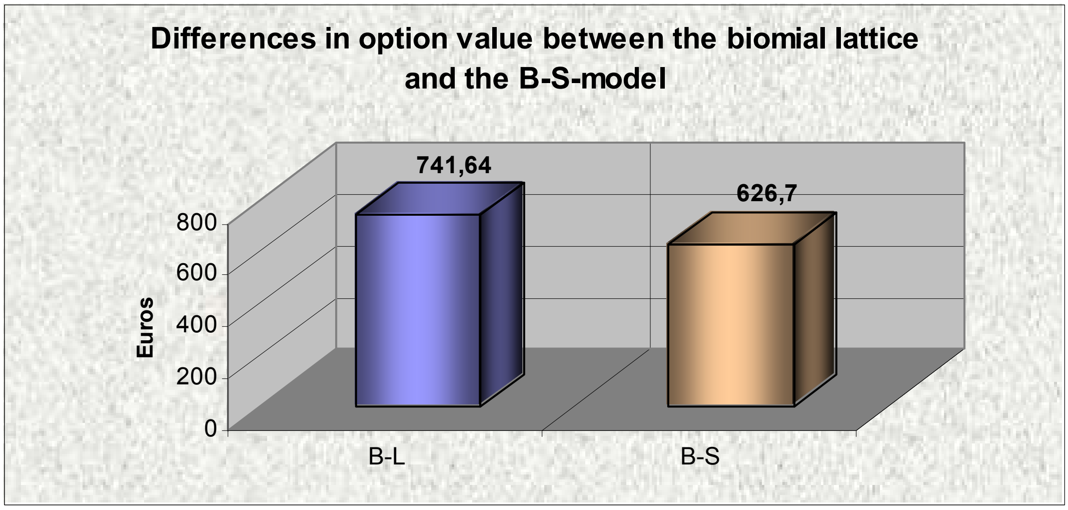
5.1 Comparison of the results

Before we proceed with a more general analysis on the empiricial study, we find it appropriate to compare the results we have calculated in the empiricial study chapter. We begin by comparing the traditional NPV that is used by Volvo Powertrain AB today with ROA that we use in this study.



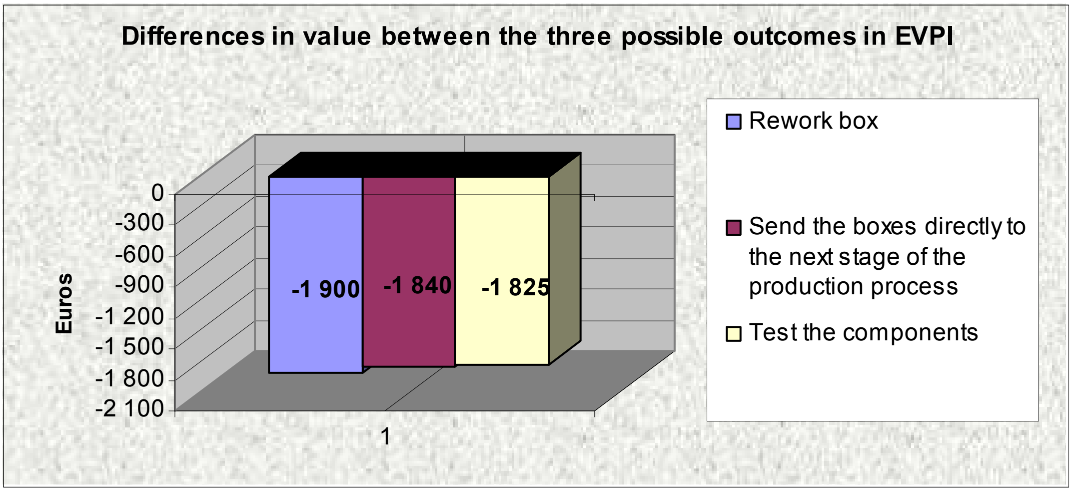
Graph 5-1 Differences in value between the DCF-method (NPV) and the Option to Defer (OTD).

As can be seen, the option to defer (€ 107 182) is showing much more attractive numbers than the NPV that the company currently use (€ -106 440). This is clearly the case due to the flexibility in the option to defer that management has the possibility to wait for additional information before making the decision whether to invest or not and thereby reducing uncertainty involved in the project.



Graph 5-2 Differences in option value between the binomial lattice (B-L) and the B-S-model.

As we already mentioned in the empiricial study chapter, the option to defer can be a parable to the American option while the B-S-model values option in the European fashion. Despite this difference, we find it interesting to compare the numbers. The option value for the binomial lattice is € 741,64 and the value for the B-S-model is € 626,7. As we have mentioned, these differences in value exists due to the fact (as Mun, 2002, also mentiones) that the B-S-model has a more accurate way of calculating the option value while the binomial lattice requires more steps (or delta t) to be more equal the B-S-model. Another factor to the differences in value is that the American option can be exercised at any date, which can make it more attractive and thereby receive a higher value than the European option.



Graph 5-3 Differences in value between the three possible outcomes in EVPI.

This graph shows the differences in value between the three possible outcomes that we had to choose among before deciding whether to invest in the tests of the components or not. As the graph shows, the possibility that consists of testing the components (€ -1 825) is more profitable than to send the boxes directly to the next stage of the production process (€ -1 1840) and to rework the boxes immediately (€ -1 900). This is the first step before deciding whether to proceed with the calculations of the EVPI or not. As our study is showing preferable numbers concerning to test the components, we can proceed with the calculations and in the end we find that the EVPI for the project is € 204/component.

5.2 Analysis on the empiricial study

We can say that the information decides the value of the option. Based on the information that currently exists, the analyst can build up different forecasts and expectations about future cashflows, investment costs, which interest rates that are appropriate to use, how the volatility looks like, how long the time to maturity is and how much value that has been lost during the options life. From the time that the option arises until the time that the option no longer can be postponed, there is information popping up constantly, that can change the value of the option. This leads to the fact that the option must be monitored for the analyst to receive a more clear picture of how this new information has affected the option value. It has to be stated that new information does not always need to be of positive character that leads to the approval of different investments by the managers, it can also have negative character that leads to the abandon of other investments. But nevertheless, it is always more advantagous to play on new information (whether it is positive or negative) and this information changes constantly. Furthermore, the higher the uncertainty involved in the investment situation, the higher the expected value of information that can reduce uncertainty involved (if this new information will lie as a base for decions to come).

If we go back in time when the first valuation process began, using the NPV-model to determine whether the investment situation was profitable or not, the project would be long gone forgotten by this time. Since the project value turned out to be negative (€ 728 226,5 – € 834 666,7 = € -106 440,2), there was no idea for the managers to pick that project, according to the "old school" thinking of, if a project has a positive expected value invest, if not, do not invest. The managers of this kind of "old school" thinking are often aware of that they do have different options to choose among, but that does not matter at that time because they can not quantify the value of the different options and thereby present representative numbers to their colleagues. The same thing holds for EVPI, managers need numbers for it to be useful in the organization and the various investment situations to implement it in the calculations.

The reason for why we identified and picked the option to defer, and why it therefore was the most suited option for Volvo Powertrain AB, was that the company had a negative NPV and did not have any intentions to expand, abandon, contract or exercise any other option available.[8] The reason for implementing the machine in the organization was to produce gearwheels, which were later send on in the produciton process. Since their first calculations regarding the investment situation (using the NPV-method) showed negative numbers, they wanted to wait for additional information and thereby resolve uncertainty concerning the project, despite the fact that the ROA calculations showed positive numbers (even if the numbers were not of any higher significance). And how did we resolve the uncertainty and received new information?

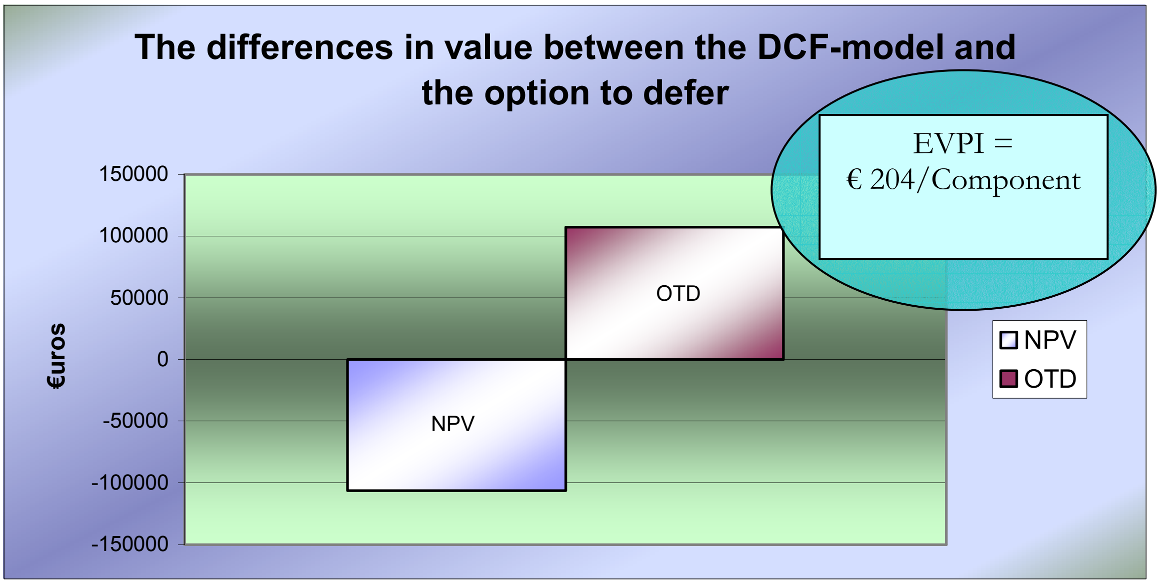
The answer to our problem is that we use the term EVPI to calculate the value of information. We constructed a decision tree (which can be used to cut down large problems into several smaller ones) with different possibilities and outcomes for Volvo Powertrain AB to choose among and that could occur. The different possibilities were to rework a box immediately and thereby receive a good box, to send the box to the next stage in the production process with a 88 % chance that a box is a good box and a 12 % chance that a box is a bad box, or to test components of different boxes and thereby determine right away if a box is good or bad. We later also calculated the likelihoods and different probabilities for the

[8] Except for the reasons mentioned in the method chapter, that Volvo Powertrain AB is a big company with many employees and a high turnover and that they therefore have the possibilities to act on the three prerequisites for ROA, flexibility, uncertainty and the arrival of new information.

different outcomes to occur, which were needed to comlete the decision tree and the calculations for EVPI. By doing this, we not only gathered additional information for various possibilities and outcomes that the managers and financial experts could play on, but we also calculated the expected value of this information, to see if it is of any value to really go ahead with these tests, or not.

Receiving EVPI means that the company gathers information about the upper limit on the value of test information. The managers and financial experts are now aware of that the test information can not be worth more than € 204/component, no matter how good the information might be. As to our examination, and based on the numbers received, the company should perform the test, since this indicates that it is the optimal decision in this situation, because it will lead to the highest expected return. By this mean, EVPI serves as an excellent complement to the option to defer. Both methods used (along with the DCF-method) can increase the expected payoff and remove or reduce the uncertainty involved in various investment situations and make life easier for managers to make decisions concerning the companies future.

As presented in our empirical study, the cash inflows for the project was € 728 226,5 and the cash outflows was € 834 666,7. Since these numbers were already discounted to represent todays value, we can simply subtract the inflows from the outflows to find out the net present value, which is € -106 440,2 (€ 728 226,5 – € 834 666,7). The value of the option to defer received from the calculations was € 107 181,84. Clearly, the method that includes the flexibity, uncertainty and the arraival of new information is showing more representative numbers for the project and should therefore be the method used along with EVPI, which serves as an further complement for valuing the additional information gained, when managers and financial experts are to make decisions concerning the comanies future. Still some reservation has to be made since the option value did not show so impressive numbers. The option value was calculated to € 741,64, which is not a number of any higher significance. We can show the numbers graphically.



Graph 5-4 The differences in value between the DCF-model (NPV) and the option to defer (which we in the graph call OTD), while EVPI is adding additional value to the ROA-model.

5.3 Problems with the empiricial study

Often (if not always) when performing calculations using a method that requires assumptions to be made, there exists some marginal error to the extend that the valuator does not fully understand the assumptions that the method requires for it to present the most representative value. Kleinmuntz (1968) says that many decision makers follow the correct Bayesian rule in updating prior probabilites, but that they fail to appreciate the full impact of the evidence. It is clearly important for the decision maker to fully understand the concept, not only from the numbers received, but also to undertand how it is used in the various investment models.

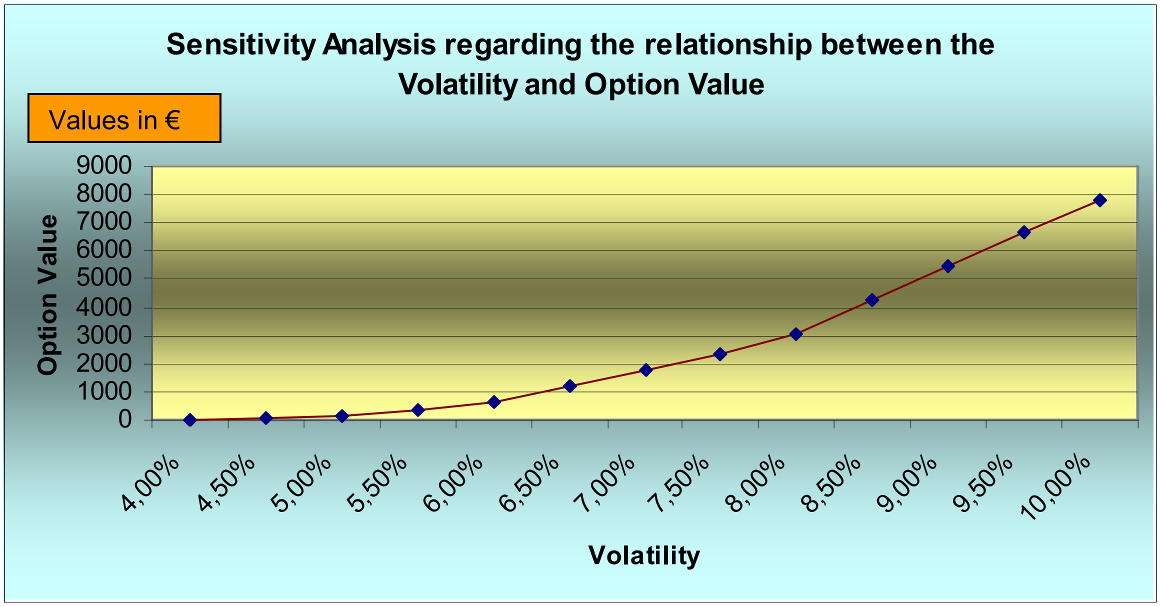
While being aware of that problems may arise when performing such analysis, we will point them out and discuss them below in the subheadings 5.3.1, and 5.3.2. We are also aware of that a discussion can be brought up whether to use parts of the problems that can arise in the method chapter or not. We want to argue that to fully get a grip of the problems and to realize the importance of being aware of them, it is better that we place them altogether below.

5.3.1 Problems concerning the Option to Defer

We are aware of that the numbers received from Volvo Powertrain AB can have some marginal error, but we have to believe that they are representative. An important remark that has to be stated is for example that the same discount rate has been used on the calculations for both the incomes and expenses. Based on logical guesses and Luehrman (1998a), they should be separated, due to the fact that the incomes are more difficult to forecast over such a long period of time, why they should be calculated with a higher discount rate that accounts for the higher risk, while the expenses are of more certain character and should therefore be discounted using a lower rate. But, these kind of mistakes are not rare in the calculations of different investment situations when dealing with the NPV-model.

A big concern when estimating the volatility of a company that is not listed is the basic fact to gather information of its standard deviation that is later used in the calculations. A marginal error will always occur when using an other company´s numbers, whether it is historical numbers or performing forecasts of possible future events. We had to find a company on SSE that matched the characteristics of Volvo Powertrain AB, and we found that Alfa Laval AB was the closest one. Another error was that we only could find close courses for the first Monday in the week and not the close course on a daily basis. The fact that we only could use the historical courses, two years back in time will also affect the accurecy in the calculated numbers, since a bigger sample of the close courses would provide a higher accurecy on the volatility. Due to this, we found it necessary to perform a sensitivity analysis to see how the volatility will affect the option value. We show the results in graph 5-2.

We can identify three levels of development on the sensitivity analysis graph. The first, ranging from 4 % - 6 %, the standard deviation has almost no affect on the option value. The second level is a bit more sensitive, ranging from 6 % - 8 %, changing about € 500 - €600 for every 0,5 percentage point. The last level is more sensitive to changes in the standard deviation, ranging from 8 % - 10 %. Here the standard deviation has an affect of about € 1 100 - € 1 200 for every 0,5 percentige point. Despite these differences in value, we assume that the volatility of Volvo Powertrain AB does not have an exceptionell difference from Alfa Laval (why we have used these numbers when perfoming the sensitivity analysis) and since the marginal adjustments to the volatility does not have a huge affect on the option value in absolute terms, the option value calculated for Volvo Powertrain AB can be accepted. The higher the voalitility, the higher the option value.[9]



Graph 5-5 Sensitivity analysis regarding the relationship between the Volatility and the Option Value.

When dealing with financial options, there exists a date for when the option expires, but this is not the same with real options. We had to set an enddate for the managers and financial experts to be able to make the optimal decsion and receive the highest expected payoff. After a discussion (along with a manager in the company) about this area, we could come to the conclusion that 1 year is the maximum time that the company can defer the decision.

We have in this study assumed that the project is not affected by the option value lever "value lost during options life", due to limited access to information. We could have made assumptions to include this lever aswell, but since we do not have any solid ground to stand on when it comes to this lever, we find it more appropriate to assume it away, since assumptions concerning this issue could affect the validity negatively.

5.3.2 Problems concerning EVPI

We believe that our numbers on the prior probabilities presented are in the range of what can be accepted using different machines. Since we talked with some workers with many years of experience in dealing with the production process, we do not believe that our probabilities are of the extreme character, why they should be accepted. Though, it is still important to consistently update the probabilities, since when dealing with the Bayesian rule, the information value is calculated before the behavior of the managers or workers can be observed. If the probabilities change, it also leads to the fact that the final information value changes. If these "new" probabilites are not incurred in the calculations, it may lead to that the tests are made on false grounds, that the information no longer holds the value it did on the "old" probabilities. It can also be difficult to constantly update the probabilities, to identify when and how they arise.

[9] See Appendix 7 for further details about the calculations on the sensitivity analysis.

Another problem that has to be stated is that when performing analysis on EVPI, it may lead to that new alternative actions can be identified (or new information that has arrived, which shows new sorts of outcomes or possibilities that can be taken). These alternative actions may not have been considered in the early stages of the calculations and therefore also not included in the calculations of the probabilities or the final value of EVPI. This problem then brings up the discussion of if all the outcomes and possibilites should be included in the calculations in relations to cost and time. Clearly, when dealing with a (for Volvo Powertrain AB at least) minor investment situation as the machine that produces gearwheels, they can not put all their resources in just to find the optimal value of the expected information. Different companies also have different possiblities when it comes to determing the value of information and different investment situations require different attention in relations to it resources, depending on size and capital invested.

As we already mentioned, information has no value unless the new information that has arrived is laying as a base for the following decisions. This has to be considered when identifying new alternative actions in relations to cost and time. It is not certain that all information gathered and calculated will lie as a base for the new decisions that follows and some of the alternative actions identified will therefore have no value which leads to incorrect calculations of EVPI (if they are included). Therefore, every manager and financial expert must make a well-blanced decision in how much to invest in the calculations.

Hogarth (1975) brings out two interesting points when it comes to analyzing the empiricial studies on probability assessment. He argues that it is important to realize that the quality of the assessment depends on two dimensions:

- The assessor´s knowledge about the matter under study
- The assessor´s ability to express his opinions in probabilistic form

That is, if the managers or financial experts knowledge concerning the investment situation is unique or superior to any objective source, it would then be foolish not to take advantage of their knowledge. But conflicts may arise between a manager and the company that he or she represents. For example, the relation between a managers or financial experts attitude towards risk may be different from the companies attitude towards risk. The decision maker may have a much more risk-seeking attitude, while the company is in a sensitive stage and therefore more risk-averse. This means that the decision maker may be willing to pay more for the project than the company has afford to lose, if something goes bad. To make decisions that are in accordance with the companys situation, and thereby build up calculations that can reflect the ability for the company to perform various investments, managers and financial experts need to have, at least somewhat, the same risk preferences. Since we consider ourselves risk-neutral in these calculations, we have assumed that the company is risk-neutral and the decision makers follows this line along with the company.

5.4 Concluding results/discussion

To get an overview of how EVPI and the option to defer interacts in this study (along with DCF), we can show it in a framework as follows:

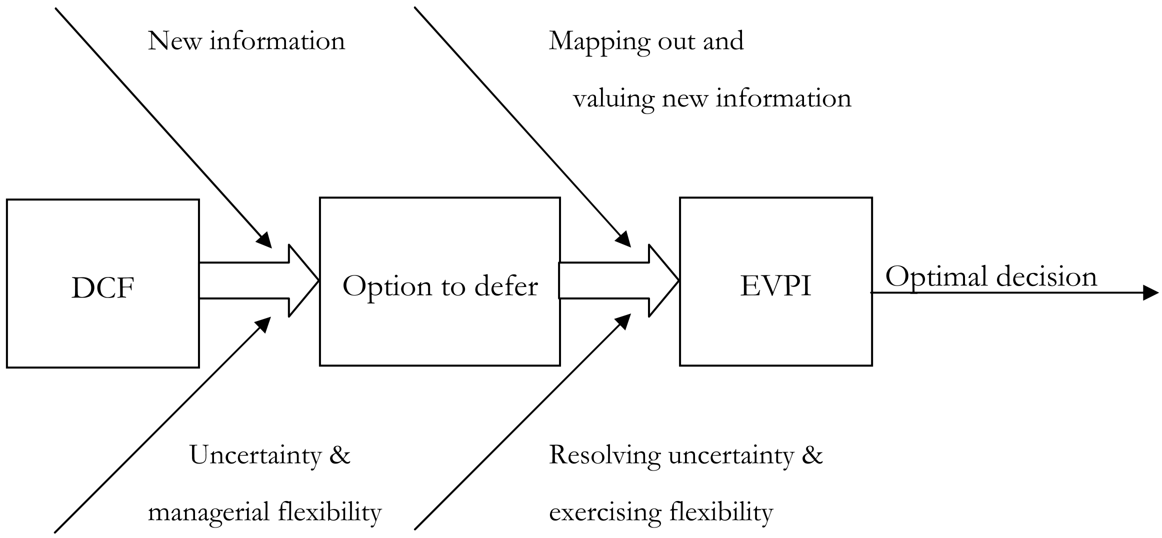


Figure 5-1 The framework presented and used in this study.

What is important to remember is that one method does not substitute the other, but they complement eachother. Traditional DCF-method (NPV or IRR) serves as the basic method that gathers the appropriate numbers needed to perform the Real Option Analysis. The Expected Value of Perfect Information complements the Option to defer, by mapping out and reducing additional uncertainty that is involved in the investment situation. Yet again, all three methods are needed to reduce uncertainty and help decision makers in their way of making the optimal decision for the company.

Another important thing to mention is the different uncertainties that the respective method concerns. While the Option to Defer reduce the market uncertianty, Expected Value of Perfect Information reduces Technological uncertainty, or as Copeland and Antikarov (2003) puts is, quantity (market) and price (technological) uncertainty. This is another part where the Option to defer and EVPI complement eachother. So, using the methods of this study, we not only increase the expected future payoff of a project, but we also reduce uncertainty involved.

To summarize our problem as to how information can be valued as an extension on the option to defer, we use the term EVPI, which means that the company gathers information about the upper limit on the value of test information. By using the framework presented in figure 5-1, the decision makers and financial experts gathers more explicit information about an investment situation, in comparison to the use of a singel model, and they can determine whether the arrivial of new information is realy adding value to the project or not. We can in other terms conclude that when exercising the option to defer, you are exercising the right to wait for additional information and thereby reduce uncertainty involved in various investment situations (i.e., the managers and financial experts has the flexibility to wait for additional information and thereby reduce uncertainty involved in the project). In these situations, managers and financial experts has two possibilities, either to purse passive or active management. We always prefer the later one. We have provided an example to how active managers and financial experts can receive additional or new information and value this information, and which will in the end help them in their decision making process. Still problems may arise, as we have mentioned, when managers are faced with multiple decisions concerning an investment situation. By applying the framework presented in this study, atleast a few questionmarks can be mapped out and the uncertainty can to some extend be resolved about future events. Since EVPI is contributing information about possibilities and outcomes, it will increase managers and financial experts understanding about the situation and also lead to the identification of the highest expected payoff.

ROA and EVPI can be seen as a revolutionary step towards a more representative valuation of investment situations, due to the fact that these methods include intangible assets in the calculations of various projects. It is indeed a step in the right direction when it comes to value intangible assets and helping managers and financial experts in their decision making procces. But nevertheless, we want to point out something that Nordström and Ridderstråle wrote in their book "Funky business" (1999) regarding the IT-revolution we currently are in, that you can not utilize all its benefits when you are in the revolution, but that the benefits come in hand when you stop to get your breath. We believe that parallels can be drawn no matter if it considers the whole IT-revolution or only a part of it and so also for economics and the use of ROA and EVPI. You sometimes have to stop, take two steps back, observe, question, analyze, to then be able to take five steps forward.

Real options helps to quantify the value of different options, as in this case of the Option to Defer. It is not a tool to quantify future cash flows of a firm or to give a better or "true" estimation of them. It says what the value of different actions managers can make are and EVPI can in turn be a tool to not just value information but also to map out different outcomes and possibilities that can occur and which will, hopefully, in the end lead to the optimal decision.

A remark concerning perfect information and optimal decision is that our logical minds tells us that it is impossible to receive perfect information about future events. A discussion can be brought up whether to use the term optimal or satisfying decisions. We will not get deeper involved the discussion in this work but leave the question open. But, we do want to say that since all actions have been taken to gather information about an investment, the decisions made will be optimal based on that informtion.[10]

Something we came to think about during the course of this study, and specially when calculating the probabilities needed for EVPI, was that to find the probability of a unknown factor, you use logical guesess and resonable imaginations. This probability can though never reach an absolute level of certainty, only an almost level of certainty, that an event is going to occur, or not, depending on which thes you put up. Nevertheless, which or what factor affects this almost that an event is going to occur or not?

There can also be a discussion whether the use of ROA and EVPI can provide the notorious "true" value. We do not believe in the word "true" value when it comes to generalizing different investments. The word is to subjective and has to be carefully defined when used even if it can not reach its climax. Again, we will not extend this discussion, though we found it appropriate to mention it, specially because we found a pretty good quotation from Rene Descartes to end this study with (www.lucidcafe.com/library/96mar/descartes.html, 040715):

[10] For further research about this area, a starting point can be to look at the work of Simon (1987) and Simon (1998)

"If you would be a real seeker after truth,

it is necessary that at least once in your life

you doubt, as far as possible, all things"

5.5 Future research

There exists several studies about information valuation that are based on highly complex mathematical and statistical formulas, the latest one we have been in contact with is Murto (2004). As we have mentioned earlier, these highly complex methods does not serve as any greater help for managers and financial experts, because they require alot of time and energy. Research can be made on simplifying these methods so that they can be used on management level, because it would be interesting to find out if there can exist other methods to value information and not only the one presented in this study.

Many companies that calculates on invesments have generalized programs which simplifies the calculation process. A big company like Volvo Powertrain AB for example have different investments to consider on a daily basis. The framework presented in our study will therefore not be suitible for smaller investments because they require the time and knowledge to be performed. We would therefore encourage others to perform a study were they try to include our framework presented in programs that simplifies the calculations for the managers and financial experts.

It would also be interesting to find out how much time and costs are being spent in relations to finding the optimal decision among practitioners and which methods they currently use and the knowledge they possess about the methods they use and of other methods that exists aswell.

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Appendix 1

Copeland and Anitkarov (2003) gives a brief explanation of what the real option levers mean:

Present value of expected cashflows – If the present value of a project increases, the NPV (without flexibility) will increase and therefore also the real option.

Present value of fixed costs – The NPV (without flexibility) will be reduced if there is a higher investment cost, and this will in turn reduce the real option.

Value lost over duration of option – The real option will decrease with an increase in cash flows lost to competitors.

Risk-free interest rate – Since an increase in the risk-free rate will increase the time value of money advantage in deferring the investment cost, the real option will increase.

Uncertainty of expected cashflows – An increase in uncertainty will increase the real option in an environment with managerial flexibility.

Time to expire – A longer time to expiration will increase the real option since it will be allowed to learn more about the uncertainty.

Appendix 2

Trigeorgis (1993) has listed the most common options used today:

Time to build option (staged investment) –	Staging investment as a series of outlays creates the option to abandon the enterprise in midstream if new information is unfavourable. Each stage can be viewed as an option on the value of subsequent stages, and valued as a compound option.
Option to alter operating scale (e.g., to expand; to contract; to shut down and restart) –	If market conditions are more favourable than expected, the firm can expand the scale of production or accelerate resource utilization. Conversely, if conditions are less favourable than expected, it can reduce the scale of production. In extreme cases, production may temporarily halt and start up again.
Option to abandon	If market conditions decline severly, management can abandon current operations permanently and realize the resale value of capital equipment and other assets in secondhand markets.
Option to switch (e.g., outputs or inputs) –	If prices or demand change, management can change the output mix of the facility ("product" flexibility). Alternatively, the same outputs can be produced using different types of inputs ("process" flexibility).
Growth options –	An early inestment (e.g., R&D, lease on undeveloped land or oil reserves, strategic acquisition, information network/infrastructure) is a prerequisite or link in a chain of interrelated projects, opening up future growth opportunities (e.g., new generation product or process, oil reserves, access to new market, strengthening of core capabilities). Like interproject compound options.
Multiple interacting options –	Real-life projects often involve a "collection" of various options, both upward-potential enhancing calls and downward-protection put options present in combination. Their combined option value may differ from the sum of seperate option values, i.e., they interact. They may also interact with financial flexibility options.

Mun (2002) gives additional examples on options:

Compound options –	Means that the execution and value of a strategic option depend on another strategic option.
Sequential options –	Means that the execution and value of future strategic options depend on previous options in sequens of execution.
Chooser options –	Implies that the management has the flexibility to choose among several strategies, including the option to expand, abandon, switch, contract, and so forth.
Barrier options –	Means that the execution and value of a strategic option depend on breaching an artificial barrier.

Copeland and Antikarov (2003) also mention the rainbow option:

Rainbow options –	The underlying asset is driven by multiple sources of uncertainty.

Appendix 3

Collection of information

King and Cleland (1975) have identified 8 steps when it comes to the collection of information and the information analysis methodology. They provide a process of management information system (MIS), which focuses on the determination of the information requirements of managers in a formalized fashion. The concept with MIS is to provide an objective framework for analyzing information requirements while at the same time significantly involving the managers in the design process. The following steps are presented:

1. Identification of User Set and Interfacing Organizations
2. Identification of Decision Areas
3. Definition of Decision Areas
4. Development of a Descriptive Model of the System
5. Development of a Normative Model of the System
6. Development of a Consensus Model of the System
7. Decision Model Identification and Specification
8. Specification of Information Requirements

Identification of User Set and Interfacing Organizations

The user set consists of those managers who are designated to be the primary users of the system´s output. They are specified by the stated objectives of the system, which must be defined clearly prior to embarking on an anlysis of information requirements. An analyst initially defines the user set by using statement of objectives for the MIS, organization charts, job descriptions and other documents, as guides. This kind of information must be prospective and focused toward those environmental and competative elements of the organization that will most critically affect its future, to be useful for strategic planning.

The variety of MIS must consider both external interfacing organizations as well as internal users, due to the objective of MIS. Those organizations with which information is communicated in support of, or as a result of, the functions which the MIS is to support, are organizations defined in terms of specific informational inputs and outputs.

Identification of Decision Areas

Analysts will use existing theory and refine this through discussion with the appropriate managers who will be the users of the system. Areas that can be affected of this step is e.g., direction of operations, organizing activities, budget, tactical planning, new programs, training, research, etc. According to the authors, they assume that the analyst will usually begin from a theoretical point of view based on his or hers higly abstracted view of the organization and then proceed to revise the inventory based on discussions with executives and members of the user set. This will ensure that major omissions are avoided and provide a good theoretical foundation, while at the same time avoiding the problems of confusing terminology and overlapping decision areas.

Definition of Decision Areas

The decision area must now be specified in detail. This will be done by discussion with executives and the members of the user set will assist greatly in achieving the desired level of specificity. Another purpose with this step is the obtaining of support and acceptance of the people on whom ultimate success will depend. The process that follows in this step is alot like the previous step except that the decision areas are broken down into decision elements on the basis of their homogenety, need for common informational input, or performance by a single individual or unit. The authors have identified that these assessments must be made on rather loose grounds, since rigorous formal criteria are probably unwarranted at this preliminary definitional stage.

Development of a Descriptive Model of the System

This step involves the utilization of the user set and decision areas to develop a descriptive model of the organizational and evironmental systems which are relevant to the MIS. This can be done by using a two-dimensional format which is an adaption and extension of the concept of a "linear responsibility chart" (LRC), which is a simple organizational model who was originally introduced to provide a more realistic description of the operation of organizations than does the traditional hierarchical chart. This is accomplished by describing authorities, responsibilities, and roles in a matrix form which relates positions and tasks through the use of coded symbols designating the specific roles to be played by each position in the accomplishment of each task.

Development of a Normative Model of the System

The analyst can collect the best knowledge and theory of management to construct a normative model of the organization which is consistent with the descriptive model. This can be done in an attempt to influence the restructuring of the decision making process so that the MIS may be oriented toward the support of more a nearly optimal process, rather than creating an information system to serve an existing organizational system.

Development of a Consensus Model of the System

An objective comparison, which is compared and evaluated by managers with the aid and advice of analysts, of a descriptive model with a normative model, develops a consensus model. This kind of consensus model provides the basic framework for analysis of both formal and informal information requirements. It also provides to the identification of specific involvements of users in each element of each decision area and it indicates the direction of the information flow in each phase, both within and outside the organizational system.

Decision Model Identification and Specification

As the above step is developed, the analyst can begin to identify the specific "decision models" and criteria which are used to perform the activities specified in each element of the chart. A description of this system by the authors can be that each "Approval" activity can be detailed in terms of the criteria applied to the approval decision, and each "Execution" activity will need to have a model of the execution activity specified. A decision can be specified through a process of manager-analyst interaction in a case where the manager uses the conceptual framework.

Specification of Information Requirements

The information requirements from the consensus model of the system and the specific "decsion models" is determined in the final step. The idea behind this is that the decision models will serve to specify specific information requirements and the consensus systems model prescribes the linkages and relationships of these elements of information.

Appendix 4

Numbers collected from Volvo Powertrain AB.

All numbers in Euros	*Disc rate:*	Disc. Rate	12,0%

PPE (outgoing payments)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
- Investment	-5 535,4	-15 718,9	-2 410,5								
- Installation,transportation etc											
- Renovation											
- Other											
Total investments	*-5 535,4*	*-15 718,9*	*-2 410,5*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*
Residual value											
Total PPE (outgoing payments)	**-5 535,4**	**-15 718,9**	**-2 410,5**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**

Change in Working Capital	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
- Inventory											
- Accounts receivable											
- Other											
- Accounts payable											
- Other											
Change in Working Capital	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
Total Capital	*-5 535,4*	*-15 718,9*	*-2 410,5*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*

Others incoming payments	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
- Sales											
- Other											
- Other											
- Other											
Total Others incoming payments	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**

Others outgoing payments	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
- Material		-115 426,7	-148 560,6	-149 646,9	-152 587,8	-152 587,8	-152 587,8	-145 766,4	-145 766,4	-145 766,4	-145 766,4
- Direct hours											
- Overtime											
- Maintenance											
- Administrative expenses											

- Please specify											
- Please specify											
- Please specify											
Total Others outgoing payments	**0,0**	**-115 426,7**	**-148 560,6**	**-149 646,9**	**-152 587,8**	**-152 587,8**	**-152 587,8**	**-145 766,4**	**-145 766,4**	**-145 766,4**	**-145 766,4**

Cash Flow	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
PPE (outgoing payments)	-5 535,4	-15 718,9	-2 410,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Change in working capital	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Others incoming payments	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Others outgoing payments	0,0	-115 426,7	-148 560,6	-149 646,9	-152 587,8	-152 587,8	-152 587,8	-145 766,4	-145 766,4	-145 766,4	-145 766,4
Total Cash Flow	*-5 535,4*	*-131 145,6*	*-150 971,1*	*-149 646,9*	*-152 587,8*	*-152 587,8*	*-152 587,8*	*-145 766,4*	*-145 766,4*	*-145 766,4*	*-145 766,4*

Net Present Value	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
NPV *Disc rate: 12,0%*	*-5 535,4*	*-117 094,3*	*-120 353,2*	*-106 515,7*	*-96 972,3*	*-86 582,4*	*-77 305,7*	*-65 937,3*	*-58 872,6*	*-52 564,8*	*-46 932,9*

Operating Income	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Others incoming payments	0,0	57 387,1	77 925,7	117 522,9	148 801,5	162 247,4	168 325,9	171 981,6	169 450,2	165 241,8	166 117,1
Others outgoing payments	0,0	-115 426,7	-148 560,6	-149 646,9	-152 587,8	-152 587,8	-152 587,8	-145 766,4	-145 766,4	-145 766,4	-145 766,4
Depreciation											
Residual value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other											
Estimated operating income effect	0,0	-58 039,6	-70 634,9	-32 124,0	-3 786,3	9 659,6	15 738,1	26 215,2	23 683,8	19 475,4	20 350,7

Net Present Value	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
NPV *Disc rate:*	*0,0*	*51 238,5*	*62 121,9*	*83 650,5*	*94 566,0*	*92 063,5*	*85 279,1*	*77 795,7*	*68 438,1*	*59 587,8*	*53 485,3*

Appendix 5

Numbers used to calculate B-S.

Using B-S Model

Inputs	
Stock price (So)	728226,5123
Standard Dev - Annual	6,10%
Riskfree Rate - Annual (rf)	2,50%
Exerxcise Price (X)	834666,6871
Time to Maturity - Years (t)	1

Outputs	
d1	-1,79607593
d2	-1,8570755
N(d1)	0,036241168
N(d2)	0,031650144
Call Price ©	626,7041757

Appendix 6

Numbers used to calculate the Volatility.

N	109
Medelvärde x	0,004039558
Summa $(x_i - \text{medelvärde } x)^2$	0,4018622755
Volatility of the period	**0,060999566**

Datum	Senast	Hög	Låg	Köp	Volym	xi	(xi-medelvärde x)2
2004-11-22	109,5	109,5	107,5	109	1458694	0,009174	0,0000263664
2004-11-15	108,5	109,5	104	108,5	2971057	0,037563	0,0011238280
2004-11-08	104,5	106,5	100	104,5	5081842	0,044017	0,0015981867
2004-11-01	100	101,5	99,5	100	2482984	0,005013	0,0000009467
2004-10-25	99,5	101,5	98,75	99,5	2686175	-0,019901	0,0005731577
2004-10-18	101,5	107	97	101	6636740	-0,04338	0,0022486425
2004-10-11	106	109	105	105	1880041	-0,027909	0,0010206968
2004-10-04	109	111	106,5	108,5	3625689	0,023203	0,0003672336
2004-09-27	106,5	107,5	102	106,5	3839041	0,023754	0,0003886626
2004-09-20	104	108,5	103,5	103,5	2354385	-0,03774	0,0017455589
2004-09-13	108	109	104	107,5	3474299	0,04256	0,0014837947
2004-09-06	103,5	108,5	100,5	103,5	4691891	-0,028573	0,0010636032
2004-08-30	106,5	108,5	105	106,5	2068747	-0,009346	0,0001791695
2004-08-23	107,5	109	103,5	107,5	3634080	0,0331	0,0008445063
2004-08-16	104	108	100	104	8291921	-0,10488	0,0118633897
2004-08-09	115,5	119	114	115,5	1256038	-0,017168	0,0004497522
2004-08-02	117,5	124	116,5	117	1636408	-0,041673	0,0020896102
2004-07-26	122,5	124	121,5	122,5	1457418	0,008197	0,0000172824
2004-07-19	121,5	125	118,5	121,5	1742790	0	0,0000163180
2004-07-12	121,5	125,5	115,5	121	2150553	0,016598	0,0001577117
2004-07-05	119,5	120,5	117	119,5	1721261	0,004193	0,0000000235
2004-06-28	119	121	118	118,5	3051618	-0,008368	0,0001539537
2004-06-21	120	122	117	120	2424394	0,021053	0,0002894711
2004-06-14	117,5	117,5	115	117,5	2383988	0,008547	0,0000203176
2004-06-07	116,5	119	115,5	116,5	3185501	0,004301	0,0000000684
2004-05-31	116	116,5	113	115,5	2218181	0,008658	0,0000213306
2004-05-24	115	115	106	114	4594069	0,053584	0,0024546761
2004-05-17	109	111,5	104	109	3205401	0	0,0000163180
2004-05-10	109	112	105	109	4470307	-0,009132	0,0001735027
2004-05-03	110	116,5	109,5	109,5	15597703	-0,044452	0,0023514082
2004-04-26	115	119,5	105,5	115	9345369	0,053584	0,0024546761
2004-04-19	109	110	103	109	3349060	0,051776	0,0022787936
2004-04-12	103,5	105,5	102,5	103	2292393	0	0,0000163180
2004-04-05	103,5	105,5	101,5	103,5	3252716	0,004843	0,0000006449
2004-03-29	103	104	98,5	102,5	4767712	0,034571	0,0009321900
2004-03-22	99,5	100,5	96	99,5	3568647	0,005038	0,0000009965
2004-03-15	99	102	97,5	98,5	3232406	-0,020001	0,0005779324

Datum	Senast	Hög	Låg	Köp	Volym	xi	(xi-medelvärde x)2
2004-03-08	101	105	98,5	101	3051362	-0,03884	0,0015085327
2004-03-01	105	106,5	100,5	104,5	4508967	0,04879	0,0023804801
2004-02-23	100	102	98,5	100	2660301	-0,004988	0,0000248756
2004-02-16	100,5	105	100	100	6848248	-0,067333	0,0045337491
2004-02-09	107,5	110	104,5	107	1681613	-0,00464	0,0000215331
2004-02-02	108	110,5	105,5	108	1634905	-0,022884	0,0005236909
2004-01-26	110,5	114	109	110	1499864	0,004535	0,0000205676
2004-01-19	110	113	107,5	109,5	2067305	-0,018019	0,0003246665
2004-01-12	112	113,5	105	112	2264752	0,041008	0,0016816580
2004-01-05	107,5	112,5	106	107,5	3424512	-0,009259	0,0000857351
2003-12-29	108,5	110	106,5	108	1347326	0,004619	0,0000213347
2003-12-22	108	108	106	107,5	801859	0,018692	0,0003493958
2003-12-15	106	107,5	102	106	4888742	0,023867	0,0005696567
2003-12-08	103,5	108,5	103,5	103	3102719	-0,033257	0,0011060428
2003-12-01	107	110	106	107	2269502	-0,009302	0,0000865345
2003-11-24	108	109	101,5	108	2744693	0,067011	0,0044904353
2003-11-17	101	103,5	97,5	100,5	2224225	-0,024451	0,0005978561
2003-11-10	103,5	104	101,5	103	1647702	-0,004819	0,0000232255
2003-11-03	104	104,5	100	103	3427226	0,009662	0,0000933525
2003-10-27	103	105,5	96	102	14238363	0,065186	0,0042492120
2003-10-20	96,5	100	95	96,5	1510396	-0,030615	0,0009372559
2003-10-13	99,5	102,5	96,5	99	1487451	0,041031	0,0016835755
2003-10-06	95,5	98	92	95,5	1551415	0,021165	0,0004479492
2003-09-29	93,5	96	85,5	93,5	2645693	-0,015915	0,0002533017
2003-09-22	95	100,5	93	94,5	1514962	-0,066182	0,0043800448
2003-09-15	101,5	102	97	100,5	2740424	0,019901	0,0003960559
2003-09-08	99,5	103	96,5	99	1660912	-0,014963	0,0002238876
2003-09-01	101	105	96	101	3368364	0,045578	0,0020773093
2003-08-25	96,5	97,5	92,5	96,5	2678674	0,015666	0,0002454272
2003-08-18	95	96,5	90	94,5	2677217	0,043017	0,0018504954
2003-08-11	91	91	83	91	2492980	0,080043	0,0064068351
2003-08-04	84	88	82	84	1245144	-0,035091	0,0012314007
2003-07-28	87	89	80,5	87	1073345	0,059189	0,0035033225
2003-07-21	82	83	78	82	753227	-0,012121	0,0001469274
2003-07-14	83	84	80,5	82	1295361	0,030583	0,0009353458
2003-07-07	80,5	83	78	80,5	2359788	0,031548	0,0009952989
2003-06-30	78	78	73,5	77,5	1759420	0,019418	0,0003770621
2003-06-23	76,5	78,5	74,5	76	1964668	-0,019418	0,0003770621
2003-06-16	78	78	74	77,5	2355898	0,025975	0,0006747259
2003-06-09	76	80	75,5	75,5	2435550	-0,032365	0,0010475116
2003-06-02	78,5	81	78	78,5	3073046	-0,018928	0,0003582696
2003-05-26	80	80	75	79,5	2499598	0,064539	0,0041652207
2003-05-19	75	78	73	74,5	2134690	-0,039221	0,0015382643

Datum	Senast	Hög	Låg	Köp	Volym	xi	(xi-medelvärde x)2
2003-05-12	78	82	77,5	77,5	1298707	-0,043894	0,0019267002
2003-05-05	81,5	84,5	77	81	1315184	0,012346	0,0001524197
2003-04-28	80,5	82	74,5	80,5	1548400	0,044452	0,0019759592
2003-04-21	77	80,5	74,5	77	1094178	0,013072	0,0001708793
2003-04-14	76	80	74	75,5	642548	-0,006557	0,0000429995
2003-04-07	76,5	78	72	76	1144190	0,033226	0,0011039437
2003-03-31	74	74,5	68	73,5	1699253	0,041385	0,0017127361
2003-03-24	71	73	70,5	70,5	1018793	-0,020907	0,0004370895
2003-03-17	72,5	73,5	66,5	72,5	3406655	0,064079	0,0041060999
2003-03-10	68	70	64	68	2134381	-0,007326	0,0000536709
2003-03-03	68,5	75	68	68,5	2287585	-0,042864	0,0018372972
2003-02-24	71,5	71,5	65,5	71	2836178	0,09531	0,0090840304
2003-02-17	65	68	60	64	2713370	0,039221	0,0015382643
2003-02-10	62,5	63	58	62	1635574	0,016129	0,0002601570
2003-02-03	61,5	63,5	58,5	61,5	1273016	0,05001	0,0025010422
2003-01-27	58,5	67	58	58,5	1957916	-0,135666	0,0184052270
2003-01-20	67	69	66	67	1354108	-0,007435	0,0000552789
2003-01-13	67,5	69	65	67,5	3433069	-0,014706	0,0002162708
2003-01-06	68,5	71	64,5	68	2460497	-0,007273	0,0000528930
2002-12-30	69	72,5	68	68,5	2496543	-0,00722	0,0000521320
2002-12-23	69,5	69,5	65	68,5	267108	0,036634	0,0013420597
2002-12-16	67	70	63,5	66,5	2913269	0	0,0000000000
2002-12-09	67	68	65	66,5	6207014	0,038027	0,0014460828
2002-12-02	64,5	69	61,5	64,5	2389482	-0,038027	0,0014460828
2002-11-25	67	69	59,5	66,5	5425506	0,127155	0,0161684387
2002-11-18	59	63	56,5	59	3733893	-0,0415	0,0017222277
2002-11-11	61,5	62	54	61	3580463	0,158224	0,0250348358
2002-11-04	52,5	57,5	44,2	52,5	14384623	0,145301	0,0211123994
2002-10-28	45,4	73,5	43,1	45,3	11842354	-0,440101	0,1936885423
2002-10-21	70,5	74	66	68,5	2863981		

Appendix 7

We used the following steps to calculate the sensitivity between the volatility and the option value (http://kursportal.gu.se/data/FE5324/Kursmoment/Lecture%20Material/RO%20Lecture% 203%20-%20OH.doc, 040225).

We created a row with different values of the volatility and a column for the option value. We marked the rows that we wanted to test and clicked on "Data" on the top menu and chosed "Table". We choose the volatility cells in "Row input cell" and then create a diagram using "Diagram and Series).

Sensitivity analysis

Volatility		4,00%	4,50%	5,00%	5,50%	6,00%	6,50%	7,00%	7,50%	8,00%	8,50%	9,00%	9,50%	10,00%
Option value	741,63	5,03	37,86	170,18	357,6	611,41	1235,28	1801,41	2324,24	3016,11	4275,66	5485,34	6654,21	7789,31