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ERP SYSTEMS AS INVESTMENTS: ANALYSING COSTS VS. BENEFITS

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ABSTRACT

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An ERP system investment analysis method using a Fuzzy Pay-Off approach for Real Option valuation is examined. It is studied, how the investment can be incrementally adopted and analyzed as a compounding Real Option model. The modeling allows follow-up. IS system development model COCOMO is presented as an example for investment analysis. The thesis presents the usage of Real Options as an alternative for the valuation of an investment. An idea is presented to use a continuous investment follow-up during the investment. This analysis can be performed using Real Options. As a tool for the analysis, the Fuzzy Pay-Off method is presented as an alternative for investment valuation.

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Tutkielma käsittelee Sumean tuottojakauma-menetelmän käyttöä reaalioptioiden arvonmäärityksessä Informaatiojärjestelmäinvestointien alalla. Tutkielmassa käytetään Reaalioptioita arvonmäärityksessä

Tutkielmassa tutkitaan investointien jaksottamista ja reaalioptioiden käyttöä seurantatyökaluna. Tietokoneohjelmistojen kehityksen kustannusarviointityökalu COCOMO-malli esitellään investointianalyysiesimerkkinä. Tutkielma esittelee reaalioptioiden käytön vaihtoehtona arvonmääritykselle. Tutkielmassa esitetään idea käyttää jatkuvaa investoinnin seurantaa investoinnin aikana joka toteutetaan reaalioptioanalyysinä. Analyysityökaluna tähän esitellään tuottojakauma-malli jonka avulla saadaan reaalioptioarvot helposti laskettua. Malli mahdollistaa jatkuvan seurannan investointiprojektin aikana.

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Foreword

It seems to be a habit to express gratitude of support in this space. I am grateful of all the support I've had during the studies and especially during the making of this thesis

I thank my supervisor, Prof. Mikael Collan for making this thesis possible and for exceptionally supportive role in supervising. My parents and sister and our dear little dog deserve a big thank you. My friends, you know who you are, our everyday coffee table talks on a variety of topics have helped me to cope with the writing process. Thanks for that! This time here has definitely been an interesting experience and I must say, I've learned a lot.

1.1 Background of the study

1.1.1 Introducing ERP investments.

The advances in the Information Technology have brought new possibilities along. One such example is an ERP system. An ERP system is a tool, but also a further development step for higher corporate efficiency. For a successful ERP implementation, however much more than a simple installation must be done. This Master's Thesis is written on the analysis methods for successful ERP implementations. The examples of failure serve as an example of what could happen if the planning of an ERP investment was inadequate. The focus of this thesis is the ERP system investment and profitability analysis thereof. The thesis suggests using a Real Options-based approach for the cost-benefit analysis of an ERP investment as an alternative to more traditional DCF based models.

The focus of the Thesis is presented in the picture 1.

Picture 1, focus of the Thesis

ERP Investments

ERP investments profitability

So-called old models (DCF, NPV IRR and COCOMO)

ERP investments & Real Options
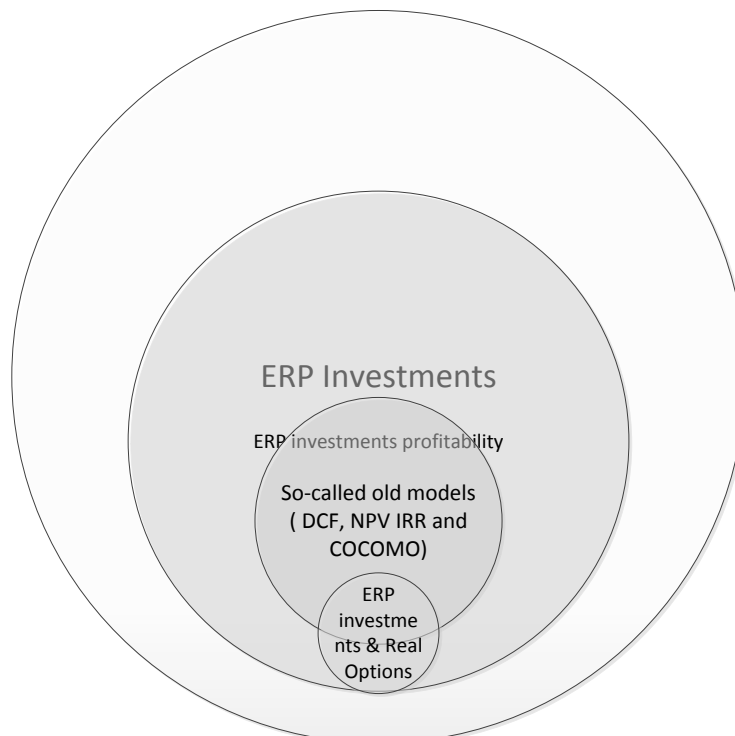
The picture 1 describes how the thesis is focused from a more generalized topic of ERP investments. The ERP investments' profitability is in the centre. Everything else in the picture is related to the profitability analysis. The models to analyze the profitability are presented chronologically and a focus of the thesis is combining the ERP investments and Real Options by using a Fuzzy Pay-Off approach first presented by Collan et al. (2009)

1.1.1.2 The research questions

The research questions are the following.

1. What is the added benefit of Real Option models in investment analysis, while the NPV is a text book standard?

2. What kind of special factors in ERP systems separate them from other investments?

3.What are the benefits and costs of these investments and how these can be analyzed?

4.What can be done to alleviate the risks of unexpectedly expensive project or delayed completion?

The questions relate to each other in following way: The ERP systems benefits and risks should be known prior the commencement of the investment project. It is important to know what would be the best tool to reach that information. However as the risks do not vanish even if these are known, measures to help to lessen the risks are needed.

1.1.2 The role of ERP systems in corporations

The ERP systems have interesting features. According to Klaus et al. "Usually called enterprise resource planning systems (ERP), these comprehensive, packaged software solutions seek to integrate the complete range of business processes and functions in order to present a holistic view of the business from a single information and IT architecture

(Klaus, Rosemann, Gable 2000) Enterprise resource planning (ERP) systems are integrated systems proposed for seamless information transfer between business functions, promising to deliver mesmerizing business benefits that include standardizing processes across multiple business units, consistent information base across the entire organization and reducing cost (Lozinsky, 1998, Blackwell et al., 2006 and Papiernik, 2001). In the modern company an ERP system is an important tool for the process. The size affects that how much risk the company in question can have. ERP-software benefits include operational improvements, including reduction of time to market, reduction in cycle time, product development time, improvement in operation, reduction of inventory cost (Stein, 1999) and higher customer satisfaction level (Al-Mashari, 2002). Indeed these benefits pose a difficulty to valuation; how much a higher customer satisfaction is worth exactly?

1.1.3 The Development of ERP systems

The ERP systems were developed in the late 1970's from the MRP systems. MRP stands for management resource planning. "MRP – the predecessor to and backbone of MRP II and ERP – was born in the late 1960s through a joint effort between J.I. Case, a manufacturer of tractors and other construction machinery, in partnership with IBM. At the time, this early MRP application software was the state-of-the-art method for planning and scheduling materials for complex manufactured products" (Jacobs, Weston 2007).

In 1972 SAP was founded in Germany. In the 1980's the systems developed into what is now called MRP2 "At the time, the firm worked with relatively small firms that had a need for general ledger, payroll and accounts payable as well as manufacturing planning and control. The idea of an integrated software package where sales, inventory and purchasing transactions updated both inventory and accounting information was an innovation" (Jacobs, Weston 2007) "The term enterprise resource planning (ERP) was coined in the early 1990s by the Gartner Group (Wylie, 1990).

Further according to Jacobs and Weston "It is our judgment that ERP systems have now reached a level of maturity where both software vendors and users understand the technical, human resource and financial resources required for implementation and ongoing use" (Jacobs, Weston 2007) The ERP systems as a whole are a relatively new, fast developed and important tool for improvement through technology.

1.1.4 Principles of the ERP investment forecasting

As in any investments it is impossible to calculate anything without information about costs and benefits. These benefits are not easy to see in advance: An example of which could be hard to evaluate is that the Reaction time to competitive pressures and market opportunities could also be improved by technology (Badawy, 2009).

1.1.5 Common mishaps in ERP implementations; examples of failures of an epic scale.

There have been in the past more than a few spectacular failures in implementation of an ERP system. Such examples include: Unisource Worldwide, Inc. wrote off US$168 million as it abandoned the nationwide implementation of ERP software (Stein, 1998). And. FoxMeyer Drug went bankrupt in 1996 and filed a US$500 million lawsuit against SAP, blaming for its woes (Key, 1998). A recent article in a Swedish internet newspaper shows that the Swedish manufacturer Electrolux made a write down of 906 Million SEK following a failure with SAP system implementation, which the company abandoned last year after starting the project already in the year 2007 (Computer Sweden 2014)

According to Statistical data from the past studies it is found out that 70% of ERP implementation projects fail to achieve the expected goals set prior to the implementation (Buckhout et al., 1999). Another worrying fact regarding current state of ERP implementations is that when measured in monetary terms "The decision makers need to evaluate the risk

undertaken by the company and calculate the Return On Investment. Failure as an implementation that does not achieve the ROI identified in the project approval phase finds that failure rates are in the range of 60–90%" (Ptak and Schragenheim, 2000).

An example of the problem in ERP investments could be the following: One does not buy a chainsaw and choose a cardboard box that seems reasonably heavy and has a price tag, that says that this box either costs €95 or €897 or anything in between and you only get to open it after you have paid. This item is non-refundable. On the other hand, corporate investments into software projects resemble that example, and an analysis is needed

1.1.6 An alternative for risk alleviation

In this Thesis, however a suggestion for such an investment analysis is presented. The problem, in Adam Savage's, a world famous TV presenter's, words: "I reject your reality and substitute my own" sic. (Myth Busters, Season 1, Episode 12). That resembles ERP valuation problems. Often these benefits of the project that are not quantified do not reflect the reality but are a perception. The cost-benefit analysis cannot act as an analysis if neither the benefits nor the costs are represented numerically encoded. "Enterprise resource planning (ERP) systems are highly complex information systems. The implementation of these systems is a difficult and high cost proposition that places tremendous demands on corporate time and resources" (Umble, Haft, Umble 2003)

In cost-benefit analysis, a calculation of a net present value of a project with an appropriate risk factor is important. The project of implementation of an ERP-system is not a constant. It is also said that "Implementing an ERP system is not an inexpensive or risk-free venture. In fact, 65% of executives believe that ERP systems have at least a moderate chance of hurting their businesses because of the potential for implementation problems" (Umble, Haft, Umble 2003.)

1.1.6.1 The importance of risk alleviation

In the literature accordingly it can be found that "The existing organizational structure and processes found in most companies are not compatible with the structure, tools, and types of information provided by ERP systems" (Umble, Haft, Umble 2003) The need for strategic change is noted as well as that "It is well known by now that improper implementation of (ERP) software projects can cause considerable problems for companies" (Motwani et. al. 2002) and "Strategy led cautious implementation process backed with cultural readiness, inter-organizational linkages (with the vendor), and careful change management are factors that contribute to successful ERP implementations."(Motwani, et al. 2002)

Picture 2: Success factors of ERP investment (Motwani, et al. 2002)
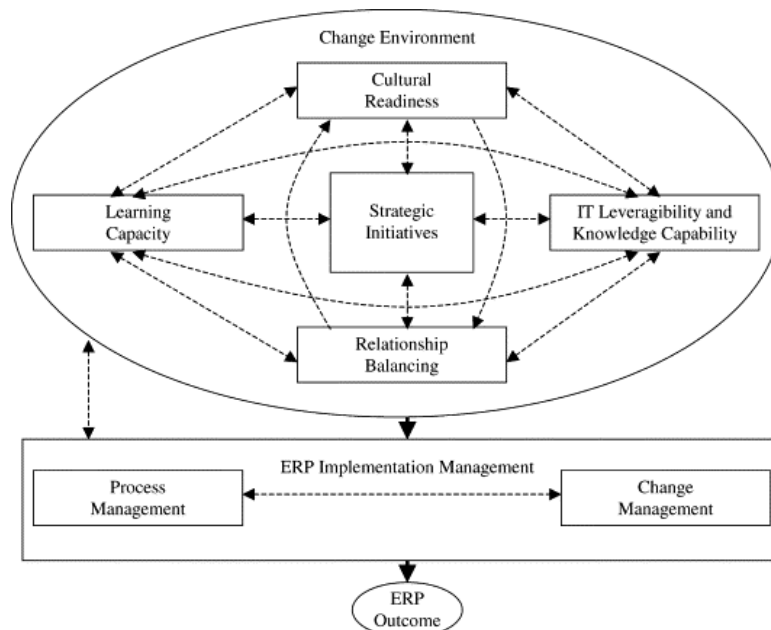
In the picture 2, the complexity of the relationships of the different success factors are shown. The implementation management and the organizational change is a critical factor in success. The entire organization must change when the ERP is implemented. In the picture

the complex relationships are seen. A critical lesson is that the success factors involve organizational change, not the choice of ERP vendor or installation methods. In order to have a successful ERP system installation a change is needed for the whole organization.

1.1.8 The structure of the Master's Thesis

In this Master's Thesis the broad topic is the analysis of real option logic, pay-off method and other valuation methods in context of ERP-investment.

Firstly the current information is presented and it is shown that what the intended contribution of the thesis is. Then the different methods are explained, how these work and more importantly why. Then it is shown, that how the pay-off method works and what can be achieved with it and the work will end in a summary of what was achieved.

Picture 3 the structure of the thesis.
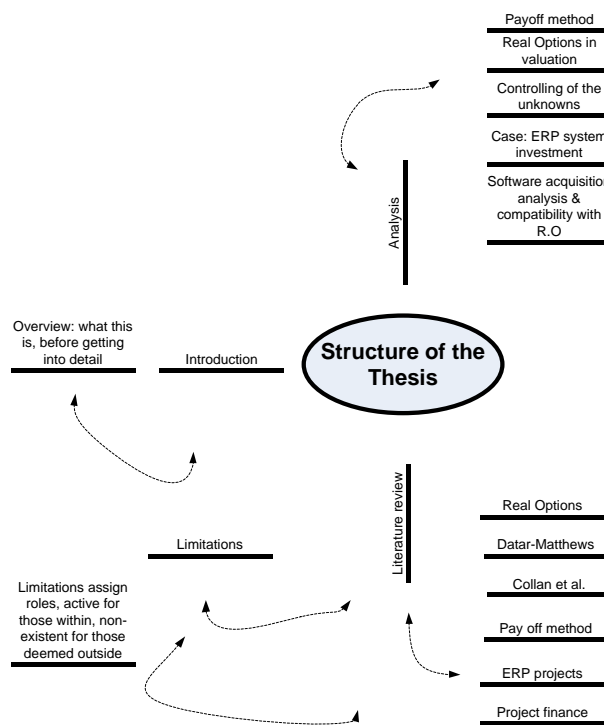
In the picture 3 it is shown how the ERP investments are examined. A possible analysis involves the fuzzy pay-off method. Literature review is compiled on different real option analysis methods. Although the real options have wide possible usages, this thesis limits the scope into ERP and IS systems in general. The thesis proposes an alternative for ERP investment analysis.

1.2 Motivation of the study

The benefits from utilizing an ERP system include positive market reaction for announcement of ERP implementation, which is significantly more positive if the vendor is large (Hayes et al 2001) Financial analysts' reaction was overall positive for such announcements with higher post-implementation earnings forecasts (Hunton et al 2002) According to (Poston, Grabski 2000) the general financial performance did not improve after adoption of an ERP system but they found a significant decrease in the ratio of employees to revenues and a reduction of cost of goods sold to revenue in the year 3 after the adoption. Also while the financial performance of the adopters did not improve, the performance of non-adopters decreased (Hunton et al 2003) rendering the adoption of an ERP system necessary in order to stay competitive. (O'Leary 2004) Also these perceived benefits have been classified under two rather broad categories: Tangible and Intangible. In Deloitte consulting's study (1998) these benefits were classified in these two categories in a following manner. These results are shown in table 1

Table 1: Tangible and Intangible benefits (Deloitte Consulting 1998)

TABLE 1
Tangible Benefits Realized[a]

Inventory Reduction	32%
Personnel Reduction	27
Productivity Improvements	26
Order Management Improvements	20
Financial Close Cycle Reduction	19
IT Cost Reduction	14
Procurement Cost Reduction	12
Cash Management Improvement	11
Revenue/Profit Increases	11
Transportation/Logistics Cost Reductions	9
Maintenance Reductions	7
On-Time Delivery	6

Source: Deloitte Consulting (1998).
[a]Percent of firms mentioning.

TABLE 2
Intangible Benefits Realized[a]

Information/Visibility	55%
New Improved Processes	24
Customer Responsiveness	22
Cost Reduction	14
Integration	13
Standardization	12
Flexibility	9
Globalization	9
Y2K	8
Business Performance	7
Supply/Demand Chain	5

Source: Deloitte Consulting (1998).
[a]Percent of firms mentioning.

These benefits show that ERP systems are important for the companies. The tangible benefits, are easily quantified. However the intangible benefits are not. This however doesn't mean that intangible benefits should be forgotten. Both type of benefits are important for the companies and for the wider society.

1.2.1 The field of study - a description

The thesis is composed of the following disciplines: Finance, Managerial Accounting and Information Systems (IS) study. The methodologies are mainly from finance, as the tool of choice is Real Options- based. The suggested methodology involves the company; hence managerial accounting is related to the thesis.

ERP systems belong to information systems. This thesis is limited to the analysis of an ERP investment. In the following picture this is shown: The shaded area is the niche in which this thesis is found. The thesis thus belongs to all of these sciences.

Picture 4: The topic of the thesis in the context of wider fields
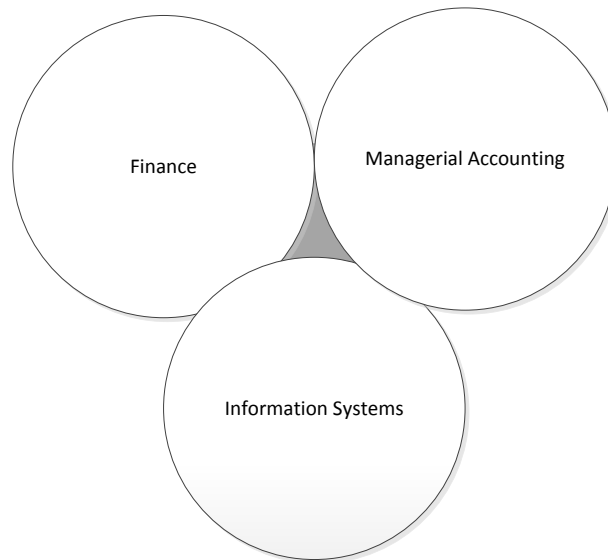
1.2. The importance of ERP investments

The financial importance of ERP system investments is clear. One of the most well-known ERP vendors is the German company SAP. According to their financial report of 2012 the segment Software and software-related service generated revenue of 13,165 Billion euros. (SAP annual report 2012). According to Panorama Consulting, the market share of SAP was 24% (Panorama Consulting 2010) Also in the study the lowest average project cost of any ERP vendors was with Tier 3 vendors, amounting 1.1 Million USD. (Panorama Consulting)

ERP systems are many times highly customized for the needs of the company. Customization is a crucial, lengthy, and costly aspect in the successful implementation of ERP systems, and has, accordingly, become a major specialty of many vendors and consulting companies (Gefen 2002) According to Gefen, nowadays companies are more dependent on

vendors and consultants in customer support in customization of modern IT infrastructure.

ERP Implementations pose major challenges to organizations. Though results from these studies have been diverse, recurring themes have emerged, such as management support, project team performance, the implementation process, education and training, as well as change management and minimal ERP customization. (Rothenberger, Srire 2009) Too much customization decrease the maintainability of the system as well as the customizations may need to be completely rewritten in case of a system upgrade (Rothenberger, Srire 2009) Next the thesis will continue towards cost-benefits analysis that is the basis of any investment analysis. That can be seen at the picture on the process flow.

Picture 5: Process flow
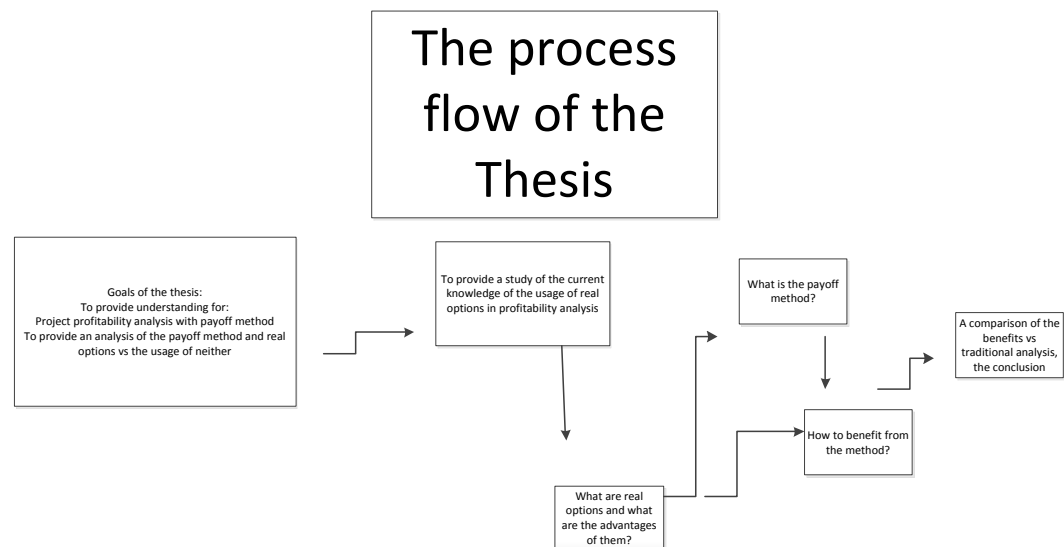
1.3. Evaluation of costs and benefits

The Cost-Benefit analysis is an analysis that intends to list down the costs and the benefits that can be attainable with the investment decision. The investment is "an outlay of money usually for income or profit" (Merriam Webster Dictionary). Let us consider a simple example. A company has initially analyzed the potential increase of sales a new software could promote via more accurate price forecasts. If the analysis was poor it

could result in losses due to false investment decision. Then the calculation is not to be blamed but inputs. The investment analysis must be based on facts, identified by analysis

Cost and benefits are expressed as "Both cost - benefit analysis (CBA) and cost - effectiveness analysis (CEA) are useful tools for program evaluation. These seemingly straightforward analyses can be applied any time before, after, or during a program implementation, and they can greatly assist decision makers in assessing a program's efficiency." (Riegg Cellini, Kee 2010 pp.493) As Riegg Cellini and Kee put together, the analysis gives a start point for the more complicated analysis that can be made afterwards.

Important to notice: "The concepts and basic equations presented so far are seemingly simple, yet obtaining accurate estimates of costs and benefits can be extremely challenging." (Riegg Cellini, Kee 2010 pp. 494).

The steps of performing a full cost benefit analysis can be made to complement the information, according to Riegg Cellini and Kee (2010)

1. Set the framework for the analysis
2. Decide whose costs and benefits should be recognized
3. Identify and categorize costs and benefits
4. Project costs and benefits over the life of the program, if applicable
5. Monetize (place a dollar value on) costs
6. Quantify benefits in terms of units of effectiveness (for CEA), or monetize
Benefits (for CBA)
7. Discount costs and benefits to obtain present values
8. Compute a cost - effectiveness ratio (for CEA) or a net present value (for
CBA)
9. Perform sensitivity analysis

10. Make a recommendation where appropriate (Riegg Cellini, Kee 2010 pp. 495)

It must be noted that these outlines are wide and can be used purposefully. Further according to Riegg Cellini and Kee (2010) an important step is to decide whose costs and benefits are analyzed. In ERP investments the answer is obviously the company's costs and benefits that are analyzed.

Furthermore "In conducting a cost - effectiveness or cost - benefit analysis as part of a program evaluation, the third step is to identify and categorize as many of the known benefits and costs of the program as possible. " (Riegg Cellini, Kee 2010 pp. 499)

1.4 Information systems as investments

Immaterial investments can be for instance computer software, education that increases productivity, a course in fuel efficiency to save fuel on vehicles of a transportation company etc. As seen, the investment opportunities in corporate finance are plentiful. The corporate investments are such that shareholders want the company to take if the project makes the company more valuable (Brealey, Myers, Allen pp.129). By definition these can contain everything the company spends its assets for to increase shareholder value. In this Thesis an emphasis is on ERP investments. As in any investments, ERP system investments' main purpose is to enhance shareholder value.

1.4.1 Investment analysis models - NPV and IRR

However intuitive the usage of the Internal Rate of Return, IRR is, there are several pitfalls with IRR method usage. Unlike NPV, which has an effectively identical mathematical background, IRR can lead to miscalculations. Literature identifies such as that as not all cash flows

have NPV's that decline as the discount rate increases. This leads to that the IRR can either mean lending money at the IRR or borrowing at the IRR, these two have clearly opposite outcomes. There can be cash flows that have multiple rates of return, thus having multiple different IRR's. This is due to a double change of sign of the cash flows during the period. IRR can lead to misleading results if the projects are mutually exclusive, a larger project with smaller IRR can still have a larger NPV. Also IRR is not comparable whenever there is different opportunity costs of capital, implicit assumption is that the long term rates are same as the short term. (Brealey, Myers, Allen pp.137-142)

Traditional investments in textbooks are often seen as simple examples of a company that purchases a machine and thereby earns a higher income on subsequent years. One such textbook example is for example: A company has an opportunity to invest on either of the three projects. In all the projects the initial cash outlay is 2000 $. The project A has subsequent cash flows on years 1 and 2, 500 $ each and on year 3 it has a cash flow of 5000$. Project B is similar, it has an initial cash outflow of 2000$ and on year 1 it earns 500$ back. On year 2 the cash flow is 1800$ and onwards it is 0. The project C has otherwise identical numbers, but the year 1 cash flow Is 1800$ and year 2 it is 500$.

The Net Present Values (NPV) of these projects are following, at 10% discount rate: A:2624$, B: -58 $ and C: +50$. (Brealey, Myers, Allen pp. 133)

In this case the cash flows without proper discounting and omission of the time value of money (that a dollar today is worth more than a dollar tomorrow as it can be invested to earn interest in the meantime), the initial investments would end up positive: Project A would be worth of 4000 $ (6000-4000) and projects B and C would be of an equal value for the company: Both would be +300 $, and thus increasing the shareholder value by 300$. Here an important lesson is learned. First of all the timing of the cash flows matter, the project with the 1800 of income incurring later is worse off, in fact it is diminishing the shareholder value. The project B

that has the cash flows occurring later destroys the shareholder value by 58$ as the project C, which has otherwise identical cash flows still increases the shareholder value by 50$. In that notion it is demonstrated that what effect time has on project profitability.

The other lesson of the text book example is that the clear winner of this project comparison is the project A. It is the best alternative of these 3 to the company and by taking on the project the company shareholders are 2624$ better off than without the project. In fact: the NPV is a simple idea that is quite obvious: "When we calculate an investment project's NPV we are asking whether the project is worth more than it costs" (Brealey, Myers, Allen pp.900). That simplicity is intriguing and in many cases of investments the only thing to consider.

1.4.2 Criticism of the discounted cash flow-based valuation

NPV models are still used and indeed usable in projects that have clear projected cash flows, a certain initial cost of investment and a possible known salvage value at the end of the period. The company knows its discount rate. In ERP systems this is changed to unknowns.

"Implementing ERP systems successfully calls for strong leadership, a clear implementation plan, and a constant watch on the budget (Wagle, 1998). From a project managers' point of view, the most important consideration is a clear implementation plan and a strategy to implement that plan" (Mandal, Gunasekar 2003).

"Cooke and Peterson (1998) found that the organizations that had no SAP implementation strategic plan performed poorly 90% of the time compared to those who had a plan" (Mandal, Gunasekar 2003). It is clear that a simple and quick solution for ERP valuation neither exists nor could ever exist. The used analysis model must be much more allowing for strategic planning. The ERP investments need more planning than NPV models possibly allow.

2. State of the Art analysis on the literature

This chapter follows an example of State-of-the-Art method of creating an efficient literature review on the articles that particularly discuss the investment analysis of IS investments using real option analysis approach. In this section the pre-existing knowledge is gathered under one roof and a literature review is conducted. The research is done on the following databases: Google Scholar, Elsevier, EBSCO Business source complete and Emerald Journals. The databases are accessed and suitable search strings used. Also the website (www.payoffmethod.com) of Prof. Collan includes a lengthy list of good source articles under "citated works" These articles contain references to other articles that are thereafter regarded as source material for this thesis.

A good literature review will create such a situation for the thesis and form a solid entity on its own. The picture depicts a situation where different articles create a solid box.

Picture 10: The articles and the magical box they form.

From separate entities into a
single box
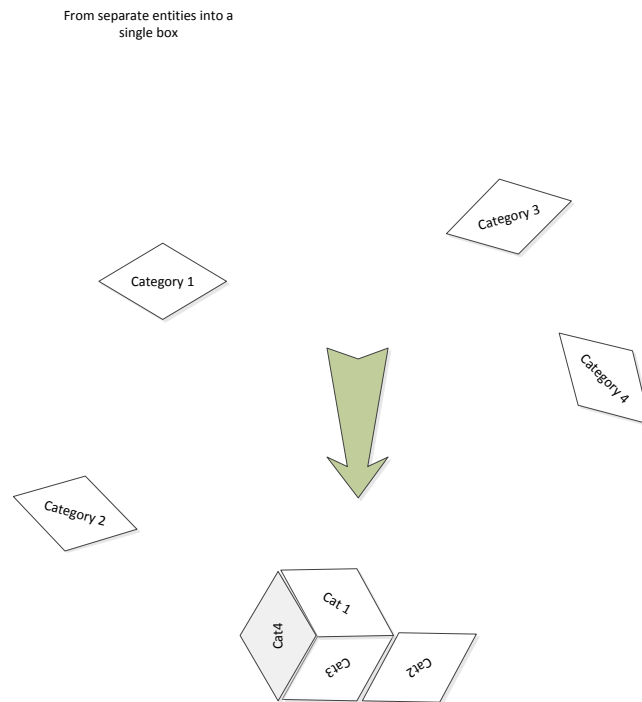
In this picture the current state is ambiguous. The box can be a near complete box with one side open. Or the theoretical framework can be currently open. The box is both open and empty, and the information about the real state of the matter is missing, and the substance must be put into the box. Or the box is nearly intact, but it is unknown what is inside.

The purpose of the literature review is to make the box intact. The literature review is the box.. The bigger picture is the box, what it contains and what it is, and the different types of the articles put together form the box. The way the box can either be seen full or empty, is a metaphor. The reality is formed from different ingredients that put together create an entity. The literature review serves the purpose to create the box which is simultaneously open and closed, depending on the way one looks at it. The picture tells a more common story; the information is scattered and how the summary is made, that creates the box. That can be drawn without leaving the tiny little gaps between the tiles to create a solid box. Or then it is very much more realistic to avoid the strict depiction of reality

that leaves no room between the tiles. Without these tiny little gaps the illusion is lost and the box is a simple box. With these gaps between the tiles the illusion is created, that the box is either empty or unknown. These little gaps contain the room for discussion, the room for the uncertainty, the room for the fuzziness of the fuzzy payoff method and the real options. The illusion is a metaphor for the different dimensions of the overall framework for the method. When one only gives a quick glance on the box it seems to be a simple box. When one looks a little more carefully then the tiny little gaps that represent the room for discussion and uncertainty, only then the box opens up and reveals itself. The gaps are the important parts that enable the box to be seen either way. The research questions are not inside the box, nor are the questions painted on the box. They exist between the small gaps. The research questions enable the framework to be created from these different aspects that are there. And when the gaps stay open so does the box, and only then, the box can be seen as being open or closed. In that metaphor a stress must be given to that, that too strict a framework leaves the real substance hidden inside from view. That is the purpose of the literature review. Simultaneously to create a framework from different aspects and to leave space for free thinking. The known pieces create the framework but the gaps create the magic.

2.1. State of The Art – the process

The literature review is an integral part of this thesis. The literature review is presented as a state-of-the-art analysis. The purpose is to gather all the existing information under one roof and to be able to further differentiate the subcategories of articles from each other. In the procedure of gathering the relevant texts under one framework, the box is made. The analysis is of following kind.

Picture 11: State of the art procedure

First step, search in databases
using appropriate search string.

Second step, scanning the search
result, Titles and abstracts are read
and appropriate articles chosen.

Third step: Backward tracking, the
introductions and literature reviews
are read on the 2nd step articles
and important references are
included on 3rd step.
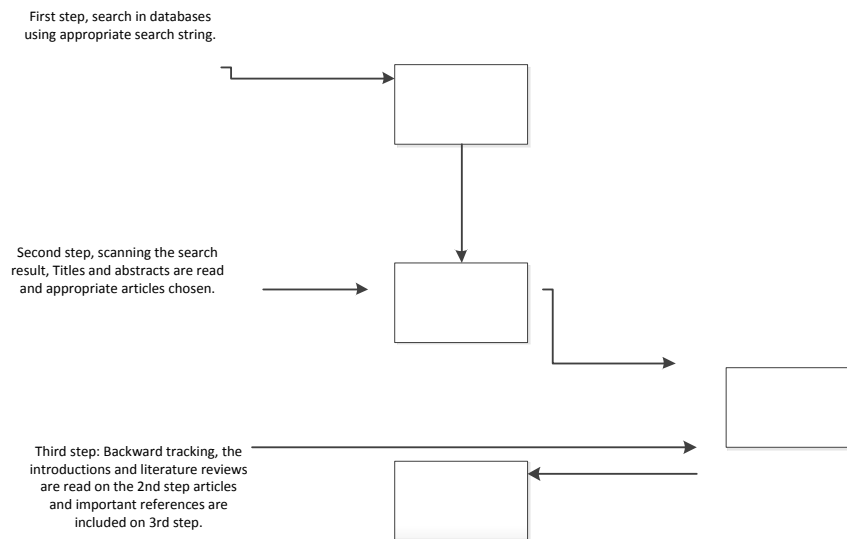
The process when it's performed will end up having a large number of initial result articles, that reduce into a lesser number of articles after reviewing them and then in the 3rd phase the articles are added from the 2nd phase article references if a need shall arise. The articles of the last phase are the included material in the research, everything else will be omitted and deemed inappropriate in this particular context.

2.2 State of the art-the research

In this subchapter the research is compiled and presented with all the keywords that are used in order to make the research easy to replicate in the future. The research is done on the following databases: EBSCO – Business source complete, Elsevier Science Direct, Emerald Journals. The research result are then presented in a picture that resembles the procedure description, and moreover the amount of articles that are accepted is listed there. Moreover the preliminary research term has been the following:

"**ERP Valuation real option**"

That yields 254 articles. The 1st stage is extremely simple: a search query is compiled; in this case multiple different options were tried prior the selection of the final term. A good search term has relevant articles

beneath. A great search query has a relatively small amount of defined articles that are found. Then the work continues in scanning through the articles. Also other relevant articles are searched for using the results' own literature reviews. The articles are then shortly presented in a table and shortly described of their content and contribution to the science. The limitations that are used in this thesis are strict: the articles need to be about the utilization of real option-based logic in IS / ERP implementation / investment context. Everything else is off-topic and is not reviewed. The literature in the field is extremely wide.

In the following space the articles are shown in a table. The table contains the names of the articles, the publishing year, the authors and a brief description of the contents.

Table 2, A listing of state-of-the-art articles

Author, Year	Name	Description of contents
Collan, Björk, Kyläheiko (2014)	Evaluation of an information systems investment into reducing the bullwhip effect – a three-step process	A description of an example of the utilization of the pay-off method in the valuation of an IS system in the fine paper supply context.
Wu et al. (2009)	An approach to the valuation and decision of ERP investment projects based on real options.	A description of risks and possible benefits of an ERP project that utilizes a Stochastic integer programming model in compound real option analysis. Discusses tangible benefits as sources of

		real option value.
You et al. (2012)	A real option theoretic fuzzy evaluation model for enterprise resource planning investment	A description of a case study that utilizes the Fuzzy pay-off method in real option valuation and discusses the need to implement the ERP installation project in stages that are in order of essentiality. Contains a numerical case to facilitate discussion of the principles of the method in practice.
Özogul, Karsak, Tolga (2009)	A real options approach for evaluation and justification of a hospital information system	The authors discuss the usage of real options in hospital information system context and utilize a binomial decision tree as a solution for the real options valuation. The authors use a Turkish health care organization as a case to further illustrate the usability of real option analysis.

These articles were found to have the highest relevance towards the topic. In the 3rd column of the table the contents are shortly described for every

article. The suitable articles are utilized as a source material for the rest of the thesis, in the numerical case example. The numerical example is based on the work of Prof Collan and his contribution on the development of the pay-off method. The numerical example is done using the pay-off method and this has been done previously by Collan, Björk, Kyläheiko (2014) and You et al. (2012). In this thesis a similar numerical example is reproduced based on these previous findings.

3. COCOMO – A Model that Boehm wrote

This chapter focuses on the underlying parts that affect hugely the chosen methodology in cost-benefit analysis with Real Options. Firstly the model and its purpose is presented and then the story develops into what this is in practice. Then the material provided by the Book software cost estimation with COCOMO 2 is utilized. The chapter first presents that what the model is and the history of the model is covered and from there the chapter discusses the uses of the model in this context. The model forms an integral part of the thesis and receives a deserved attention.

The model is almost as old as the software industry itself. As the industry developed to become a huge and a new industry among others that also became to have an effect on practically everything that is made, then it soon became clear that something has to be in existence to be used to analyze the costs of these new tools in the corporate world. There was a sincere need for cost estimation models and this particular one answered it. A pioneer in the field, Barry Boehm, first developed a first version of his work as a model called COCOMO. COCOMO stands for Constructive Cost Model, which has soon become the most important and used model in software cost estimation in the year 1981. That year his 1st book, Software Engineering Economics was published. (Boehm et al 2000 pp.XXVII). The model that this thesis follows, COCOMO 2 was created because the usage of the original was becoming more and more limited

requiring adaptation as the software life cycles have changed dramatically over the years. (Boehm et al. 2000 pp. XXVII).

In this case the necessary parts of the model are used to do an analysis of a software development. As Boehm wrote "The COCOMO 2 capability for estimation of application generator, systems integration or infrastructure developments is based on a tailor able mix of the application composition model (for early prototype efforts) and two increasingly detailed estimation models for subsequent portions of the life cycle" (Boehm et al. pp.9) The IS / ERP system investment falls subsequently mostly into category. It is after all a systems integration software. After all according to (Kallinikos, 2002), ERP systems are complex packaged software that identify integration as the major issue of corporate governance and emphasize it as one of the package's core capabilities (Elbanna, 2007). Therefore the capability of the COCOMO Model to accommodate the systems integration analysis with the fact that the systems integration is the carrying function that is firstly and fore mostly the most important feature of the ERP system, then the usage of an adaptation of the COCOMO Model is more than just justified. In fact the usage of the model is rather easy to include and the decision to completely forget the work of Boehm is more to justify.

However the work of Boehm includes 476 text pages and the whole material cannot possibly be correctly depicted in such a short space, nor that it should, but this work only utilizes such parts that are suitable in this case, but nothing else. The thesis is focused on a very small subsector of software investment analysis and it does not include technical recommendations nor takes any view on practical programming and its challenges. The most of the book falls far outside of the scope of this work and such things are not discussed at all. For people generally interested into software programming, development and industry in general the works of Boehm are almost like a Bible, and thus highly recommended read.

3.1 A rather more detailed description of Boehm's life work

  In this chapter a short description of the Model is given. On the beginning it concentrated on what the model is, a brief history of it was described and the limitations of the scope of this work was given. Now an emphasis is solely on the features of the model that are indeed usable in this context.

The model defines Key Process Areas (KPA) That relate to the Post Architecture Cost Drivers. (Boehm et al. pp. 37) According to Boehm, that model is the most detailed that is tailored for the usage of a software that has an already developed life cycle architecture. That is the case mostly found on ERP and IS systems in general. The systems are vendor-created that are customized as needed for the use of the company. According to Panorama Consulting:

"When it comes to ERP systems, the word "customization" is one of the most dreaded terms that an executive hears. In fact, I would estimate that at least 90-percent of Panorama's ERP selection clients indicate a strong preference for zero or no customization. In other words, most CIOs and CFOs want to use the system out of the box without making any changes to the software code. There will always be configuration and personalization, which every ERP implementation requires, but when it comes to heavy-duty changes to the software, most executives don't want to hear about it.

However, something strange happens during implementation. Inevitably, the business identifies one or more things that the software doesn't do quite right, so they request to make just one minor change to the way the software is designed. Of course, this is a slippery slope, and one minor change to the software code typically leads to several more. This phenomenon is true of most implementations that we help manage for our clients, and our research outlined in our 2012 ERP Report (and in the

graphic below) found that only 11-percent of organizations implement their ERP systems without customization:" (Panorama Consulting 2012)

Picture 6: The degree of customization of ERP installments (Panorama Consulting 2012)
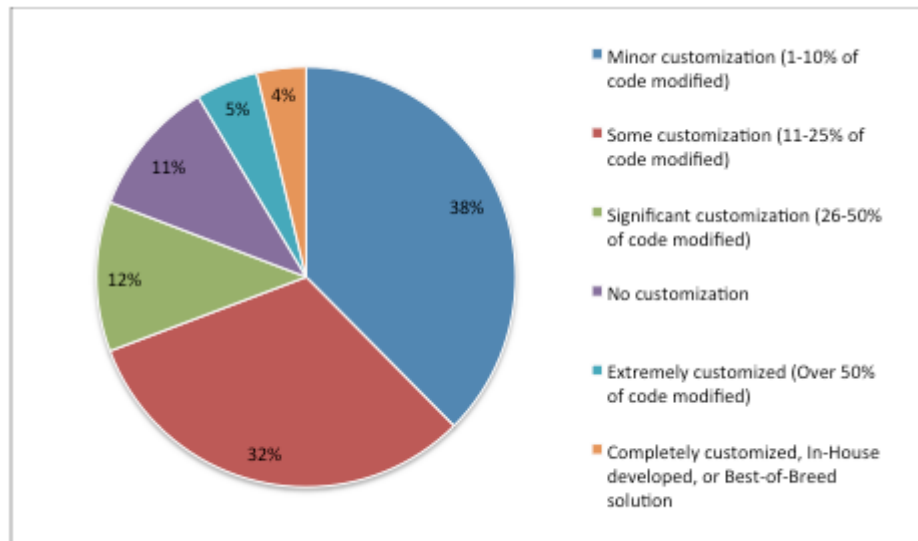
The situation is as described by the Panorama Consulting such that the description as Post Architecture cost drivers is accurate. The implementation of the ERP system and an IS investment in general is a difficult issue that has to be examined very carefully. The software comes in a package in general. In other words it does not need to be created from the scratch in the fullest extent of the word. However it is not exactly like buying MS word either. The investment is significant and has this kind of complications in the way. Therefore it is of an importance to know as much as possible. There the COCOMO model comes in handy. The amount of customization of course varies from an installation to another but indeed these can be evaluated with the COCOMO model.

There has been extension to the work of Boehm, for instance (Idri, Abran, Kijri 2000) have tried to incorporate fuzzy set theory with the traditional COCOMO'81 model. " Estimating the work effort and the schedule required to develop a software system is one of the most critical activities in managing software projects. In order to make accurate estimations and

avoid gross estimation errors, several techniques are used within an organization. The most popular techniques (at least in the literature) use the algorithmic models such as COCOMO" (Idri, Abran, Kijri 2000) Accordingly the authors explain the situation which has not according to panorama consulting, changed much in the last years since the article was published in 2000. In fact the situation accordingly remains very much similar. The authors further the contribution of Boehm by trying to utilize fuzzy set theory with the COCOMO model. The problem that the authors point out is that when the COCOMO model has cost drivers that are measured as a 6-point linguistic values every project can only have one, and a small difference can lead to a great difference when encoded into linguistic scale. (Idri, Abran, Kijri 2000) The problem is that the transition is not gradual but abrupt. A partial solution of this problem was to use fuzzy sets instead of traditional intervals. The fuzzy sets are trapezoid shaped membership functions. However the COCOMO as a whole remains incompatible unless the 3 modes of a project or the size of the code can be expressed as fuzzy numbers (Idji, Abran, Kijri 2000) As explained there has been developments outside of the original authors of the model as well.

3.2 Criticism of COCOMO model and such models in general

"Although planning is a crucial part of the system development process, it is often neglected by project managers. The problem being addressed by this paper is that of inadequate models for planning the requirements capture and analysis stage (RCA) of a software development project. It is stressed that there is a need for a new model because the existing models give inaccurate, inconsistent or unreliable predictions. Additionally, they are based on either inappropriate variables or variables that cannot be measured at the beginning of the development process. Finally, existing models do not support the planning of individual stages of the development process but only try to make predictions about the project development process as a whole" (Chatzoglou, Macaulay 1996) The

shortcomings of the cost evaluation models have been as long ago as in the year 1996, identified. According to the authors "It has been reported that, on average, software systems are delivered a year behind schedule, that only 1% of software projects finish on time and to budget, and more importantly, that 25% of all software intensive projects never finish at all." (Chatzoglou, Macaulay 1996 pp.173) The problems that according to the Panorama Consulting reports have been really problematic already back in the 1990's. The phenomenon that the projects are often late and most often not in budget is a clear information gap that must be addressed by the scientific community as a whole. The goal of project management is after all to complete the project on time and staying within the limits of the budget. Accordingly that is achieved by having 4 activities " Planning, monitoring, coordinating and reviewing " (Chatzoglou, Macaulay 1996 pp.174) "There are many different models describing the software product life-cycle such as the waterfall model, the incremental model, the prototyping and spiral model. However, several features are common to all these models. One of the common features is that the software life-cycle is characterized by different stages or phases" (Chatzoglou, Macaulay 1996 pp.174)

The situation is nowadays identical and the planning of the software investment is often described with these terms. The tools have been invented over 30 years ago. COCOMO has been used ever since. The model has been extended and calibrated afterwards multiple times. The scientific community has identified a sincere need for the adjustments for the model. In order to understand the need an example is given: Thinking of starting a diet to lose weight: one has 3 scales in start: stepping on the 1st one yields 300 kg. second scale claims that you weight 35kg and the 3rd scale says 85kg. The true weight is somewhere between these values but these values are due to wrong calibration of the scale. Say that one was meant to be used weighing babies, who typically weight 4 kilograms. The other was stolen from the Zoo, where it was used to monitor the weight of the elephant. the 3rd was used in weighing trucks on highway

when controlling for overload. "A trial of two models, Putnam's 'SLIM' and Boehm's 'COCOMO', has shown variances in results of 500-600% compared with actuality for small and medium-sized data processing and applications, and has stressed the need for special care in calibrating models to an application type and development environment". (Chatzoglou, Macaulay 1996 pp.176) The example may seem a little off, but the situation is exactly as hilarious. In order to successfully gain insightful information about weight a scale must be used that is specially meant for that, not one that is used for trucks or for elephants. When monitoring the change of the weight the change can be seen even when wrong tools are used but the measurements don't add up with other, better calibrated scales. On the other hand one does not lose weight by first stepping on the elephant scale and then on the baby scale. The comparison must be made in similar circumstances. The models must also be calibrated for the use very carefully and are not with each other very compatible at all. Vice versa, the differences of 500-600% are huge. Just as the example. But still the models can and suit with the utilizing of them for instance as a source of information that what needs to be taken into account with the evaluation. The shortcomings of COCOMO are there but these can be avoided when they are known. Things such as the inability to include fuzzy numbers in the COCOMO model as a whole, or that the models may give some very funny results then not well calibrated. These matters do not prevent the usage of the model as a source of the information about *what to include* in the analysis. In fact in this context the model is used ad hoc. It is not utilized in its fullest extent. it is used as a basis of the analysis as a source of the variables that need to be taken into account. With these amendments the worst shortcomings can be avoided. After all not all practitioners are capable of performing the calibrations for the model that are needed. The model is a fairly complicated one. The book that explains the model is around 500 pages. The usage of the model as a whole falls out of bounds of this Thesis but as a pioneering work of the field it deserves its name being mentioned and parts of the model utilized. Also by the partial utilization the traps such as

the calibration and the effect the size of the project has with the final cost estimate can mostly be forgotten. "In practice, cost models have two major problems: (I) they give very poor predictions when used on independent datasets, and (ii) they are based on subjective estimates of inaccurate input variables and, therefore, they give very different results when applied to the same problem" (Chatzoglou, Macaulay 1996) As noticed already back then, there is a constant need to improve the models that are used in the cost assessment, and it is rather good: the world is never complete and there is always an ongoing need to improve and that keeps the scientists busy for a long time. Until now the thesis has been introducing the topic of IS systems investment analysis and continued in cost-benefits analysis in mind into the practical guidelines of IT investments in general that is heavily influenced by Barry Boehm, a pioneer. From now on the focus will shift to the tools: a car is rather easy to fix if one knows what's wrong and knows that what is a fault code and what is an impact gun. The real options are the impact gun of IS investment valuation: essential tool to loosen the bolts!

3.3 Real Options in valuation

3.3.1 New approach to investment analysis.

The new model to take uncertainties in the costs of the project utilizes fuzzy numbers. The logic of the proposed approach is that when the outcome of the project is not clear and varies, then the normal, crisp, numbers are inadequate. Such inadequacy arises from uncertainty. Uncertain outcome cannot accurately be depicted by a mere number. The fuzzy numbers take inaccuracy into account by being a range, not a number. The forecasting is performed by giving a lower and upper bound for the eventual outcome and a base outcome, and the fuzzy value is the range, which has a fuzzy mean. The fuzzy mean can be used as a real option value. The methodology was first presented by Prof M. Collan (Collan, et al. 2009) and it is called the payoff method. The method of choice is used because it is an implementation of theory that is more easily attainable for real-life usage than other ways to perform Real Option valuation. The Real Option valuation is a wide topic and therefore in this paper that receives suitable attention. The valuation of Real Options will later on be discussed with their different pros and cons in very much in depth.

Real options serve as a tool to early detection of events that may lead to an unwelcomed result. A generalization should read ". Prior research, for example, has made the case that pricing "real options" in real world operational and strategic settings offers the potential for useful insights in the evaluation of irreversible investments under uncertainty." (Benaroch, Kauffmann 1999) It should be kept clear that the IS systems investments clearly are irreversible and uncertain. "The high failure rate of ERP implementation is due to a common pitfall that ERP projects are often enacted as merely investment into installation of IT infrastructure, rather than systematic planning of operation changes, business process re-engineering and a paradigm shift for the operation and management." (You, Lee, Jiao 2012). Next, a formal literature review is carried out.

3.3.2 Options

Let us first discuss Options. The theory on the Real Options is based on the general options theory, which considers options in the context of financial options. Therefore the financial options are shortly introduced. In options there are two parties involved. The buyer and the writer. In an option contract the writer grants the buyer of the option the right but not the obligation to purchase from or sell to the writer something at a specified price within a specified period of time, (or at a specified date) (Fabozzi, Modigliani, Jones, 2010 pp. 542). The issue of the book cited is the 4th edition of the book, and Franco Modigliani, Nobel Laureate in Economics from the year 1985 and a world renowned Professor at the Sloan School of Management at the Massachusetts Institute of Technology (MIT) passed away in 2003. However in this chapter the 4th edition, published in 2010, is used, to avoid confusion about the publishing year this is noticed.

In the option contract the writer grants the right in exchange of a sum of money, which is called the option price. The price at which the underlying asset may be sold or bought is called the exercise price, or the strike price. The date after which the option is void, is called the expiration-, or the maturity date. (Fabozzi, Modigliani, Jones, 2010 pp.542)

The option is therefore not binding for the buyer, the buyer is not obliged to act upon it that is different from the futures contract, in which the buyer must exercise the future. The difference to options is that the option is a possibility, the futures contract does not allow a possibility to not to use it.

There are different types of options. Call option is an option where the buyer has the right to purchase from the seller at a pre-agreed price. When the buyer has the right to sell the underlying asset to the seller, then the option is called a put option. (Fabozzi, Modigliani, Jones, 2010 pp.542) Therefore the put option could be considered to be a minus call option. The timing of the possible future transaction, is an important characteristic

of the contract. There are options that may be exercised at any time up to the expiration date, these are referred to as American options. Other options can be exercised only at the expiration date, but no sooner: these are called European options. A Bermuda option can be exercised only at a pre-specified date. (Fabozzi, Modigliani, Jones, 2010 pp.542)

These characteristics of the options are an important thing to know before proceeding to the valuation of the options.

3.3.3 Valuation of the options.

The options' valuation is very similar in the world of financial markets as well as in the field of real options. Now the valuation of the options is presented briefly before proceeding to real options. The financial options valuation is the basis for much of the valuation of real options as well.

The theoretical price of an option is not as easy to define as the price of a futures contract. The option price is the sum of the option's intrinsic value and a premium that is referred to as the time value. (Fabozzi, Modigliani, Jones, 2010 pp.574). The intrinsic value of an option is its economic value if it is exercised immediately. However the intrinsic value cannot be lower than 0. The intrinsic value is the difference between the current price of the underlying asset and the strike price. If the difference is positive, then the intrinsic value is the difference, if the difference is 0 or negative, the intrinsic value is 0. (Fabozzi, Modigliani, Jones, 2010 pp.574) To complicate the option value has also a 2nd component, the time value, or the time premium as it is also known. The time premium is the amount by which the market price exceeds the intrinsic value. Other things being equal the time premium increases with the amount of time to the expiration. (Fabozzi, Modigliani, Jones, 2010 pp.575).

An important relationship holds: the put call parity, where, put option price – call option price = present value of strike price + present value of cash distribution – price of the underlying asset. (Fabozzi, Modigliani, Jones,

2010 pp. 576) That holds for European options and American options do conform approximately.

The factors that influence the price are these: 1. Current price of the asset. 2. strike price. 3. time to expiration of the option. 4. expected price volatility of the underlying asset. 5. short term risk free rate. 6. anticipated cash payments on the underlying asset. The impact of these depends on whether the option is a call or a put, or if it is an American or a European option. (Fabozzi, Modigliani, Jones, 2010 pp. 577)

As Fabozzi, Modigliani, Jones, put it in their book, the options are seemingly simple financial instruments that however, as next is shown, are quite complicated to valuate. The option pricing models are developed in order to be able to calculate the theoretical value of an option. These will be gone through next. These may seem at a first glance a little off topic, but a short introduction of the options pricing is in fact the very core of the entire thesis. These models are a little complicated at times but extremely necessary also in practical considerations.

3.3.4 The options pricing, from the basics into what earns you a Nobel prize.

Binomial model of options pricing.

The option pricing is first explained in the context of financial options, after the pricing is explained then the focus is shifted to more practice oriented themes and in this case into real options. In order to understand real options the financial options give a good starting course.

The options can be priced using a binomial model, an example of that is given:

Picture 7. One period option pricing model illustration:

Expiration date

Current period

1,25* (80$)=100$ Max (0, (100-80)]= 20

80$ C

0,875 (80$) = 70$ Max (0, (70-80)] = 0
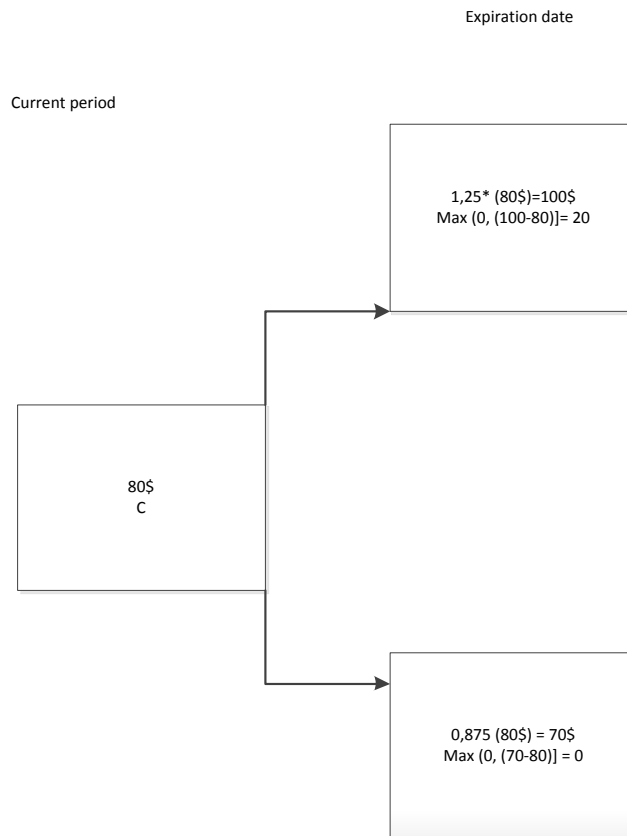
(Fabozzi, Modigliani, Jones, 2010 pp.583)

In this simplified example there are only 2 alternatives for the option payoff after only one period. The current asset price is now 80 $ and after 1 period it is either 100 or 70. In the case of one being able to purchase an asset priced 70 $ after one period, paying 80$ is nonsense. Therefore the value of the option is 80, and the buyer is better off not exercising the option and buying from the market instead. On the other hand if the asset price was 100 $ the exercising of the option would indeed be profitable and the option value would be 20$.

In general, the equation is: $= \left(\frac{1+r-d}{u-d}\right)\left(\frac{C_u}{1+r}\right) + \left(\frac{u-1-r}{u-d}\right)\left(\frac{C_d}{1+r}\right)$,

Where: r = risk free rate, C = current price of a call option, u = 1+ percentage change in the assets price if the price goes up in the next

period, d = 1+ percentage change in the assets price if the price goes down in the next period, C_u = Intrinsic value of the call option if the asset price goes up and C_d = Intrinsic value of the call option if the asset price goes down. (Fabozzi, Modigliani, Jones, 2010 pp.583)

However the options price is calculated with the Black-Scholes formula. This Nobel-Winning contribution goes as following:

$$C(S,t) = N(d_1)S - N(d_2)Ke^{-r(T-t)}$$
$$d_1 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)\right]$$
$$d_2 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)(T-t)\right]$$
$$= d_1 - \sigma\sqrt{T-t}$$

The price of a corresponding put option based on put-call parity is:

$$P(S,t) = Ke^{-r(T-t)} - S + C(S,t)$$
$$= N(-d_2)Ke^{-r(T-t)} - N(-d_1)S$$

For both, as above:

- $N(\cdot)$ is the cumulative distribution function of the standard normal distribution
- $T - t$ is the time to maturity
- S is the spot price of the underlying asset
- K is the strike price
- r is the risk free rate (annual rate, expressed in terms of continuous compounding)
- σ is the volatility of returns of the underlying asset

(Black, Scholes, Merton, 1973)

The model is used to valuate European options. The model assumes normal distribution for the stock price, in the context of real options this usually does not entirely hold. In the last part of this chapter real options are introduced and the real options are in a large extent analogous to financial options and the rules of pricing apply. However it must be noticed

that the option pricing formula assumes normal distribution. The effect of that is later on explored in context of real options.

3.3.5. From derivatives to metaphors – an unexpected journey

The mechanics of options was introduced by exploiting the idea of a financial derivative. The financial derivatives may seem rather far away from the theme of the thesis: a valuation of a IS investment. That is however very much untrue: the real options can be understood after the options themselves have been understood.

"In a narrow sense the real options approach is the extension of financial option theory to options on real assets" (Amran, Kulatilaka 1999 pp. 6) The knowledge of financial options is therefore almost a prerequisite to the ability to understand real options. Also one important thing to notice is that the discussion about the distribution of the underlying asset price relates to the Black-Scholes model's requirements. The ability, to calculate option values also when the underlying asset does not follow normal distribution is the underlying reason why there is a need to recognize other valuation methods. The probability does not necessarily follow normal distribution.

The Real Options allow flexibility to the investment decision. The real option is an option that has no underlying stock that the options is on, but the real option is an option to perform something that is real, examples being building an extra door to a warehouse to allow the warehouse to be split up in the future if a need arises. The flexibility achieved with that extra door has a monetary value: a real option has a value. That oversimplified example is still an example, but even such things as minor as an extra door in a building can be an option. A real option analysis is beneficial in for example following circumstances: "When there is a contingent investment decision, when uncertainty is large enough that it is sensible to wait for more information, when the value seems to be captured in possibilities for future growth options than the current cash flow, when

uncertainty is large enough to make flexibility a consideration and when there will be project updates" (Amran, Kulatilaka 1999 pp. 24)

As evident in all of the examples the real options deal with flexibility, uncertainty and management of the uncertainty and taking that into account. The real option is a tool to visualize the uncertainty that couldn't otherwise be done. The real option analysis deals with the uncertainty and future possibilities. The idea is to analyze future possibilities to ease uncertainty. The real options are a clever extension not only for the investment analysis but also for the option theory of finance. The original financial markets-born idea is utilized in an otherwise unrelated context. That is a clever invention that deserves the full attention of the members of the scientific community. Further on in the next chapter, a much more detailed picture of the real options and their usage is given citing journals that have written about the ERP implementations. This chapter is written as an introduction to the world of options and as starters it went through the questions that what are options, how their value is calculated, and ended in incorporating together two different worlds, that have more in common than one could think in the first place: the option logic that can be used in the world of financial assets has its use in practical investments too.

3.4 Real Options valuation in Practice

The world of options is a wide topic and widely researched upon. The part that in this case is however researched upon is the utilization of real options in corporate finance and especially in valuation of projects and controlling the uncertainty in them. This model is a direct replacement for the traditional usage of the discounting cash flow-based models and the purpose is to include the uncertainty in the picture in a better way. The main thing that must be noticed with the usage of the discounted cash flow-based models and their incompatibility in the context of an uncertain investment in IS systems is: the models do not allow for uncertainty: the values that are calculated are single crisp numbers that have little use when the actual costs and benefits are not known at all in the first place. Therefore the real options approach is a much better fit. The real options analysis especially when using fuzzy numbers to depict the uncertainty in the project is a major improvement in trying to understand the inherent uncertainty in the analysis of a risky uncertain and continuous and multi-period investment. In this chapter the aforementioned valuation is presented in practice. The analysis involves mathematics, in this chapter however it is not already the time for it, but the general strategic outline is given. By that it is meant that the strategic real options are introduced and the general outline of how the valuation of these is done. Numerical examples are not introduced yet. Numerical example on a valuation deserves own chapter on this thesis.

The real options valuation is best understood using as an example the financial options, and in order to be able to understand real options, one should also understand financial options. The real options differ from the financial options but the mechanics are the same in essence. In this chapter the mechanics of different types of real options with examples of a practical nature are given: how the different real options work and why they are used. More detailed description of different valuation methods is not considered in this chapter, however the methods: Datar-Mathews and

the Fuzzy Payoff method have chapters on their own. In this chapter different types of real options in valuation are given.

Real options come in different shapes and forms. Traditionally Real Options analysis has been used in investment analysis. First reference to Real Options was made by Myers, 1977. Since then it has been utilized in many industries. (Arashteh, Aliahmadi 2013) Real Options analysis' usage has been increasing, however restrictions exist. These include such problems as modeling the underlying asset value using a Brownian motion process. (Arashteh, Aliahmadi 2013)

However let us briefly ignore the shortcomings of the real option theory and consider only the properties of the options themselves. The real options' usage as mentioned has increased over the years. In the corporate world, nothing happens without reason: if the Real Options approach was not a valuable tool it would soon have fallen out of fashion.

3.4.1 Different real options

Different types of real options exist. The real option value arises from Managerial flexibility that the management can evaluate the market and project characteristics and change their course of action. The Real Options are not only options to abandon the project if needed but also to change direction. (Huchzermeier, Loch, 2001). In fact instead of assuming that the investments are now or never opportunities, that the investments are actually able to be delayed, much like a financial call option. The call option is exercised when the investment is undertaken. (Dixit, Pindyck. 1995 pp.62). As time goes by and the uncertainty resolves, the management has often the flexibility to alter strategy. That allows the management to improve upside potential and to limit downside losses (Huchzermeier, Loch, 2001). Because of an increase in the uncertainty and dynamic nature of the Global Market Place, Managerial Flexibility has become essential (Trigeorgis 2005). As It can be seen the usage of Real Options stems from enabling the managerial flexibility to have room in the

investment analysis. Also it can be noted that many types of different Real Options exist. Not all real options are in the category of watchful waiting until an investment can successfully be completed. In the following different basic types of Real Options are presented. The reason that why the Real Options receive such a large attention is simply: Without accounting for the options an R&D project may have a naïve NPV analysis may yield companies invest too little. (Dixit, Pindyck. 1995 pp.63)

Different Real Options exist. For different analytic purposes different real options have been developed. According to Trigeorgis (2005) the real options are following. These different categories of real options are shown in the picture below.

Picture 8. Different real options (Trigeorgis 2005)
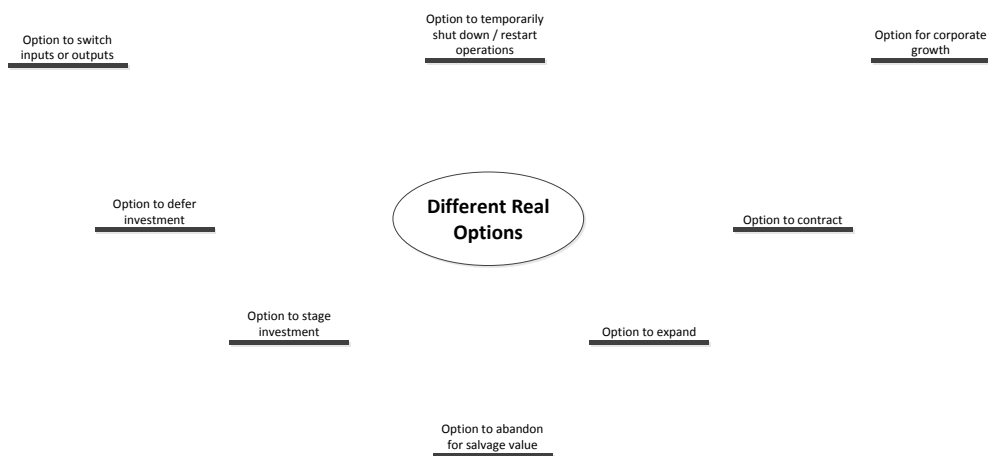
(Trigeorgis 2005, pp. 27-30)

The Real Options are not numbered in the picture in any particular order. However the most relevant will be explained a little bit more.

Option to defer investment is an option to wait until better conditions prevail. That enables the management to wait that the uncertainty resolves.

Option to stage investment is probably the most important option in this particular context. The ability to instead of spending all the money up front, to stage the investment that after every stage there is a possibility to either

abandon the following stages or continue with the project is especially well suited for projects that are multi period-projects that require considerable amount of time to be completed. The IS investments that this thesis is written in mind, do follow that path most of the time.

Option to expand refers to a situation that in which the market conditions turn out to be more favorable than anticipated, and the scale of operations can be expanded. That option is especially well suited for the mining industry as an example. The situation could be for instance that the market price of a mineral grows better than anticipated allowing more profitable operations. Option to contract is opposite from expansion: a situation where worse than anticipated development of a market price mandates a need to close down operations (partly. Option to abandon refers to a situation where an operation is ceased and the machinery associated can be sold. Option to switch inputs/outputs refers to an option that allows the company to change the end product produced according to what is more profitable and to change inputs into different raw materials if that was more profitable. Option to temporarily shut down refers to a situation where the company can terminate the production and wait for better market environment to restart. Option for corporate growth means a situation where the beginning of an operation allows further expansion of the corporation into different fields. (Trigeorgis 2005)

These Real options have all in common the fact that these always allow a practical operation to be performed accordingly. These are practice-oriented topics in general. However the situation in which each of the option can be considered as a viable alternative differs accordingly. In the case of an ERP / IS system investment the ability to stage investment is the most important option in the toolbox. According to Wu et al. particularly important for ERP implementations is that the projects often have multiple stages, that in which similar activities are repeated for different parts of the enterprise or for different software components, that enables a well-defined choice in structuring as a single stage or a multi stage incremental roll out (Wu, Ding, Hitt, 2003) Accordingly the staging option is especially

well advised for. Another great description of an ERP system investment is presented "The stages of an ERP implementation resemble the journey of a prisoner escaping from an island prison. First, the prisoner plans an approach, carefully considering whether to follow through on his intentions and mapping out the path he will take. Second, the prisoner takes the dive off a cliff and heads toward the bottom of the sea. Third, he attempts to resurface, anxious to do so before he runs out of breath and hopeful that he will not be shot when he emerges. Fourth, the prisoner reaches the surface and starts to swim to freedom. Finally, if the diver is successful, he arrives at a distant shore, transformed from prisoner to free man."(Ross, Vitale 2000) Between these stages real options exist.

3.4.2 How to capture value from uncertainty

In the first chapters the real options were presented, then the real option possibilities for an IS system investment were presented. Now this considers the practical aspects. In practice it was seen that the real options of this context take the shape of a staging option. The ERP system is modular in nature and that is a natural environment for staging options. Also a source for uncertainty is the dynamic nature of the business environment. The implementation process' length creates uncertainties because the implementation often takes 2-5 years of time. (Wu et al. 2008) Another problem with applying the NPV method of valuation of an ERP investment is that the NPV metric is a static one that denies possible benefits of an active management of the process of an ERP implementation. (Wu et al. 2008) The main source of the real option value is in the uncertainty and the management of the project as a changing entity in a changing environment. The static nature of a traditional NPV model completely forgets about the changing nature of the business environment, and thus the real option value. The NPV model could be thought of a picture that is taken on a beach during a storm. The picture shows that the weather is bad and the waves high. What is not seen is

that the water currents during a storm can sweep a surfer from the shallow waters. That could be seen on a video clip. The real option model for an implementation of a complicated project in fast changing environment can be compared like that. NPV model would imply that ERP investments are reversible and non-deferrable. (Wu et al. 2008) However that is clearly not true but:

"ERP projects are irreversible, deferrable, and undertaken in conditions of uncertainty (Benders et al., 2006, Dixit, 1995, Paddock et al., 1988 and Pindyck, 1988)". (Wu et al. 2008) In a study that measured statistically the factors of successful ERP implementation it was shown that 6 factors that accounted for are: "These factors are project management principles (accounted for 20.95% of the variance), feasibility and evaluation of ERP project in the firm (12.81%), top management support (9.48%), business process reengineering (8.60%), consulting services (8.03%), and cost/budget issues (8.28%)." (Ehie, Madsen 2005)

In the study a 5 stage model for implementation was proposed. The 5-stage model concentrates on the organizational change in business processes that must be developed alongside the reshaping the organization to streamline the processes when the ERP is being brought into use. Thus, and ERP system is not a mere computer infrastructure, but in order to achieve the benefits the entire company must accommodate the new way of doing things. Also it is emphasized that the top management's contribution has a central role in the process. (Ehie, Madsen 2005) The real options' role in the implementation is however central, it can simply not be emphasized too much. "Failure to consider active management implies that the organization considers that it will be unnecessary to resolve uncertainties over time, and that nothing will need to be done during the process to improve the chances of success. Because the NPV rule holds for passive management throughout the lifetime of a project, adopting it means that companies forgo active management, which is critical to successful ERP implementation."(Wu et al. 2008). The Real Option analysis for the active management of the project is the golden practice in the implementation of the system. In

practice the system is implemented in stages and the implementation takes typically a long period of time and as the world rarely remains the same around the company the steering of the project is of utmost importance, in order to capture the value from the inherent uncertainty of such project a Real Option based analysis is a must.

3.5 Datar-Mathews method in valuation

3.5.1 Short history of the method

Datar-Mathews model originates in the world of aircraft design. "A very simple practical approach for the valuation of R&D investments was proposed by Datar and Mathews (2004) (see also Mathews and Datar (2007) and Mathews (2009)). The method relies on utilizing Monte Carlo simulation to determine the real option value based on simple probability distribution cash flow projections."(Jaimungal, Lawryshyn 2011) In the article of Jaimungal and Lawryshyn a method is proposed to the analysis of real options and also in the progress the steps towards their solution are shown as well. The problem in Real Options has been a difficulty to use the existing knowledge outside of the Academia. Therefore simpler solutions for practical usage have been proposed. What in these solutions is very noteworthy is: "The major contribution of the approach is that it relies on cash- flow scenarios which managers are comfortable in projecting; namely, it relies on pessimistic, likely and optimistic forecasts. Collan, Fuller, and Mezei (2009) extend the Datar-Mathews method in a practical fuzzy numbers context." (Jaimungal, Lawryshyn 2011) "The field of real options has been slow to develop because of the complexity of the techniques and the difficulty of fitting them to the realities of corporate strategic decision-making. Such complexity, and the resulting challenge of getting senior management "buy-in," has been a major barrier to wider corporate adoption of real option techniques". (Mathews, Datar, Johnson 2007 pp. 95) As previously mentioned, the Real Option analysis derives much of its toolbox from the theory of Options in the context of Financial Markets. The method is not very complex when stock options are analyzed, but markedly more, when the options are real options. The goal for Datar and Mathews has been to create an analysis framework that uses the framework of a traditional DCF analysis, thus enabling the analysts and managers to be comfortable and familiar with them. "The result has been a method of valuation (referred to at Boeing as the "DM" Method) that, while algebraically equivalent to the Black-Scholes formula

for valuing financial options, uses information that arises naturally in a standard DCF project financial valuation." (Mathews, Datar, Johnson 2007 pp. 95) The method therefore avoids much of the complexity of the analysis with traditional Black-Scholes formula. However with the approach the possibilities that lie within the uncertainty of the project can be modeled and used in the analysis.

The method is a rather new one, dating back to the year 2000. The developers Scott Mathews and Vinay Datar, were working for Boeing and the Seattle University, respectively. They developed the Datar-Mathews method to be a consistent and uncomplicated method to calculate real options. Also one of the reasons to develop a new way of analyzing the Real Options was to overcome the strict theoretical assumptions of the traditional Black-Scholes model. The real world problems rarely fulfill all the assumptions, such as the outcomes of the project should be log-normally distributed. These assumptions under which the Black-Scholes model is developed rarely hold on Real Options context. Also notable is the possibility to incorporate existing data on real option analysis.

3.5.2 On the development of the real option analysis models

Interesting indeed the development: Real Option Valuation has been found to be difficult to implement and to understand because of the mathematical complexity. Recently methods have been developed to ease that issue. The process of valuation with real options is based on the similarity of the possibilities that financial options give to their holder, to the possibilities that real investments have within; Managerial flexibility: "an irreversible investment opportunity is much like a financial call option" (Collan, Fuller, Mezei 2009)

The Datar-Mathews method does a great deal to lessen the burden of practicing managers and analysts by simplifying the calculations needed to obtain a real option value. That was not the case before.

Mostly real options have been methodologically difficult to valuate as the valuations demand a good understanding of the mathematics. Mathematically options are not very easy. It is however a greater obstacle in traditional option valuation that the model could accurately mimic an underlying marker as a mathematical process, that often is not the case in a situation in which for the real investments an efficient market does not exist. If there even ever was a market for the investment as a whole. (Collan, Fuller, Mezei 2009) The problem is indeed that in a theoretical context the model works very well using for example Black-Scholes, but in practice that would be difficult to put in use in an actual project valuation. Indeed it could be difficult to have a normally distributed possibility frontier for the outcomes of an investment into an ERP system. The model that can be actually used in the valuation of a project must be easier to use. The next quotation expresses the point fully:

"Datar-Mathews method (DMM) was presented in [5–7], where the real option value is calculated from a pay-off distribution, derived from a probability distribution of the net present value (NPV) for a project that is generated with a (Monte-Carlo) simulation. The authors show that the results from the method converge to the results from the analytical Black-Scholes method." (Collan, Fuller, Mezei 2009). In the Datar-Mathews method the technical viewpoint allows much easier implementation. Indeed, using spread sheet software it is much easier to construct a probability distribution for the NPV of a project, when the NPV is calculated anyhow. It is much more implementable than trying to mimic a datasheet that calculates an option value for a stock index. As shown in earlier chapters, the assumptions for Black-Scholes equation are difficult to reach from the data on real projects. This is an obvious improvement in the usability of real options for practitioners. The real options' usage has been limited due to complexity and somewhat difficult theoretical requirements in valuation with Black-Scholes model. Any improvement is thus sincerely applauded. As shown by Datar-Mathews the results do converge with the results of Black-Scholes. However the calculation of the

Datar-Mathews method is much easier to perform than a Black-Scholes equation that should also fulfill theoretical assumptions of the Black-Scholes. These assumptions work in their own context but when applied to Real Options, the situation is more difficult with these same assumptions. There the assumptions hardly allow the usage. Also important criteria for good and usable practical method of valuation are that the method should be practical, easy to understand, easy to utilize and produce results that are correct. In practice it is pointless to choose methods by complexity: it does not give added value, that the more difficult a method of analysis is, the better the result. In practice that is not the case, however scientific it was.

According to the developers of the original method: "The field of real options has been slow to develop because of the complexity of the techniques and the difficulty of fitting them to the realities of corporate strategic decision-making "(Mathews, Datar, Johnson 2007) A point that must be noted is that the easier the approach, likelier it is to become mainstream in corporate valuation.

3.5.3 The functioning of the Datar-Mathews-Method, how it really works?

The Datar Mathews method has been discussed so far only as using the following rationale: In order to develop a successful method of analysis for the valuation of real options in contrast to the world of financial options, following important criteria must be noted. The method must be theoretically consistent with the results Black-Scholes gives. The method should be resistant for the requirement of the correctly distributed underlying distribution of cash flows of the projected NPV-s. Also the method should be easy to use. The easiness of usage cannot be emphasized enough: the Real Option valuation has surely its academic importance as a subject of study: however this thesis is as well as the methodologies involved are more concerned on practical applicability. So

far these theoretical issues have been discussed, now a short example of DM-valuation is given according to (Mathews, Datar, 2007):

A short introduction to the case: Boeing was considering an investment of developing an UAV-type of aircraft. That is and aircraft that is guided from ground, and with no pilot on board. These unmanned planes have their usage for instance in military purposes. Other possible uses are electrical and pipeline safety monitoring and border security. (Mathews, Datar 2007)

One founded argument against the usage of NPV-based calculations is that as the market is uncertain and that leads to the project outcome being uncertain as well. Due to the fact the managers are likely skeptical about the recommendations of NPV analysis alone. It is likely that the operating profit outcomes may be a range and the NPV requires a single value to be calculated. As a consequence low probability outcomes are eliminated from the analysis and only the most likely outcome is analyzed. Furthermore NPV based approaches discount all cash flows regardless of their individual risk at only one rate. NPV analysis can bias decision-making against projects that have major uncertainties that expectedly resolve in a few years. (Mathews, Datar, Johnson 2007 pp. 97) The fact that the NPV models are not very well suited for such projects that have major uncertainties along the way the decision-making might be against such undertakings. Projects that should be done are not considered. However the method's main advantage is the transparency, which allows more insightful project planning and evaluation particularly when the strict assumptions of Black-Scholes formula are compromised in real life. Also the terminal distribution need not be log-normal. (Mathews, Datar 2004) The authors' summary of the method is "We present a simple method for evaluating value of an R&D project. This method is algebraically equivalent to the Black-Scholes formula. The inputs required for application of this method are similar to those required in traditional NPV analysis. Further, this method is easily embraced by practitioners who are already using the NPV methodology. We show that our method may

provide a good approximation of call value even when the underlying distribution is not log-normal, and that our method is robust to the binomial and jump diffusion processes" (Mathews, Datar 2004) The valuation with a DMM approach is presented in the following chapter 2.3.4.

3.5.4 A simple example of the Datar-Mathews model

Scenario	Probability	Strategy
Optimistic	10 %	Superior product outsells the market, growth up to 40%
Most Likely	80 %	Product sales growth in line with the market at 15%
Pessimistic	10 %	Competition limits sales growth to 5% per year

r	15%	

$ M year	0	1	2	3	4	5	6	7	8	9
Optimistic		0	0	80	116	153	177	223	268	314
Most Likely		0	0	52	62	74	77	89	104	122
Pessimistic		0	0	20	23	24	18	20	20	22
Launch Cost		0	(325)							

(According to Datar, Mathews, 2007)

In real life situations such a spread sheet is compiled in DMM valuation (Datar-Mathews-Method) and these values in the table represent the annual sales of a project that has a launch cost of 325 Million. Discount rate in the example is set at 15%. At the corporate hurdle rate of 15% the project NPV was negative by $ 19 Million, thus rendering the project unprofitable and non-viable. However the manager could override the calculation by showing that there might be a potential yet less likely upside. As the market is uncertain, this gives room for doubt of the NPV analysis only. NPV model constrains the analysis into a single value only, this however further reinforced by the spread sheet software. (Datar,

Mathews 2007). Furthermore all cash flows are discounted with a single risk rate, regardless of actual risk. The advantage of real option analysis which is presented as the scenario table in the beginning of this chapter, is to create a business plan from the scenarios and have flexibility and critical decision points in the process (Datar, Mathews 2007) That helps to create a strategic discussion into something quantifiable. When such modeling is way more accurate in a sense that there is strategic thinking involved it also is a vital in that these strategic discussion points prompt discussion when there is an absolute need. In this case the project is not only left for a limited number of people that calculates and based on that give recommendations, but it enhances and prompts discussion. These strategic benchmark discussions and co-operation in general with different kinds of professionals enable much more strategic view. That strategic view when it can really be quantified and measured and certain acceptable outcome limits set, is a much more powerful tool to investment analysis than a mere NPV model. In fact it was previously discussed that NPV can lead to underinvestment, and in this view it can really be seen why it could yield such an outcome. In the next chapter an even-more intuitive approach is given and as the more intuitive the more practical the analysis is and in this thesis a very clear preference therefore is given for the Fuzzy Pay-Off method.

3.6. The Fuzzy Payoff Method in Real Option valuation.

The Real Option valuation with the traditional approach has been mostly a black box for the practitioners. The underlying assumptions have been traditionally restrictive. The understandability of the approach has been problematic for the practitioners. The difficulty involved in the analysis toolbox has been a black box. The methodology commonly used has been difficult to understand rendering the usage of the Real Options in practice uncommon. The problems mostly arise from the difficulty of the Black-Scholes method and the limiting assumptions that the method has. There is thus a sincere need for an easy-to-use method that can be employed in practical applications. In search for an application to actually perform analysis one thing must be noted. The most important single cost factor for such an analysis is time. The more man-hours the analysis takes the more it costs. The more complex the analysis the more time it takes. The more difficult and theoretical the analysis the less likely it is to end up being actually employed. In the corporate world what the managers might know and see as complex an impractical, might not be used in real life. A tool that is not used due to complexity involved might be a great and scientific as a model. Still the method must be able to be used to be any good. The easier it is to use the better. The pay-off method of real option valuation answers to this problem: trying to create a simple to use and easy, yet c

onsistent and accurate analysis tool to be actually used in real life actual companies for the valuation of projects.

3.6.1 The brief history of the model

The pay-off method was originally conceived to help to ease the problem of the complexity and demand of a good understanding of the underlying mathematics that cause difficulties in practice (Collan, Fuller, and Mezei 2009). All of the other theories that predate the payoff method use the probability theory as a basis of the treatment of uncertainty. However there is another ways to deal with the uncertainty in the future events. That other

way is called the fuzzy logic or fuzzy sets. "In classical set theory an element either (fully) belongs to a set or does not belong to a set at all. This type of bi value, or true/false, logic is commonly used in financial applications (and is a basic assumption of probability theory). Bi value logic, however, presents a problem, because financial decisions are generally made under uncertainty. Uncertainty in the financial investment context means that it is in practice impossible, ex ante to give absolutely correct precise estimates of, for example, future cash-flows." (Collan, Fuller, Mezei 2009) There is a sincere need for new thinking. The method of utilizing the fuzzy sets can overcome the problem of the exactness of the bi-value logic. The usage of a crisp number for a future cash flow is however impossible and misleading. One can never be sure and to use traditional numbers, the mere inexistence of a certain cash flow at a certain time is indeed the risk. The risk is the source of uncertainty and the uncertainty is the risk. To by-pass this, fuzzy logic is indeed a good solution. Fuzzy sets do have a very interesting feature: the belonging to the set is not an absolute yes or no, but there can be a gradation of belonging. That can be used to formalize the inaccuracy (Collan, Fuller, Mezei 2009) The traditional models could be depicted as a mere black or white situation, either in or out. The fuzzy sets can have a range of colors and the boundaries are not there as a strict line but as a gradual. There is more in between than a sharp line between black and white. A gradual change. That takes the natural uncertainty into a more formal methodology to address the uncertainty. The method in other words acknowledges the existence of the uncertainty and does not try to depict an exact future scenario, but to depict at the same time a range of possibilities.

3.6.2 The fuzzy payoff method

As defined, real options are possibilities that exist in real investments that allow managers to capture the potential in these investments. (Collan 2011) The keyword here is the knowledge that the managers utilize the potential. As defined, real options are in the same time a tool for strategic

thinking. The term is also most practical and the value of the real options can be understood as a solution for a calculation with which the real option is valuated. The value of real options broadly speaking can be used to refer to the strategic advantage that can be obtained using real options. The strategic advantage is a practical consideration. Accordingly the more these strategic opportunities can be unleashed in the analysis of the investments, the better.

The real options have departed considerably from the traditional financial option analysis. Black & Scholes utilizes geometric Brownian motion process. Newer models such as Datar Mathews and the pay-off model utilize cash flow scenarios. (Collan 2011) As evident cash flow scenarios are much more compatible with day-to-day operations in actual corporations. These scenarios represent net present values of cash flows. The intuition is simple "The intuition of the

Datar-Mathews method in a nut-shell can be expressed as [8]:

Real Option Value = Risk Adjusted Success Probability ∗ (Benefits − Costs)" (Collan 2011) The Fuzzy logic-based payoff-method is simplistic to use. In it a triangular / trapezoidal fuzzy number is created from a payoff distribution that is treated afterwards as a fuzzy number and does not treat the distribution as a probability distribution. The real option value is then calculated as following

$$ROV = \frac{\int_0^\infty A(x)dx}{\int_{-\infty}^\infty A(X)dx} \; x \; E(A_+)$$

,Where A stands for pay-off distribution, $E(A_+)$ stands for the possibilistic mean value of the positive side of the pay-off distribution and $\int_{-\infty}^\infty A(X)dx$ computes the area below the whole pay-off distribution and $\int_0^\infty A(x)dx$

computes the area below the positive part of pay-off distribution. (Collan 2011)

Structurally the pay-off method is similar with the option valuation logic and especially with the Datar-Mathews method, of which in this thesis the chapter 2.3 explains more into detail. (Collan 2011) As the method can be classified into the newer branch of the real option valuation, and as it is structurally similar with the option valuation logic in general. It can therefore be said that the usage of said model is beneficial as it is somewhat easier to use in practice and therefore applicable in real life valuation situations.

3.6.3 The usage of the pay-off method, an example.

The pay-off method is a practitioner's model in essence. It is mostly developed for the usage of actual valuation and by that it is meant: to be able to be used in real life situations. Therefore the integration of the model and the fuzzy sets' mathematical properties can be given less attention and in this context a small example can be given.

Picture 9. The pay-off method graphically (Collan 2009)
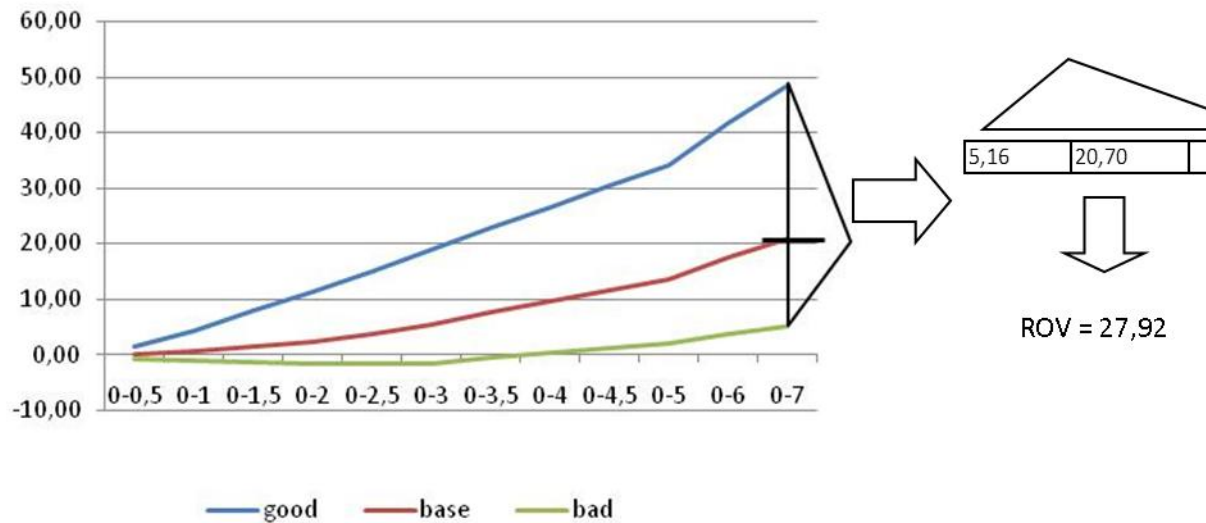
In the pay-off method typically 3 different cash flow scenarios are developed. In the picture these are represented as good, base and bad. Then these cash flows are projected. These cash flows are project NPV:s calculated for most likely, worst case and optimistic scenario. Then a triangular fuzzy number is created. In the picture that is the triangular area on the right-hand side. The "out of bounds" scenarios are deemed having a possibility of 0 and the likeliest is assigned the value of 1, which is represented as the top of the triangle. Then the real option value can be calculated using the pay-off formula and result can be obtained. In this case the real option value is as in the picture, 27.92

3.6.4 Payoff conclusions

The pay-off method is an easy-to-use analysis tool for the practitioners. The tool can be used to calculate real option values using nothing more than standard spread sheet software. The benefits of said simple method are measureable. The analysis is much more likely to be performed if the tool is understandable and not a black box, where magic happens. The results are in line with other methods for valuing real options. The data,

which is used for the valuations already, exists and no simulation must take place. The intuitiveness and the graphical results create trust in the decision-making process. The method is simple to use and does not require time-consuming modeling, that as a time consuming process is costly. In the remaining of the thesis the real options modeling utilizes the method due to the obvious benefits that are to be obtained by the business.

Now in the thesis the tools have mostly been presented in a practical mindset, so to say. In the other words the most important lesson in life is indeed the ability to keep things *entertaining.* It is a rather dry topic but to keep it readable not only it has to be explained simply and yet in a readable fashion. These tools are the way to open the analysis into a quantified and coherent valuation of a very complex world. This complexity must be cleared. To define a good model of valuation, it can be said that a good model produces consistent results. A great model however is easy enough to understand that the modeling itself is not only seen as a tremendously complex task but that the modeling is a doable way to shed light to tremendously complex world, in which everything is interconnected and the modeling is a lot easier than the world that is modeled not the other way around. There Real Options have a great usability to succeed in exactly that. In order to be a practically open and usable method it has to be applicable by companies themselves. The pay-off method of real option valuation has great potential to that.

4. Numerical case example

In this chapter a numerical case example is presented as an example of how an actual analysis using the fuzzy pay-off method can be done and how it looks like. The example is based on the work of Collan, Björk, Kyläheiko (2014) and You et al. (2012). In this example a fictional company is contemplating about a possibility to invest into an ERP system installation and decides to complete a real options analysis on the installation of the ERP system. This case example is made to illustrate that how that kind of an analysis could be done how it could benefit the decision-makers in order to facilitate higher confidence in the form of decreased level of riskiness in the installation process. Up until here this thesis has already pointed out the various factors that lead to the fact that an IS investment is inherently risky, and that shall not be repeated. The analysis is shown in this chapter in detail. In the chapter 2.4 the pay-off method was explained in full, so the whole focus of this chapter is to cover a practically-oriented example and to show how it looks like. No further attention on the method is given, as it would be merely repeating.

4.1 Numerical analysis in practise

Analysis of the investment concentrates firstly in identifying costs and possible benefits that can be attained by installing such a system for the company. The main theme is to emphasize the importance of having a clear step-by-step guideline for the increased visibility during the project and a basis for benchmark. It is a tool that essentially helps to the follow-up during the implementation. An investment project is not exactly a train that has tracks. It helps to have such anchor points that are described as real options. This process of investment is a long, multi-period and phased. That is extremely well suitable for real options. This kind of an investment that can be graphically represented as a 3-scenarios cone with a triangle at the real option value at a certain time period has an innate ability to be easily examined during the course of the project. A medical term, Triage, refers to a situation where patients are classified according to their acute need of treatment, in order to help those that can be saved.

A compound real option analysis that enables a follow up during the course of the project as well as the ability to see if and when the next phase should be taken up is a kind of a Triage of the business world. The ability to concentrate the corporate resources on projects that are not futile is a sincere and important need. When it may not be a life saver like a medical Triage, it can be a job saver. In this chapter it is shown how this kind of an analysis is done, how it looks like and explained that what was done and why.

The following contents of this chapter are organized as follows. Firstly it was fairly shortly described that what are the benefits of a numerical example in this context of a study, then it was shortly explained why this should be done. Now it will be explained what is done next: Firstly the pay-off spreadsheet is shown. Then this develops into a graphical representation of an imaginary example. Then the example is opened up to and explained. Then the chapter shortly concludes in, essentially an executive summary.

4.2 An example of a pay-off table (based on Collan, Björk, Kyläheiko)
(2014) and You et al. (2012)

Table 3. Payoff analysis spreadsheet

		0	1	2	3	4	5
COST	min possible	5					
	most expected	5,33	2,67				
	max possible	7,5	7,5				
SAVINGS	min possible			0,8	0,8	0,8	0,8
	most expected		2,16	4,32	4,32	4,32	4,32
	max possible		8	8	8	8	8
PV COST	min possible	5					
	most expected	5,33	2,54				
	max possible	7,5	7,14				
PV SAVINGS	min possible	0	0	0,66	0,6	0,55	0,5
	most expected	0	1,96	3,57	3,25	2,95	2,68
	max possible	0	7,27	6,61	6,01	5,46	4,97
PV PROJECT	min possible	-5	7,27	6,61	6,01	5,46	4,97
	most expected	-5,33	-0,58	3,57	3,25	2,95	2,68
	max possible	-7,5	-7,14	0,66	0,6	0,55	0,5
NPV PROJECT	min possible	**25,33**					
	most expected	**7,76**					
	max possible	**-11,89**					

Graph 1. Cumulative PV graph
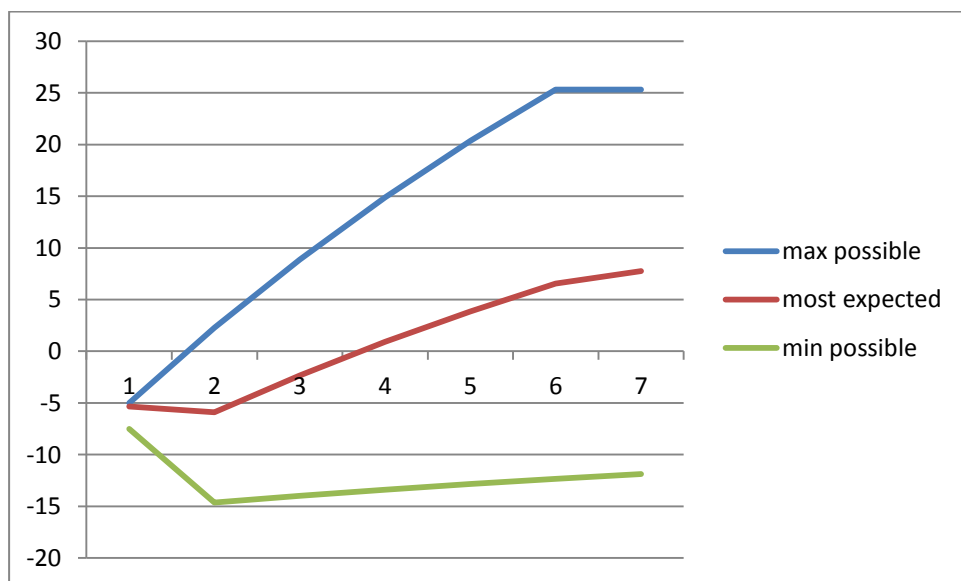
In order to identify the project's possible cumulative cash flows 3 scenarios were used. In the minimal possible cash flows the noteworthy thing is that it never exceeds 0. However the other scenarios end up with positive NPV. This picture can be used to see where the investment cumulatively is compared to scenarios. What also can be done is to calculate a Real Option value from the data. The method is simple: "weighted average of the positive outcomes of the pay-off distribution is the real option value; in the case with fuzzy numbers the weighted average is the fuzzy mean value of the positive NPV outcomes" (Collan, Fuller, Mezei 2009) That is done following, see Graph 2

Graph 2. Pay-off triangle (Collan et al. 2014)
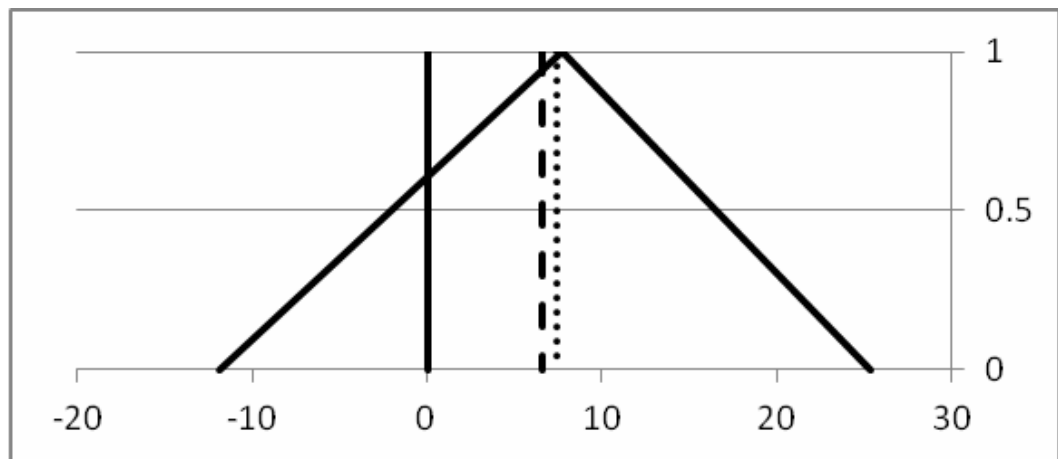
Notes: Dotted line: MNPV of the IS investment (7.41 M€); dashed line: real option value
of the IS investment (6.57 M€); and solid line: zero profitability

In the graph, for illustration purposes, the triangle is turned 90 degrees counterclockwise, it is derived from graph 1. The 0 represents a cut-off line, as a project of a negative cumulative present value is not an accepted outcome, and not a project taken. The positive area mean is the dotted line. The vertical axis from 0 to 1 represents the possibility of the said outcome happening. The peak is the most expected scenario, and it is assigned a value of 1. The least likely outcomes have the least likelihood and a triangle is drawn. The real option value is the mean of the positive values of the triangle. The real option value is not far from the most expected NPV and below it: therefore the time for the investment is good

as there is no value in waiting, which would be indicated if the option value was much higher than the most likely NPV. Also the area below 0 is small compared to the positive area indicating a high likelihood to make money for the firm. (Collan et al. 2014)

4.3 Conclusion of the numerical example

It can be seen that a fuzzy pay-off method-based assessment tool for an IS investment is a step forward. It is early on possible to see how the development of the costs and after the first stages of implementation, the development of benefits follows the optimal path. This clearly shows that this kind of an analysis serves as a pre-disaster warning if the benchmarks are well set. However it can also be deducted that if the scenarios for the pay-off are wrongly estimated this can prove difficult. Therefore a great deal of care should always be present when constructing the pay-off distributions based on scenarios. This can really be seen on the structure of the methodology itself, that this is not very prone to errors, thanks to the fuzziness of the number. Whenever people estimate, they tend to do little errors, and when small errors multiply, the result can end up a bit off. Especially important in all analysis is to know where the potential errors are, what kind of errors these might be and by how much. For practicing analysts the clear idea of having a good knowledge about the very nature of investment analysis on a very complicated investment is essential. An important notion is that: the pay-off method is much more resistant to such investment assessment errors than NPV-based methods that are basically worthless when inputs are prone to substantial errors.

 What was attempted is to make a showcase how this kind of analysis is performed. A showcase can't be all-inclusive and show all possible applications at once. In the example a pay-off analysis was shown. The steps are such: construct a 3 scenario analysis, create a cumulative PV graph from the scenarios and create a triangle where the highest likelihood event is assigned 1, the lowest likelihood events 0 and draw a vertical line from the (0.0) of the coordinates. From that the positive area

mean is used as the ROV and the size of the positive area compared to negative can indicate how likely it is not to fail. Importantly, this is achieved with no simulations or difficult-to-understand formulae.

5. Conclusions

This master's thesis was born out of a need to review existing knowledge on the real option valuation methods in the context of ERP investments. The area is sufficiently wide and knowledge far between to create an actual need for such a review on the methodology. The topic covered was limited to ERP investment analysis. The methodology for the analysis is real options-based. It integrates the usage of a fuzzy number as a solution.

In this thesis the focus is on ERP system investments. These investment's characteristics allow the usage of ROV in valuation

The research answered the questions that shall be repeated here:

1. What is the added benefit of Real Option models in investment analysis, while the NPV is a text book standard?

2. What kind of special factors in ERP systems separate them from other investments?

3.What are the benefits and costs of these investments and how these can be analyzed?

4.What can be done to alleviate the risks of unexpectedly expensive project or delayed completion?

To answer the questions:

1. The obvious benefit is that in the NPV models the discount rate is same for the course of project even when the project is multi-period and the rate might not be accurate over time and over different project phases. The method uses crisp normal numbers and thus requires exact knowledge of

costs and benefits in advance, which is unrealistic. ERP investments are better described using ranges of possible outcomes. This is what the Fuzzy Pay-Off method enables to do.

2. The ERP investments are not only investments, but a major change for the whole organization and the organization must change as well. That is a clear difference to more traditional investments such as new premises. To conclude: ERP investments are much more than computer software.

3. These investments have multiple benefits that relate to increased efficiency of corporate activities due to streamlining, new organizational processes and better control over the whole value chain. Even if the change into ERP-era is a major project, with high associated cost and this is somewhat risky, a careful examination with identifying correct success factors help to alleviate the problem. The attained benefits in the whole organization which can be had through a careful and well-planned implementation outweigh the risks associated. The whole organization must change and there is potential in increased efficiency. The COCOMO model provides a thorough platform for ERP development analysis and helps to identify costs and benefits.

The special factors of the investment are also the reasons why these should be taken: the increased efficiency, more formalized processes, increased control, and better integration with value chain. To answer the last question: The Fuzzy Pay-Off table enables to see if the investment does not go as planned and the fate of the future stages can be decided based on hard data. Thus the questions 2 and 3 are closely related.

4. The better the analysis the more likely the decision-making is good. To base the investment project on hard facts a solid analysis must precede. The costs can be analyzed with the COCOMO model and the benefits must be recognized. Literature points out the need of a fundamental organizational change and a strategic view. The Pay-Off model allows benchmarking and follow-up. The knowledge of potential problems help to do correcting measures before problems grow too large.

In order to point out the need of a more accurate investment analysis tool the previously much documented and used NPV-based methods were fairly carefully examined and judged. This was done to illustrate a large contrast between the old and new. The illustrative examples of the traditional NPV-based valuations explain why there is a need for a more advanced method of valuation. When the projects are complicated, and more unknowns present. The more unknowns, the importance of an analysis grows.

The thesis explains the theory and practice of Real Options. Firstly the story develops bottom-up. The importance of the *option logic* comes to play. The value of a real option can never be *less than zero*. It is never a liability. A real option can be worthless, but it can never be of a negative value. Importantly: the project risks when using a real option valuation can diminish but they can never increase. The real option valuation is a tool to improve investment valuation, and as such it is a powerful one.

The actual real option calculation methods that were studied were presented in an order of simplicity. The Pay-Off method does not require simulation at all. The analysis is therefore simple and thus easily adaptable to corporate settings. The logic is that the easier the method is to apply the more likely it is to be applied. The understandability and ability to simplify complicated matters make the Pay-Off method a potential tool for investment analysis in the future. It allows an easy-to-use platform to solve real options from actual cash flow scenarios. The model allows graphical depiction of the investment as well and helps to continually follow-up the project.

The thesis researched on the cost-benefit analysis of an ERP investment. The investments are fairly complicated to calculate accurately, these investments are not easily forecasted ex ante. These investments are of society-wide interest as these investments are typically large and therefore risk is involved. Another important matter is: The service providers who supply companies with ERP systems are generating billions of dollars of benefits annually and employ a considerable amount of people. The ERP

systems in general have a proven track record, and an analysis for such an investment is a real need.

A future possibility for study could be identified to be a follow up on actual ERP investments using the pay-off method as a primary investment appraisal. The current idea that in conveyed from the sources is that in very many reputable companies these investments have indeed failed and development for better analysis tools is a potentially lucrative business for consultants of the field. Also it was shown that a great number of different kind of organizations, not only companies but for example health care providers or public sector organizations in general could profit from the usage of real options in the decision-making. In the future the usage of real options in the ERP investments decision-making process, as an important tool, could yield better investments. It was shown that in the field of ERP investments even fairly large and famous companies have failed. Hopefully in the future this will change.

The society in general has changed in many ways due to the society-wide change that computerization has brought along. The importance of the IT is revolutionary, making a much more detailed control over the whole supply chain possible. The many benefits of said ERP investments were described using up-to-date sources. These benefits are however in many cases quite intangible and hard to evaluate. However there is an extremely thoroughly developed model for software development, the COCOMO model. The model was examined as it is greatly important in the field of the study of software investments. It was shown to contain important information for the ERP system investment analysis. In the future a fairly well founded area of study involves constructing real options in the in-between developmental phases of the COCOMO model and applying these into real life cases. The study could, for instance, be undertaken in a consulting project in the corporate setting as a case study.

In general the research found out that according to existing knowledge a compounding real options based analysis is suited for analyzing the costs and benefits of a multi-stage multi-period investment. ERP investments fall

into that category. However that implies also that this content could easily be taken off from ERP investments, as many investments share similar characteristics. It has also been essentially shown that the Pay-Off method is a simplest currently available solution for this particular problem. The study shows also that the tools developed by *finance* professors on an unrelated area of stocks and derivatives market can be used by *managerial accountants* in settings that are about *Information Systems* study, to remind of a picture painted on the very beginning of the thesis. This thesis is a collection of existing knowledge. For future study the effect of the usage of real options could be analyzed in the context of small & medium sized companies as well. The Pay-Off method is sufficiently elaborate to provide results and sufficiently understandable for a layman to be utilized in the SME context. Especially in situations where resources for analysis are limited the simplicity of the tool is of a great benefit. In the future especially studies on the usage of the pay-off method in case examples would definitely be worth undertaking. An automated pay-off calculator could also be of benefit as a tool for professionals specializing in investment analysis. To sum up the possible future studies: a development of a repeatable analysis spreadsheet and to formalize the analysis of the ERP investments could be the next developments for the pay-off method.

To summarize tens of pages written: a picture is worth a thousand words, it is said. Maybe the lesson of this thesis to be learned was "a good calculation is worth more than a hundred pages of explanations".

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