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Strategic Finance and Business Analytics

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**THE PAY-OFF METHOD AS A TOOL FOR  
EVALUATING THE RISK AND PROFITABILITY OF  
PUBLIC REAL ESTATE INVESTMENTS**

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## **ABSTRACT**

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Real option valuation, in particular the fuzzy pay-off method, has proven to be useful in defining risk and visualizing imprecision of investments in various industry applications. This study examines whether the evaluation of risk and profitability for public real estate investments can be improved by using real option methodology. Firstly, the context of real option valuation in the real estate industry is examined. Further, an empirical case study is performed on 30 real estate investments of a Finnish government enterprise in order to determine whether the presently used investment analysis system can be complemented by the pay-off method. Despite challenges in the application of the pay-off method to the case company's large investment base, real option valuation is found to create additional value and facilitate more robust risk analysis in public real estate applications.

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In Helsinki, August 6, 2014

Anni Kuittinen

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**Appendix 1 Summary of the investment projects**

## 1 INTRODUCTION

It is generally acknowledged by capital budgeting practitioners that real-world investments are uncertain and their costs and revenues cannot be accurately estimated for long time periods. The estimates must often be corrected during the process or sometimes it is noticed at the end of the project that the forecast did not quite reflect the final result. The experts making the estimates may have intuitive expectations of the result, arising from the risks and the potential included in the case as a whole. This intuition, however, is rarely included in the estimation, since the standard methods used by practitioners, such as net present value (NPV) or internal rate of return (IRR), tend to neglect these strategic factors (Trigeorgis, 1996).

Real option valuation can be used to address these drawbacks of the standard capital budgeting methods (Trigeorgis, 1996). The fundamental idea of real options, which is to use knowledge of existing risks and opportunities in order to gain strategic flexibility and transparency, is not new but was firstly introduced as a financial concept in Myers (1977). Since then, various real option based tools have been developed to enable more realistic and extensive investment analysis. Notwithstanding, real option valuation has not yet become as common in practice as the more traditional capital budgeting methods. In their survey, Ryan and Ryan (2002) found that only 11.4 % of their sample of *Fortune 1000* firms used real option valuation as a decision-making tool, whereas 96 % used NPV. Further, Block (2007) found that 14.3 % of their sample use real options. The survey by Bennouna, Meredith and Marchant (2010), performed on large Canadian corporations, showed that only 8.1 % of the respondents use real option analysis.

Real estate industry is an area where real options valuation is intuitively suitable since its nature is uncertain, lifecycles of projects are long and decisions are often made based on intuition. Real option valuation, when used correctly, is a great tool to visualize this intuition and makes it possible to rationalize decisions based on financial theory. Thus it seems

at the same time a challenging and intriguing task to make real option valuation more applicable and to make it fit to be used for individual business situations, where it might have truly beneficial effects.

### **1.1 Background and motivation of the study**

In order to explore the possibilities of real option valuation, it was decided to select a company within the Finnish real estate industry that would not yet utilize real options in its investment valuation practices and see if a reasonable and valuable method could be found. It was of interest whether real option valuation would be applicable in the first place and further, what kind of difficulties would have to be overcome to make it work in practice, and what kind of benefits could be achieved. This should be interesting to academics interested in real options or real estate industry and especially the practitioners of real estate that are willing to enhance their current analysis methods.

Based on this initial idea, it was decided to apply numerical real options valuation on selected project portfolios of a case company *Senate Properties*, a government owned enterprise under the aegis of the Finnish Ministry of Finance. The operations of Senate Properties follow commercial principles and the company finances its own operations. The turnover in 2012 was 620 million euros with 10 800 buildings and the value of premises worth 4.6 billion euros. In 2012 Senate Properties made investments worth 196 million euros. Operations are provided mainly to government bodies and cover renting of premises, development of services, and property portfolio as well as making investments. The investments of the company include different renovation and new construction projects in four different business areas: Defence and Security, Ministries and Special Premises, Offices, and Development Premises. (Senate Properties a.)

Senate Properties, as a government owned enterprise operating within real estate industry, is an excellent case for studying applicability of real options in the context of real estate. A wide range of possibilities is



provided for analysis, because of their large portfolio. Situation presently at Senate Properties is such that the company is currently using an investment analysis spreadsheet model called *SILK* in the analysis of their real estate investments. This spreadsheet model is complex and compares different ratios and key numbers, mostly based on static discounted cash flow analysis, to aid in the selection of new investments. These key numbers include the internal rate of return (IRR), the net present value (NPV), the relative net present value (rNPV), shareholder value added (SVA), return on investments (ROI), net income, and payback period - they all are used in the *SILK* analysis to estimate the profitability of the investment project. The analysis uses a single cash-flow scenario for each investment, with the present value of the cash flows and the residual value calculated. The present values are presented separately for the property both with and without the investment, and the cumulative net cash-flow of each investment is also presented graphically.

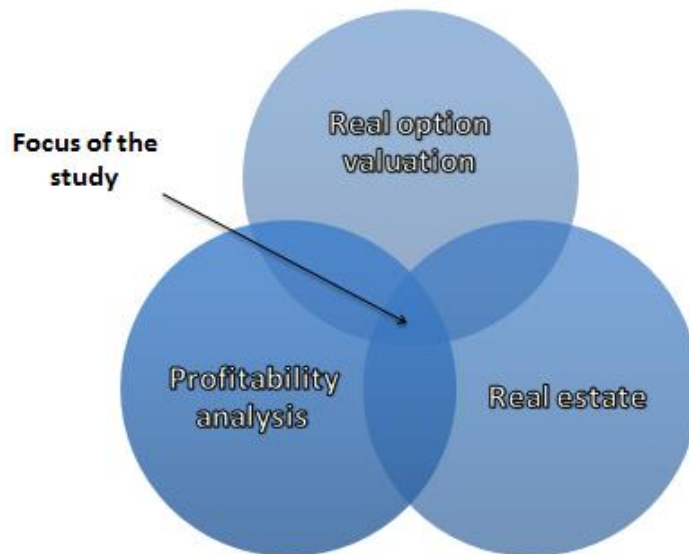
However, there is interest among the managers of Senate Properties, including the finance and accounting department and the investments and construction department, for making some reforms to the investment analysis process: Currently, there is an on-going project where a common database is built in order to combine data from different business operations and provide different functions of the enterprise with useful information. In the future, the key numbers from the *SILK*-analyses will possibly be brought directly to this database. Preceding this step - according to managers - it would be important to recognize some advantages and disadvantages of the current analysis system and bring some new aspects that might be good additions. Furthermore, it would be interesting to extend the analysis from the profitability of single projects to more general level and see how it appears, for instance, from the perspective of different client groups.

According to Oppenheimer (2002), static discounted cash flow analysis has been criticized to be misleading or insufficient in providing support for

investment decisions within the real estate industry. This means that there is a reason to believe that SILK-system could be made better. However, Oppenheimer discusses whether real options valuation always decreases the uncertainty within the analysis, since it might also cause more speculation and mathematical complexity within the model. This is understandable as real option valuation models have been criticized for being too complicated, or mathematical, and having too strict assumptions. They are also said to lack in practical applicability to real investment cases. (Borison, 2005) According to Collan (2012), managers and companies often find real options complicated and difficult to use, and thus the approach has been left for too little recognition by practitioners. Consequently, more transparent and intuitive methods should be favored, and the applicability of real option analysis in companies is an interesting and growing research topic that will also be examined in this study.

## **1.2 Focusing the scope of the study**

The three key elements of this study are profitability analysis, real options, and real estate. It is of interest to examine the development possibilities of profitability analysis, and real option valuation is the tool used for this task, whereas real estate industry is the target where the tool is applied. Thus all three aspects need to be both discussed separately and together for an extensive understanding of the research context, presented in Figure 1.

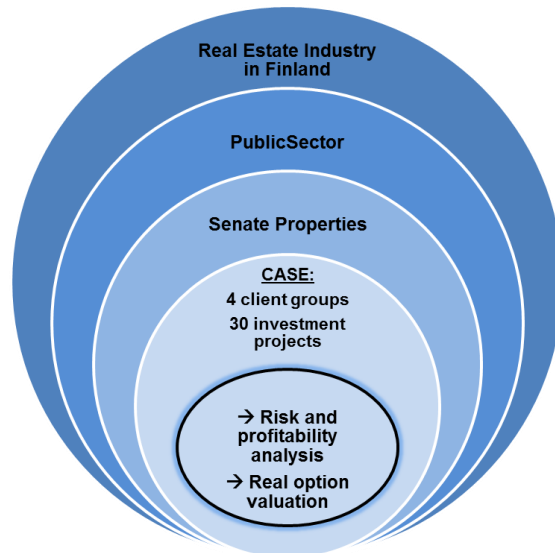


**Figure 1 The research context**

The three research areas presented in Figure 1 form the theoretical background of the study. The state of the art in real options in real estate, the third chapter of the study, focuses on presenting the results of the earlier research that combines these three areas. Articles selected for the theoretical framework were found using three databases: *EBSCO Business Source Complete*, *Elsevier Science Direct* and *Emerald Journals*. As a first step, different variations of a search string were tried using combinations of following key words: *investment profitability*, *capital budgeting*, *real option valuation*, *real estate industry*, *value*, *risk*, *public sector*, *government owned entity* and *public project*. As a second step, the titles and abstracts of the search results were scanned and the most relevant articles were selected. Finally, some backward tracking was done based on the key references of the selected articles and more relevant articles were found.

The empirical part of the study takes its place in the intersection of the three areas. It focuses on the Finnish real estate industry, which has not been researched in the context of real options very frequently. Furthermore, the empirical case study is specialized in public sector real

estate, as the case company Senate Properties is a government-owned entity that provides its services mainly for government clients. The empirical focus of the study is presented in Figure 2.



**Figure 2 Empirical focus of the study**

As Figure 2 shows, the empirical analysis is performed on four key client groups of Senate Properties. Four different client groups are selected based on their strategic position, as it is of interest to compare how they perform in the real option analysis. In total, 30 investment projects are selected to present the client groups and their existing profitability analysis. SILK-spreadsheets are used as a starting point for the real option valuation.

The methodology used for real option analysis in this study is called *the pay-off method* (Collan, 2012). The main idea of the method is to add positive and negative scenarios to the already existing best-guess scenario of the cumulative net present value of the investment. The pay-off method is based on *fuzzy logic*, a mathematical system for treating imprecision in a precise way. The triangular pay-off distribution of the investment is treated as a fuzzy number, based on which the real option value of the investment can be easily calculated and presented graphically. (Collan, 2012)

The scenarios of the investment projects are built using the annual portfolio ratings of the properties. This procedure enables the investment analysis to take into account the risk factors and the potential of the client and the property, whereas the current analysis method is mostly based on the project-specific factors. Based on the results of the analysis on single projects, mean net present values and other key numbers are calculated at the property level and compared at the client group level. Finally, the applicability of the real option valuation and the selected method is evaluated regarding the needs and the characteristics of the case company.

### **1.3 Research questions and main objectives**

Objective of this study is to shed light upon the application of real option valuation in real estate industry, especially in the environment of Finnish real estate industry and a government-owned enterprise. Furthermore, the objective is to consider the possibility of providing more robust risk and profitability analysis tools for the case company by using real option valuation. Evaluating the applicability of the selected method and the future prospects for its use in the case company are also key objectives of the study.

The main research question of the study is:

*Can the risk and profitability evaluation of public real estate investments be improved by using real option methodology?*

The sub-questions are:

1. *In prior literature, how has real option valuation been used in the context of real estate related issues?*
2. *Can the presently used investment analysis system of Senate Properties be complemented by real option valuation?*
  - a. *Based on the selected investment cases, how do the results of the real option analysis differ from the original analysis?*

*b. Is the selected real option valuation method applicable to and compatible with the case company?*

*c. What future prospects exist for expanding the use of the selected method?*

#### **1.4 Research method**

Though numerous profound methods have been developed for applying real options valuation in the industry, it is certain that there are no ready-to-use methods or ways of conducting the real options valuation in this special case study. This makes the task both challenging and interesting, since the most suitable methods need to be found, applied and modified in order to get the best possible compatibility for the case enterprise. Hence the results of this study are unique and can provide useful knowledge for both the real options research as well as the real estate finance research. On the other hand, the results are case-specific and thus cannot be generalized.

Case study approach is a suitable choice for this study, since the nature of the research problem is rather experimental and descriptive. According to Marchan-Piekkari and Welch (2004), case studies are a preferred approach when “how” or “why” questions are to be answered and the focus is on a current phenomenon in a real-life context. However, the authors remind that case study is not synonymous or suitable for only qualitative studies; case study can be even entirely quantitative. This study, however, requires both the qualitative and quantitative aspects, since numerical analysis is used for profitability valuation and yet discussing possibilities, disadvantages and applicability is part of the qualitative approach.

#### **1.5 Structure of the study**

The remainder of this study is organized as follows. Chapter 2 presents the theoretical background of the study, starting in the first subchapter with the classical investment valuation methods, such as NPV and IRR, and

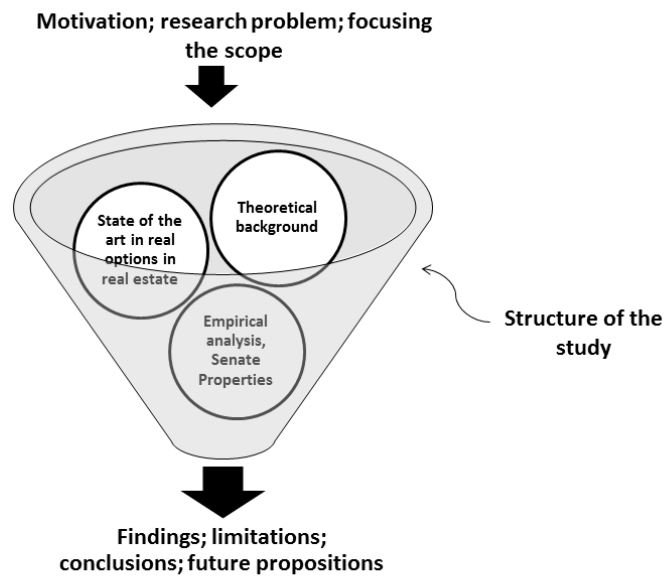
next going through the basics of real option valuation. The second subchapter introduces fundamentals of real estate valuation and also discusses some of the more recent trends in real estate industry and public real estate related issues.

Chapter 3 presents the state of the art in real option valuation in real estate industry. The selected articles are divided into 5 sections: theoretical articles evaluating structural real options, cases of public real estate with real options, cases with classical real option methods, cases with Monte Carlo simulation, and cases with more modern real option valuation methods. These 5 sections were formed based on the most frequent types of research in the sample of selected articles that discuss real options in real estate.

Chapter 4 contains the empirical part of the study, where real option valuation is applied in the case company Senate Properties and its investment project portfolios. Firstly, the presently used investment analysis system is presented and possible improvement needs are examined. Secondly, the selection of the best method for the case is discussed and some case-specific modifications are made. Thirdly, the data is selected and the chosen client groups are presented. Finally, the actual pay-off analysis is performed and the results are presented and discussed. The applicability of the used method is also evaluated, leading to future propositions for Senate Properties' operations.

In chapter 5, the findings of the study are summarized and concluded. Finally, the limitations of the study are discussed and suggestions for the further research within the field are proposed.

Figure 3 represents the structure of the study and how its different parts merge into a whole, creating the results of the study.



**Figure 3 Structure of the study**

As Figure 3 presents, the study is started with a set of questions and a motivation to find answers to them. This forms the input of the study, the research problem, which is focused around the selected theoretical background, the state of the art in the field and a related empirical analysis in Senate Properties. The final outcome is formed by evaluating the findings of the analysis, taking into account the possible limitations and the applicability of the results in the future, both in the operations of Senate Properties and in the research.



## 2 THEORETICAL BACKGROUND

Firstly, this chapter presents different investment profitability analysis methods, starting from the classical methods including NPV, IRR, and Payback period and following with different real option valuation methods. Second, some general articles presenting real estate industry and investment profitability within that field will be discussed. Finally, more recent trends in real estate valuation and articles presenting public sector real estate projects will be shortly discovered.

### 2.1 Capital budgeting methods

This chapter discusses how investment analysis is practiced in firms and how capital budgeting methods have changed during the history. In the first sub chapter, more classical methods, such as net present value (NPV), internal rate of return (IRR), and Payback period are presented. In the second sub chapter, the focus is on real option valuation, which is a more modern and less frequently used investment analysis method.

#### 2.1.1 NPV, IRR, payback period, and other classical methods

Net present value (NPV) is often referred to as the most common and reliable investment analysis method, as it is frequently mentioned in the financial theory literature and has the support of the majority of academics.

The NPV of a project can be written as

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \dots + \frac{C_T}{(1+r)^T} = -C_0 + \sum_{i=1}^T \frac{C_i}{(1+r)^i}, \quad (1)$$

where  $-C_0$  is the initial investment,  $C_T$  is cash flow at date  $T$ , and  $r$  is the appropriate interest rate (Ross, Westerfield and Jaffe, 2003, p. 78). Other common methods include IRR (internal rate of return) and the payback period. IRR can be calculated by solving the interest rate  $r$  in the equation

$$NPV = C_0 + \frac{C_1}{1+r} + \dots + \frac{C_r}{1+r^T} = 0, \quad (2)$$

and the payback period by simply solving the number of annual cash flows that equal the initial investment, without discounting them or taking into account cash flows after the period (Ross et al. 2003, pp. 141-152).

However, it seems that when it comes to practical use of capital budgeting methods in firms, NPV can quite easily get replaced by even simpler methods. There are also a growing number of academics that find drawbacks and gaps in NPV and other classical methods and suggest that more modern and sophisticated methods should be used instead. Below it is discussed how the popularity on NPV method has evolved during past decades and what kind of drawbacks it has according to the earlier research.

The longitudinal survey by Pike (1996) finds that between 1975 and 1992 firms have become significantly more aware of the need to assess the possibility of a project failure. In addition, the quality of the capital budgeting and forecasting process has gained more attention through post-completion audits. Pike finds that this has increased the popularity of discounted cash flow methods in firms. Size of the firm influences the quality of the computer-based capital budgeting tools, such as sensitivity analysis and discounting methods, which might partly explain the popularity of such methods in larger firms. In the study by Pike (1996), it is discussed whether discounted cash flow methods have been 'oversold' to and excessively favored by managers in the recent decades. The author finds that possibly investments should be viewed within a wider strategic framework.

Ryan and Ryan (2002) study capital budgeting methods and the cost of capital estimation procedures used by the Fortune 1000 companies. According to the authors, the pay back technique has been the most preferred method during past decades. Also accounting rate of return has been used, and the discounted cash flow method was found to be the least preferred method, in contrast to the financial theory. In general, the earlier literature shows that managers have found the IRR to be easier to

understand and more cognitively efficient than NPV. Academics, however, prefer NPV over IRR since it assumes intermediate term cash flows to be reinvested at the cost of capital, and not IRR, and as it is not as sensitive to multiple sign changes in cash flows. According to Ryan and Ryan, WACC was agreed in most companies to be the best starting point for determining the discount rate.

Furthermore, the survey by Ryan and Ryan (2002) examines the supplemental capital budgeting tools used in companies. The study finds that sensitivity analysis was used by firms as a supplemental capital budgeting tool always or often by more than 65 per cents of the respondents, scenario analysis by more than 40 per cent, and inflation adjusted cash flows and economic value added (EVA) by more than 30 per cent. Incremental IRR was used by 27.7 per cent of the respondents, simulation by 19.4 per cent, and market value added by 14.9 per cent. Ryan and Ryan find that 7.9 per cent of the respondents used decision trees, and only 1.6 per cent used real options as a supplemental capital budgeting tool.

Arnold and Hatzopoulos (2000) study the adoption of different capital budgeting methods in the UK firms. The findings are that the theoretical financial analysis methods provided by textbooks are commonly used, with only minority of corporations not using discounted cash flows, formal risk analysis, appropriate inflation adjustment and post-auditing. However, it is found that firms have not abandoned the old and trusted rule-of-thumb techniques but still use them as complementary enrichments for the more formal approaches. It appears that these intuitive techniques are thought to have many qualities that new approaches are lacking.

Moreover, Arnold and Hatzopoulos (2000) argue that using more computer based and numerical valuation does not necessarily mean that decision making has become more rational - there are various issues, including the multiple goal structures of organizations, the political and social environment, moral hazard, information asymmetry, and tendency for satisficing rather than optimizing that may interfere with the rational

decision making. The ritualistic role of accounting information and the legitimization of the previously agreed strategic decisions are factors that make capital budgeting practices less flexible and further, there may be real options that are not captured in the profitability analysis. The authors suggest that more in-depth studies concerning capital budgeting practices of individual corporations and focusing more on qualitative factors affecting these practices should be conducted in the future.

Meier and Tarhan (2007) summarize the most important primary findings from previous capital budgeting related literature as follows: firstly, firms seem to show increasing tendency to use discounted cash flow based methods over time. Secondly, most firms seem to use weighted average cost of capital (WACC) as the discount rate, and thirdly, when calculating the discount rate, the cost of equity is typically based on the CAPM.

Brunzell, Liljeblom and Vaihekoski (2013) also study the usage of capital budgeting methods and further the selection of the hurdle rate premium in firms. The authors mention that although previous studies have shown the discounted cash flow methods, especially NPV, to have become more common and popular, there is still a large number of firms that use less sophisticated methods and higher hurdle rates than the financial theory would suggest. Further, the authors point out that firms rarely use project related risk as a determinant but use a single discount rate for all projects.

According to Brunzell et al. (2013), some rational reasons can be found to explain the usage of less sophisticated methods and high hurdle rate premiums. Explanations have been suggested, for instance, by Jagannathan and Meier (2002), McDonald (2006), and Holme'n and Pramborg (2009). These explanations include real options, agency problems, managerial over-optimism, limited capital, political risks, managerial short term pressure, and CEO/CFO characteristics. Thus one of the hypotheses by Brunzell et al. (2013) is that firms with more real options may use higher hurdle rates and rely on complementary capital budgeting methods in addition to NPV method. As found by McDonald (2006), managers may perform multiple formal calculations and make the

decision by weighing them and using subjective judgment, which might take into account the hidden real option value.

It is suggested by Jagannathan and Meier (2002) that firms with complex projects including use of skilled manpower, long construction time, organizational constraints, and tendency to lock in much of the capacity of the firm would have a hurdle rate premium that is optimal for a range of different costs of capital. Growth firms are found to have higher hurdle rates than value firms. (Jagannathan and Meier 2002) In addition, Holme´n and Pramborg (2009) assume that firms with high short term pressure, such as political risk, tend to use high hurdle rates and rely on the payback method rather than NPV.

The findings of the survey by Brunzell et al. (2013), performed on listed companies in five Nordic countries, suggest that only 41.29 per cent of the Nordic firms use NPV as the main capital budgeting method, whereas for the US firms the rate is significantly higher - more than 74 per cent. In the Nordic firms, 5.16 per cent are found to use NPV with real options. Such behavioral characteristics as CFO being less educated or more than 50 years old are found to correlate negatively with use of NPV. It is also found that higher hurdle rates are used in firms that score lower in the sophistication index. An average hurdle rate premium for the sample is four per cent, which implies that large economic losses can be caused in the Nordic countries in terms of underinvestment. For further research, authors suggest more in-depth studies of the capital budgeting methods in firms in order to capture different firm specific divisional practices and hierarchies as well as the actual inputs in the project calculus.

### **2.1.2 Real Option Valuation**

As discussed above, the discounted cash flow methods seem to be strongly favored by managers these days, but there are numerous drawbacks that may cause unprofitable investment decisions. For instance, according to Trigeorgis (1996), it is nowadays widely recognized that discounted cash flow methods, such as NPV, cannot properly capture

management's flexibility in investment decisions. Managers, however, are often able to adapt to unexpected market changes and revise decisions related to them. Real option valuation is an approach addressed to these drawbacks of NPV method, as it can work as an extension for the classical capital budgeting methods. As Trigeorgis (1993) states, correct valuation requires both the passive NPV of expected cash flows and a value component for the combined value of the flexibility represented by the project's real options:

$$\text{Expanded NPV} = \text{Passive NPV} + \text{Combined Option Value}. \quad (3)$$

The idea of real options is not new but it was firstly introduced as a financial concept by Myers (1977). Real option theory arises from the pricing of financial options, which in turn is based on the work of Black, Merton and Scholes:

$$Se^{-\delta t} * \{N(d1)\} - Xe^{-rt} * \{N(d2)\}, \quad (4)$$

$$\text{where } d1 = \{\ln(S/X) + (r - \delta + \sigma^2/2)t\} / \sigma * \sqrt{t}, \quad (5)$$

$$d2 = d1 - \sigma * \sqrt{t}, \quad (6)$$

and where  $S$  presents stock price,  $X$  exercise price,  $\delta$  dividends,  $r$  risk-free interest rate,  $\sigma$  is uncertainty,  $t$  time to expiry, and  $N(d)$  cumulative normal distribution function.

According to Black and Scholes (1973), "An option is a security giving the right to buy or sell an asset, subject to certain conditions, within a specified period of time". Option is a right but not an obligation to act and thus the yield of an option cannot be less than zero. Classically, there are two main types of options: one that gives the right to buy (call) and one that gives the right to sell (put) an asset at a predetermined price. Options can be European and thus exercised only on a specified future date, or they can

be American, which can be exercised at any time up to the date. (Black and Scholes, 1973)

Leslie and Michaels (1997) present the real-market equivalents of the factors of the Black and Scholes formula as follows:

**“Stock price (S):** *the present value of cash flows expected from the investment opportunity on which the option is purchased.*

**Exercise price (X):** *the present value of all the fixed costs expected over the lifetime of the investment opportunity.*

**Uncertainty ( $\sigma$ ):** *the unpredictability of future cash flows related to the asset; more precisely, the standard deviation of the growth rate of the value of future cash inflows associated with it.*

**Time to expiry (t):** *the period for which the investment opportunity is valid. This will depend on technology (a product’s life cycle), competitive advantage (intensity of competition), and contracts (patents, leases, licenses).*

**Dividends ( $\delta$ ):** *the value that drains away over the duration of the option.*

*This could be the cost incurred to preserve the option (by staving off competition or keeping the opportunity alive), or the cash flows lost to competitors that invest in an opportunity, depriving later entrants of cash flows.*

**Risk-free interest rate (r):** *the yield of a riskless security with the same maturity as the duration of the option.”*

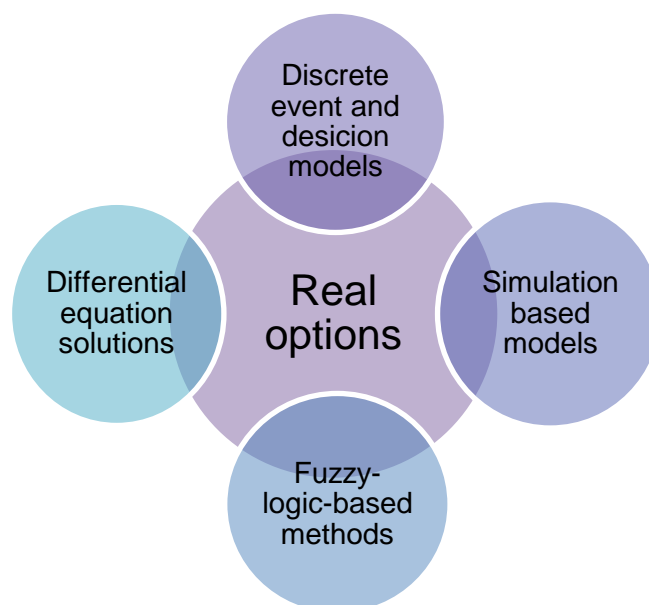
Trigeorgis (1996) defines real options as follows: “As with options on financial securities, management’s flexibility to adapt its future actions in response to altered future market conditions and competitive reactions expands a capital-investment opportunity’s value by improving its upside potential while limiting downside losses relative to the initial expectations of a passive management.”

Traditional discounted cash flow methods presume the management to passively commit to a certain operating strategy, such as to initiate an investment project immediately and operate it continuously until the end of its expected useful lifecycle. Real option approach, however, takes into account the different opportunities to alter this strategy as new information arrives and uncertainty about market conditions and future cash flows is resolved. In order to capitalize on favorable future opportunities or to mitigate losses, management may be able to defer, expand, contract, abandon or otherwise alter the project at various stages of its lifecycle. (Trigeorgis, 2006)

Collan (2009) examines previous real options related literature with the following findings: Real options literature can be divided roughly into two categories - general theory and application. The general theory area has covered, for instance, entry and exit decisions, growth options, and the valuation of interrelated projects, whereas the applications have included research in petroleum, mining, natural resource, information technology, corporate strategy, real estate, and area development, just to mention a few.

The real option valuation has been researched for decades and four main fields of methodology have been formed, shown in Figure 4: the differential equation solutions, the discrete event and decision models, the simulation based models, and the fuzzy-logic-based methods (Collan, 2011). The three first models are based on probability distribution, whereas the fourth is based on a fuzzy number. The differential equation and the discrete event and decision models are more traditional, whereas the simulation and fuzzy-logic-based solutions are more recent and easier to adapt to managerial use.





**Figure 4 Real option valuation methods**

Black and Scholes option pricing formula (1973) forms the basis of differential equation solutions. The formula was created to value a European call options contract and is based on strict assumptions about the financial markets. The model is based on random walk stochastic process, geometric Brownian motion (gBm), and creates a continuous log-normal probability distribution of the future value of the option. The idea behind the construct of Black and Scholes formula is the “replication argument”, according to which any two assets with the same cash flows and the same risk must have the same price under perfect markets.

According to Collan (2011), the model is brilliant, as it allows for a closed form solution that returns the value of a call option as a single number. Nevertheless, models assumptions about perfect markets are strict, and in real world there are many imperfections the real option model should be able to cope with.

The binomial option pricing model by Cox, Ross, and Rubinstein (1979) forms the basis of discrete event and decision methods. The model estimates the variation of the underlying asset’s price based on a “discrete time” binomial tree. The binomial process allows for two possible

directions for the value of the underlying asset - up or down - at each time step. In the three step process the decision tree is constructed, the option value at the end of the maturity is calculated, and finally the option value is solved by iterating backwards from the final nodes. As a result, the model forms a discontinuous quasi-log-normal distribution based on the gBm with a compounded risk free rate used as a discount rate. The model is based on similar assumptions to Black and Scholes model and it does not separate the cost and the revenue sides of the real options, as mentioned in Collan (2011).

The Datar-Matthews model for real option valuation (Datar and Matthews, 2004) presents the simulation based modeling. The valuation algorithm, especially constructed for real option valuation, is based on operational cash flow scenarios of the investment project provided by firm managers and experts. The scenarios are brought to Monte Carlo simulation that creates the probability distribution, known as the pay-off distribution, from which the real option value is calculated by finding the probability weighed mean while mapping negative values to zero. If the same assumptions are used that are in place when one uses the Black and Scholes model, the results of the Datar-Matthews method and the Black and Scholes method converge.

According to Collan (2011), the simulation based modeling is highly user-oriented and flexible, since it allows for using complicated cash flow scenarios and different discount rates for revenues and costs. Further, the spread-sheet applications enable automated discounting of the future value distribution.

The pay-off method, introduced by Collan, Fullér and Mezei (2009), is a fuzzy logic -based real option valuation method that is especially built to serve practitioners. As a difference to the previous methods, the pay-off method is not based on using probability distributions to model the future value of an asset, but on using a simple possibility distribution that is treated as a fuzzy number to represent it.

Fuzzy number is a set that contains real numbers within an interval  $A$  having varying levels of degrees of membership from 0 to 1. As the level of degrees of membership for  $x \in A$  increases from 0 to 1, the confidence of  $x$  belonging to the interval  $A$  increases as well. (Bojadziev and Bojadziev 1995)

Similar to Datar-Matthews, the pay-off method includes making a best guess, optimistic, and pessimistic cash flow scenarios based on expert opinions and calculating the cumulative cash flows based on them. As a result, the best guess, maximum, minimum, and mean NPV's are obtained and they form a triangle shaped probability distribution based on fuzzy numbers. In addition, simple and informative key numbers can be deduced from these values: real option value, success ratio, and standard deviation can be easily calculated for the distribution and these measures help the decision maker compare the profitability of different investments. (Collan et al., 2009) Most importantly, the model does not rely on the strict assumptions of the perfect markets but is based on the subjective, real life managerial opinions and expertise.

In addition to the four types of real option models mentioned above, there are also market indicator based models. One of these is the Marketed asset disclaimer (MAD) approach, originally introduced by Copeland and Antikarov (2001). According to MAD approach, the cash flow itself is the underlying asset. The authors assume that the present value of the cash flows without option value is the best unbiased estimator of value of the project, as if it were the traded asset. As Collan and Haahtela (2013) discuss, the most distinctive feature of this approach is that it relies on both the observable market data and the managerial assumptions related to cash flows.

Collan and Haahtela (2013) map different ROV methods and their applicability to different types of uncertainty. Three types of uncertainty and six different ROV models are discussed in the article with illustrative examples. The three types of uncertainty are *risk*, where probability of

future events is objectively known or knowable; *parametric uncertainty*, where structure of the problem is known but the probability is not; and *structural uncertainty*, where even the structure the future events can take remains uncertain.

The authors find that the traditional real option models, such as the differential equation models and discrete lattice models, are not very compatible when parametric uncertainty occurs. Further, they find that most of the models are not applicable for the structural uncertainty, with only fuzzy pay-off based models being able to create direction-giving quantitative results. The authors emphasize that choosing the right method for the situation is crucial for successful decision making, as wrong model may lead to unreliable results and money losses. According to the authors, mapping different options can be helpful in the selection process. (Collan and Haahtela, 2013)

Trigeorgis (1993) examines the managerial flexibility embedded in investment projects and finds that it often takes a form of a *collection* of real options. The author studies the different interactions of these real options and proposes that the value added with the real options seems to decrease, as the number of options increases. The author argues that neglecting a single option may not cause estimation errors, but evaluating each real option individually and summing them can overstate the value of the project.

In their empirical study, Schneider, Tejada, Dondi, Herzog, Keel, and Geering (2008) discuss the advantages that real option valuation has as opposed to classical discounted cash flow models, such as NPV. They mention that in NPV, the discount rate is based on the CAPM, the central assumption of which is that all investors are well diversified and thus face only systematic, market related risk. Nevertheless, this is not the case in real life investment decisions, where also project related risk exists and must be considered. In their R&D related case study, the authors select to use the MAD approach to capture market uncertainties that cannot be diversified by investors.

This subchapter has discussed real option theory in general and provided some examples of their applicability in different business environments. The next chapters will focus on real estate, first describing general characteristics and main capital budgeting methods used in the industry, and further discussing the application of real option approach in the real estate business.

## **2.2 Real estate valuation**

This chapter takes a look at the basics of real estate investing and discusses issues that may arise specifically in this industry in comparison to financial markets and assets. The first subchapter presents general theories and some recent trends in real estate valuation, whereas the second subchapter shortly introduces characteristics of and risks involved in public sector real estate projects. Finally, the public-private partnership as a value-adding method is reviewed.

### **2.2.1 Fundamental approaches and recent trends in real estate valuation**

Goddard and Marcum (2012) present some fundamental approaches that investors should be familiar with, when dealing with real estate investments in comparison to financial investments. One of the fundamental thoughts is to analyze the quantity, the quality, and the durability of the cash flows that investment would provide during its maturity. This is called QQD-analysis and should always be done separately for each real estate property in the portfolio.

Further, the authors present some general real estate concepts, such as *the holding period*, which is similar in real estate as investment horizon or maturity for stock investments. In real estate terminology, market timing strategy is called *rotation strategy*, which refers to buying at low and selling at high price. Rotation strategy, arbitrage strategy, and opportunistic strategy may lead into shorter holding periods, whereas growth and value strategies often lead to longer holding periods. Value

investments tend to involve holding period of 7 to 10 years and have often strong quantity, quality and durability. (Goddard and Marcum, 2012)

According to Goddard and Marcum, other real estate investment strategies include contrarian investment strategy, which refers to investing in properties that are currently out of fashion, and tenant strategy, which refers to purchasing investment properties that have specific tenants found desirable by the investor. Some investors choose to concentrate on properties built only for credit quality tenants. In these cases the holding period depends on the durability of the income stream, also defined as the length of the remaining lease term. In blue chip property investing, similar to tenant strategy, investor is wishing to choose very visible, unique, and well located properties that are timeless and typically have a long record of success.

Goddard and Marcum (2012) mention NPV and IRR as the primary methods for real estate investment valuation. However, IRR has some problems in valuing real estate investments: multiple IRR's are possible when the cash flows go from positive to negative and back to positive over the course of a holding period. This could happen easily during the early years of investment when the property has no tenants or payments and sudden large costs can occur. The authors also remark that IRR is more project specific and may not be able to be duplicated in the future investments, whereas NPV is rather conservative.

In statistical analysis, three scenarios of IRR should be formed considering the QQD-framework, Goddard and Marcum (2012) find. If a property has tenants of a higher financial quality with leases of a longer length, they should on average have less variability not meeting the QQD-criterion. If majority of the income is expected from the sale of the property at the end of the maturity and not from the annual cash flows, more risk is involved. Goddard and Marcum (2012) suggest partitioning the IRR as a solution for this problem.

Furthermore, when one uses IRR method, it is assumed that reinvestment happens at the calculated IRR, not the required rate of return, which is the case with NPV. MIRR (terminal IRR) is a solution addressed to this problem and has been used frequently to replace IRR. Finally, Goddard and Marcum emphasize that the cost of capital is highly more difficult to estimate for real estate projects than for stocks and bonds, since they are very heterogenic compared to financial assets. This is caused for instance by various debt scenarios, diverse management, heterogenic markets and submarkets, and mixed tenant scenarios. This heterogeneity problem can be partially compensated with specific real estate valuation methods, which take into account vacancy rates and other industry specific issues. One solution for this problem is real option valuation, which has grown in popularity among real estate researchers in recent years. (Goddard and Marcum, 2012)

Goddard and Marcum (2012) describe the real estate appraisal process with three main approaches to value: the sales approach, the cost approach, and the income approach. The idea of the sales approach to value is to find comparable real estate properties with, for instance, the same area or similar economic conditions and to calculate the average property price per square foot based on these properties.

The cost approach to value, according to Goddard and Marcum, is the most suitable for new construction properties. It can also be useful for existing ones, since the appraiser provides information about the effective age of the property. The effective age of the property is defined as the remaining economic useful life given the quality of the construction and the improvements made to the property, and it can be remarkably longer than the actual age of the property. According to the cost approach, the investor should not pay more than the value of the land plus the replacement cost to build a similar property. The authors point out that the approach is not very intuitive, but it can have relevance for lenders trying to determine the length of a loan amortization for a given property.

The last approach discussed by Goddard and Marcum, the income approach, is a commonly used method but only for investment properties that receive rental income from a third party tenant, not for primary residences or sites of business. The approach has three different methods: *gross income multiplier*, which is the simplest one of the methods, *direct capitalization*, which includes calculating the net operating income and the capitalization rate by dividing income by sales price, and finally the discounted cash flow method. According to the authors, discounted cash flow method values the property irrespective of whether the property is indebted or if there are tax benefits from accrued depreciation. Consequently, operating expenses do not include interests, depreciation or amortization. Usually leasing commissions and tenant improvements, which are not calculated in the capitalization method, are captured by the discounted cash flow method for multi-tenant office, retail or industrial properties.

McParland, Adair and McGreal (2002) research the application of different real estate valuation methods in European countries. They find that in France the triennial lease system is the most common method, and since making market forecasts has been challenging, the discounted cash flow method is not used as much as capitalization method. The authors mention that in Germany the market is not truly transparent and clients tend to expect the traditional capitalization method, which makes it the most common method in German valuation, with the cost method as a subsidiary method. Swedish and Dutch firms, however, are found to use discounted cash flows as the most common method, probably due to more transparent and available market data.

As Goddard and Marcum discuss the differences between the three approaches, they mention that sales approach often values property higher than the other methods during a good economic season. Further, the direct capitalization is only a one year snapshot whereas the discounted cash flow method is a multiyear approach. All in all, the



authors suggest that appraiser could take a rounded average of the values calculated by different methods for the most comprehensive judgment.

According to Farragher and Kleiman (1996), real estate investment decision-making process is complex and includes various steps, such as setting strategy, establishing return/risk objectives, forecasting expected cost returns, assessing investment risk, making a risk-adjusted evaluation of the forecast costs and returns, implementing accepted proposals, and post-auditing the performance of operating investment. Consequently, it is highly important to pay attention to different risks that real estate investment may have.

Goddard and Marcum (2012) discuss the different types of risk in real estate, shown in Figure 5. They define business risk as the risk that arises from fluctuations in the economy and appears in changes in the financial statements of the investment property. These changes can occur, for instance, in capital expenditures, gross potential income, vacancy factors, credit losses, operating expenses, and in the final property value. In addition, investor should pay attention to changes in market demand, population changes, and changes in area's base employment. Business risk can be partially alleviated by investing in multiple geographic areas or countries and by diversifying the tenant base from the industrial perspective.



**Figure 5 Risk in real estate**

Further, Goddard and Marcum (2012) mention management risk: all investment properties need property management to some level. Depending on the structure of the lease it can include mainly curing structural deficiencies or handling daily issues. The risk involved in poor management, for example misjudgments in daily management tasks that leave tenants dissatisfied can lead to losing tenants and property value. Another risk that investor should pay attention to is liquidity risk, by which the authors mean the lack of a deep market with lots of buyers and sellers. The less liquid the market is, the more likely the sellers are to make concessions. Real estate is less liquid than other forms of investment, given the time needed to consummate a sale. For special properties that have a limited number of potential buyers, the cycle can be rather long: from the initial search for a potential buyer to, finally, the legal transfer of the property. (Goddard and Marcum, 2012)

Goddard and Marcum describe the legislative risk as a change in regulatory environment that increases costs or negatively affects the attractiveness of lending. Real estate sector is highly regulated, and the standards can be of municipal, governmental, or international origin. Thus investor should follow possible changes in tax laws, rent controls, zoning allowances, and other restrictions that may affect the investor returns.

Furthermore, the inflation risk exists, as the income increase experienced does not always keep pace with overall price level. Compared with other investments, however, real estate investments perform well against inflation and real estate appreciation compares favorably with it.

Interest rate risk occurs, according to Goddard and Marcum (2012), often for real estate investments that are highly levered and have variable interest rates. As the variable rate index increases, the interest rate risk of the investor increases as well. Furthermore, environmental contamination can be a severe risk in real estate investment. Environmental risk concerns the specific property and its effect on land, water, air, sewage and aesthetics of the surrounding area and of the community at large. An unresolved environmental problem will reduce the appraised value of the property typically by the cost of remediation. (Goddard and Marcum, 2012)

Vandell (2007) discusses more recent trends in real estate valuation. Valuation of real estate illiquidity has gained more attention in the recent years, in comparison to fully liquid assets, such as stocks and bonds. According to the author, possible additions to the traditional *three approaches to value* are receiving attention. One alternative is the Replication method by Lai, Vandell and Wang. In Replication method, one may simply obtain an optimal weight for the sales estimate itself, rather than compounding potential error in the value estimate. (Vandell, 2007)

Furthermore, appropriate ways of valuing real estate assets have gained attention from the perspective of public capital markets and in a portfolio context, Vandell mentions. This phenomenon has created new “derivative” debt and equity products associated with real estate assets, each of which should be valued according to their own characteristics and markets. Also other capital market innovations, such as house price future contracts and other hedging contracts have been introduced in order to protect investors from future downturns in real estate value. This creates a “real time need” to develop new methods for valuating these products. However, the real estate industry often tends to lag behind in the appraisal practice and the

more traditional methods seem to still have strong foothold (Vandell, 2007).

Still, as Krumm and de Vries (2003) remark, more traditional real estate valuation methods often fail to handle the insecurities that are characteristic of real estate industry. One growing trend addressed to this problem is real option valuation, as it is able to balance risks in financial decisions and provide more flexible solutions.

Also CAPM has been used in the previous research in order to quantify the risk-return ratio of real estate investments. According to Liapis, Christofakis and Papacharalampous (2011), the main problem in applying CAPM to private real estate investments is the calculation of a meaningful risk factor beta, especially in countries where the amount of real estate market data is very limited.

In a recent study, Liapis, Christofakis and Papacharalampous (2011) call into question some of the traditional assumptions of real estate valuation. In their case study, the income, the direct and indirect costs, and the price or the purchase amount are changed into the rent and capital gains of the property, the cost of the property or the direct and indirect costs, and the price of the property asset. The researchers choose to use the price to rent ratio in their case study. It is suggested that in real estate the price to rent ratio is very similar to the price to earnings ratio of a stock of a company. Nominal interest rate is used as the discount factor in the evaluation process and it incorporates the total funding cost of investments in property assets. Thus the interest of the investor in real estate capital is equal to the rent to price index plus a constant growing rate. However, the authors argue that the P/E is not a useful tool for the valuation of assets with different growth rates or for assets with different risk levels.

### **2.2.2 Real estate investments of the public sector**

Real estate projects of Finnish municipalities provide an example of the special characteristics and risks that public sector real estate can have. The article by Collan (2009) describes the area development projects of municipalities, mentioning that Finnish municipalities have traditionally required a very low return of the invested capital in the municipal engineering and infrastructure investments. According to Collan (2009), the required rate has often been close to the risk free interest rate or sometimes even no return at all has been required for an investment.

As Collan (2009) mentions, financial analysis and the decision to make an investment have been based on the assumption that tax income streams are risk free, which has been reflected on the discount rates. The author finds that the most significant economic risk in municipal engineering and infrastructure arises from uncertainty of costs, since cost overruns in infrastructure are well known. All in all, in municipal projects the aim is to develop the area according to plans with close to neutral, no gain no loss long-run result.

The Private Finance Initiative (PFI) was introduced by the UK government in 1992. PFI can be defined as *“a policy to allow and regulate privately financed public projects, or rather as a method involving private sector entity taking the responsibility to design, build, finance and operate (DBFO) an asset used in the provision of a public service for a contract period of up to four decades”*, as described in Rintala (2004). Grimsey and Lewis (2002) present, how over the past decades governments of numerous countries have faced the pressure to reduce public sector debt. At the same time they have been expected to improve public facilities, which has led to inviting private sector entities into long term agreements. According to Grimsey and Lewis (2002), Public-Private Partnerships (PPP) can be defined as *“agreements where public sector bodies enter into long-term contractual agreements with private sector entities for the*

*construction or management of public sector infrastructure facilities by the private sector entity.”*

As stated by Rintala (2004), it has been widely recognized that PFI method can remarkably add value and profit for both the public sector clients and the private sector actors, as a result of improved economic efficiency. Real estate and infrastructure industries have typically been very fragmented, and the opportunities to minimize costs during the project life cycle have been limited. This is due to several separate contracts and agreements, and other contractual or organizational boundaries. In the PFI, the private entity has an improved opportunity to innovate in its real estate development as well as to minimize costs and to recover from increased capital expenditures during the long lifecycle of the project. (Rintala, 2004)

According to Rintala (2004), traditional real estate projects with a public sector client are characterized by capital cost and construction time overruns, since the client cannot transfer the construction and design risks effectively. This results from the fragmented responsibility in construction and design, which enables the contractor to claim client for unanticipated costs. The client may also face legal difficulties in demonstrating liquidated damages. In a PFI project, however, cost and time overruns should not occur since the client is enabled to effectively transfer the construction and design risks to the private entity.

Grimsey and Lewis (2002) discuss the nature of the public infrastructure projects. First of all, they find, the duration of such projects is long, since infrastructure is long-lived and has a long gestation process. Second, the projects are illiquid, with a limited secondary market, and capital intensive, with large scale and high leverage. Third, these kinds of projects are rather difficult to value, since there are several issues with taxation, pricing rules, embedded options, and guarantees. As a result, the whole evaluation process is a complex and specialized activity.

For the past decades, the dominant approach in Europe has been that infrastructure projects are provided by government-owned enterprises. As Grimsey and Lewis (2002) discuss, the trend has clearly been moving from public to private provision of infrastructure. There has been a market change in thinking on these matters, for example, from thinking “taxpayer pays”, to thinking “user pays”, which is assumed to lead to better economic use of the services. Thus prior monopolies may have faced new competitors and regulations over prices, and the situation has led to new public-private-partnership (PPP) arrangements.

### 3 STATE OF THE ART IN REAL OPTION VALUATION IN REAL ESTATE INDUSTRY

After examining real option valuation theory and real estate valuation separately, it is interesting to combine the two areas and see what kind of research has been done in the field of real options and real estate valuation. 26 relevant articles or books were found and classified in 5 categories, summarized in Table 1: In the first category, the articles are more theoretical, and most of them are focused on evaluating different structural real options and forms of flexibility. The second category includes case studies of public or government real estate projects and properties, related to real option strategies. In the third category, real estate cases are studied using more traditional real option methods that are based on financial theory, whereas the articles in the fourth category focus on examining Monte Carlo simulation in different real estate applications. In the last category, some articles with more modern methodologies, such as fuzzy logic and genetic algorithms, are presented and discussed.

**Table 1 Five categories of real options and real estate related literature**

Category	Authors	Year
<b>Forms of flexibility and theoretical assumptions of ROV</b>	Shen, Pretorius	2013
	Williams	1991
	Lucius	2001
	Pomykacz, Olmsted	2013
	Titman	1985
	Guma et al.	2009
	Oppenheimer	2002
<b>Public projects and properties</b>	Lagus	2008
	Charoenpornpattana	2003
	Collan	2009



<b>Classical real option valuation cases</b>	Quigg	1993
	Barthelemy, Prigent	2008
	Greden, Glicksman	2005
	Leung, Hui	2002
<b>Cases with Monte Carlo simulation</b>	Amedee-Manesme et al.	2013
	Bao et al.	2012
	Baroni et al.	2007
	Du, Li	2008
	Gimpelevich	2011
	Liapis	2011
	Hoesli et al.	2006
	Loizou, French	2012
<b>Cases with modern ROV methods</b>	Byrne	1995
	Collan	2012
	Pfnür and Armonat	2013
	Vimpari et al.	2014

The mapping of the selected articles shows that articles examining Monte Carlo simulation have been by far the most popular category in recent years. Furthermore, articles discussing theoretical issues and different structural real options have also been frequently studied, as Table 1 shows. More traditional, finance-based real option methods have been less frequently used in the practical real estate application as well as fuzzy-logic-based solutions and other more modern methods.

### **3.1 Forms of flexibility and theoretical assumptions of real option valuation**

Real option theory is widely used in financial markets, but infrequently applied in real estate valuation, as Pomykacz and Olmsted (2013) discuss. Nevertheless, real option valuation should be applied to real estate appraisal, as it improves accounting for value and risk, the authors find.

Expertise is, however, often needed, since the analyses require important adaptations and special uses of real estate data.

According to Shen and Pretorius (2013), there are plenty of theoretical studies investigating flexibility in real estate development. Flexibility may mean the option to delay development, time to build -option, the option to alter land density, the option to switch land use, and many others. Practical application of real options in real estate, however, remains rare. This could be due to theoretical difficulties and mathematical complexity that is typical of real option valuation and does not fit well in the fragmented real estate industry with its specific problems. (Shen and Pretorius, 2013)

The study by Titman (1985) is one of the first real option researches performed in the field of real estate. In the research, real option approach is used in forming a valuation equation for pricing building on vacant lots in the future. It is found that if uncertainty about the real estate market prices is high, then an option to delay the investment decision, and to choose the type of the building later on in the future, can be attractive. If prices are more certain, building at the current moment seems more attractive. Uncertainty decreases the building activity and, as a result, some acts of the government that are meant to increase the activity, may even decrease it, if the form and duration of the effects is unclear. (Titman, 1985)

In the research by Williams (1991), optimal exercise policies are calculated for the options to develop or to abandon real estate projects. According to Williams, developing real estate is a lot like exercising an option, though owners' options are more complex and stochastic state variables are different. Further, in real options, the option never expires and the renovations and such are exercised only if it is compulsory and sensible due to passage of time. Thus the building process is postponed until the value of the property would be significantly higher than the construction cost.

A basic assumption in the research article by Williams (1991) is that both the operating cash inflows and the development costs are driven by stochastic processes. The greatest difference to financial options is that owner can define the density and the scale of the property. The author argues that maximizing market value is optimal, if the capital markets are efficient, even though the real estate market were not.

The research article by Shen and Pretorius (2013) studies individual real options, but perceives the options as an asset portfolio at the firm level. The aim of the study is to address the gaps between theoretical real option research and the practical application of real option analysis in real estate development. The authors find that theoretical real option models and forms of flexibility may not apply, when industry specific characteristics are involved, since theoretical approaches assume options to occur in a perfect and institution-free world.

The argument of Shen and Pretorius (2013) is supported by the earlier work by Lucius (2001), who reminds that in the application of real option valuation in real estate, one has to be aware of the fact that real estate investment differs essentially from other real investments. Some of the main characteristics of real estate are immobility, heterogeneity, limited substitutability, high investment volume, high transaction costs, and long time-span of a project life-cycle. One of the largest theoretical problems in the application of real options is the presumption of perfect real estate capital market, which is complicated by the heterogenous nature of real estate market. Moreover, in real estate projects, several important variables can be subject to stochastic processes. Even the stochastic process itself can be a problem, since the geometric Brownian motion (gBm), the basis of most financial options, cannot be taken for granted in the case of real estate. (Lucius, 2001)

Also Oppenheimer (2002) criticizes the use of real options in real estate valuation. He argues that the required assumptions and criteria for using real option models can easily be absent in the real estate environment,

which raises the question whether real option valuation produces better results or only creates more uncertainties for end users due to various adaptations and forecasts.

According to Oppenheimer (2002, pp. 229-230), the assumptions required for the security option pricing models used in the classical real option approaches are as follows:

- *Complete markets*
- *No arbitrage opportunities or fully diversifiable risk*
- *An observable underlying (twin) asset that has perfect correlation or constant correlation with the asset in question*
- *Log-normal returns for underlying asset*
- *A known and constant mean return and variance of the underlying asset that is identical to the asset in question*
- *A known and constant risk-free rate*
- *A well-defined mathematical process that the underlying asset follows in time, such as a gBm process*

Oppenheimer points out that real estate industry may not provide the risk-free arbitrage environment required for option-based modeling. Moreover, it is impossible to fully diversify risk, and thus using risk-free rate in evaluation might be inappropriate. In addition, real estate projects are unique, and it can be difficult to evaluate whether the model fits and is able to define reality. Most of the critique by Oppenheimer (2002) falls on the more traditional real option valuation methods that are based on strict mathematical assumptions. The more recent, practically oriented real option valuation methods do not have the same strict assumptions, and they may be able to reflect the real investment environment better.

The case study by Shen and Pretorius (2013), for instance, takes into account some firm-specific factors and practical details in real estate development that have not been thoroughly discussed in the previous literature. Firstly, the firm perspective, rather than project perspective, is

used as the basis of the valuation. Furthermore, some effects on the project value, caused by institutional arrangement and regulatory requirements, are considered. Consequently, as Shen and Pretorius find, theoretical models can be used in practical business applications; they just should be developed further and adapted accordingly. The analysis of the institutional environment surrounding the projects reveals that the real options included are not well-defined, and several project or contract related details need to be identified. (Shen and Pretorius, 2013)

In real estate development, several parties, including developers, government, and contractors are involved in the process, Shen and Pretorius (2013) discuss. In countries that manage their land as a publicly owned resource through leasehold, there is even an additional layer of participation and complexity within the process. Moreover, one real estate project cannot be completely isolated from other projects of a firm; there is often interaction involved, as developers may prefer firm perspective over project perspective. Direct interaction, which means the effect that one project has on multiple projects within the firm, has not been widely researched in the previous studies. Indirect interaction, which means capital budgeting regarding multiple projects of the firm and sharing of the resources between them, has been more commonly researched.

In their case study, Shen and Pretorius (2013) find that project value, which can include land value or real option value, is influenced by the policies and the regulations that restrict the flexibility. It is also found that interaction between different assets in the investment portfolio increases the value of the property or decreases costs, which results in a lower investment threshold for projects, and more profitable early stage development. This is caused by reduced fixed costs, shared inputs, and complementary land uses.

The financial constraints, in contrary, are found to decrease the property value and increase the investment thresholds, Shen and Pretorius (2013) remark. Thus reallocating the financial resources according to the existing

real options is found to improve firm performance. Even though the projects might not interact with each other, they still compete for the same limited resources and are subject to capital budgeting constraints. The article by Shen and Pretorius (2013) describes financial constraints, varying capital cost, and opportunity cost within the firm, and incorporates how these factors can affect the project value. Financial constraints and financing costs can force the developer to wait longer and reduce the project value, whereas several real options would increase the flexibility value of early exercise.

The research by Guma, Pearson, Wittels, de Neufville and Geltner (2009) demonstrates the potential value of vertical phasing as a valuable real option strategy in real estate development. They find that vertical expansion can have significant organizational and logistical advantages for corporate developers, such as providing an access to convenient expansion space while limiting the downside risk. Commercial developers, in turn, can find the ability to scale back in designs in case of a market downturn valuable. Although the process of vertical phasing can be complex and requires additional investments in the original design, it should be considered as a possibility for real estate industry.

Lucius (2001) remarks that as property investors gradually adopt new financial concepts, it is clear that real estate valuation will have to change, and real options valuation is one of the most promising areas for that. The more uncertainty is included in the investor's considerations, the less reliable the traditional real estate valuation methods appear. Especially entrepreneurial flexibility gets easily undervalued with the traditional methods, since they ignore important alternative decisions.

According to Polykacz and Olmsted (2013), many analysts use lowered discount rates in their discounted cash flow analyses, when they conduct real option scenarios, compared to rates they would use in deterministic models. This is due to the fact that the deterministic model is an average, or typical and possibly biased forecast. Thus it includes more uncertainty,

and there is a greater risk of cash flows not materializing as forecast. It is argued that in real option valuation, each scenario should be discounted at its safe rate. This is because the possibility of the failure has already been accounted for in the selection and weighing process and thus does not need to be accounted for in the discount rate.

Lucius (2001) finds that when real estate is defined as a real option, it changes the view of real estate completely. Real estate is no more perceived just as a triangle of space, money, and time, but as a product of miscellaneous decisions an investor has taken out of a bunch of options. According to Lucius, real option valuation can significantly support weaknesses of the traditional real estate valuation methods.

### **3.2 Public projects and properties**

Mapping of the real estate related real option studies revealed that combining public real estate projects and real options has been a growing research topic in recent years. The number of the studies, however, is not yet remarkable, possibly due to the limited resources that public enterprises, municipalities and governments may have for adopting the most recent methods and practices. Nevertheless, the studies performed so far have shown promising results.

According to Lagus (2008), an option strategy tool was built for municipal area development in order to simulate the profitability more accurately. Municipal area development projects are often of large scale and have a unique nature, which makes it sometimes impossible to execute them according to the pre-made plans. Costs and schedules are difficult to forecast and manage, which may have crucial effects on the economy of the municipality. With right co-operation models and tools, however, the risk can be significantly reduced, Lagus finds.

As mentioned by Lagus (2008), the option strategy tool that was developed to support municipal area development is especially helpful in negotiations, since the economic consequences become more transparent

to different parties. It is important to see the effects regarding the whole life cycle of the project, and the tool helps decision makers to perceive the long run view. The new model has been inspired by the practice in Holland, where investment banks are often co-operating in the government and municipal projects. There independent area development corporations, called project companies, are often founded to provide transparency and clarity. (Lagus, 2008)

Charoenpornpattana, Minato and Nakahama (2003) research government support in privately financed build-operate-transfer (BOT) highway projects. The researchers argue that government support to privately financed investments lacks quantitative evaluating methods, which often causes the supports to be subjective or irrational. Therefore real option approach is proposed, and government support is perceived as a bundle of options. The researchers use binomial model with risk-neutral approach. With this method, government can value its supports and formulate them to desired value.

Firstly, in the study by Charoenpornpattana et al. (2003), the cash flows of the option model are divided into two parts: cash flows without government support and with support components. The support component contains a bundle of options, composed of several option elements that can be valued separately. The option types include minimum traffic guarantee and shadow tolls. It is found in the research that the present value of cash flows of BOT highway projects is highly sensitive to discount rate, and consequently, a discount rate that can reflect the real uncertainties is essential. Real option valuation is perceived as a good solution for the problem. (Charoenpornpattana et al., 2003)

Collan (2009) describes the traditional area development policy model of the Finnish municipalities, and proposes some new strategies and valuation practices for the area development. The analysis for the new policies is done using strategic real options. As Collan examines the economic risks the area development projects may face in different



stages, he finds that despite the high risks, the traditional policies are often followed, even though they might not be the best or even economically profitable strategies.

Consequently, as Collan (2009) discusses, the nature of the area development projects themselves is not the reason for the high risk level, and it can be managed or even significantly lowered by the change of the policy. Mapping the real options included in area development projects plays a crucial role. The choices the municipalities have, for instance, to sell or not to sell land, are considered as strategic level real options. The optimal strategy would be a choice that fulfills all the policy objectives of the municipality and at the same time provides the highest possible profitability. Though profitability is not the only measure in the success of area development projects, its role is crucial in tight financial situations the municipalities often face.

### **3.3 Classical real option valuation cases**

Classical real option valuation methods, such as Black and Scholes or Binomial models, have not been used as frequently in recent years as more modern and simulation based methods in the context of real estate. However, four articles using classical methods for practical cases in real industry were found among the selected articles.

Quigg (1993) studies the existence of a real option premium for optimal development time of real estate in a large empirical sample of real estate transactions. The real option model used – which is classical and based on the Black and Scholes formula - is found to have significant descriptive value. Market prices reflect a premium of 6 % on average for optimal development of the land value.

Quigg (1993) uses hedonic estimation in valuing the price of the building, which is the underlying asset for the land and the real option of the model. A hedonic price function specifies how the market price of a commodity varies as different characteristics, including the square footage of the

building, the lot, and the height and the age of the building, vary. Based on these estimates, the potential building value on undeveloped plots of land is determined. Generally, the findings of the research support the theory that option to wait has value.

In the study by Greden and Glicksman (2005), a real option based tool is developed in order to help managers and decision makers invest more efficiently in physical infrastructure and its ability to evolve. The researchers aim to answer the question, of how much it is worth to invest in a space that could be renovated into office space for a specified renovation cost in the future.

Three sources of uncertainty are considered in the study by Greden and Glicksman: the market price of the rent for office space measured by volatility, the date of the space need, and the amount of the space need. For the construction of the model, binomial lattice method is used to calculate the option value. Further, Monte Carlo simulation is employed to choose the random time and amount. Although, in the study, the use of binomial lattice model is limited to conversions into office space, it can be modified to any space design subject related to uncertain future conditions. The method can be useful for real estate developers, corporate real estate officers, architects, government officials and many other stakeholders. (Greden and Glicksman, 2005)

In the research by Barthélemy and Prigent (2008), option based solutions are used in order to optimize the holding period of a real estate portfolio. It is assumed that the terminal value corresponds to the real estate index, and the optimization problem corresponds to the maximization of a quasi-linear utility function. Three cases are considered, first of which assumes the probability distribution to be known and the deterministic optimal time to sell to be chosen at the initial time. In the second case, the investor is assumed to be perfectly informed about the market dynamics, and therefore, at the initial time, he can determine the optimal time to sell for each path of the index. In the third case, the focus is on analyzing inter-

temporal optimization, based on the American option approach. The optimal solutions for each case are calculated and compared. (Barthélémy and Prigent, 2008)

The results of the study by Barthélémy and Prigent (2008) illustrate that the value of a real estate portfolio depends strongly on the optimal time to sell. The first case, with the optimal holding period selected at the beginning, was found to be time inconsistent, as the same computation at a future date leads to a different solution. Moreover, the second case with a perfectly informed investor was found to be rather unrealistic. The third case, with the American option approach, was found to be more rational, as it takes account of inter-temporal management and cumulative information. Further, the American approach allows the reduction of the probability to get small portfolio values.

Leung and Hui (2002) examine the appraisal method adopted by the government for Hong Kong Disneyland, and explore the real options that might add value to the project, using binomial option pricing model. The option to switch use, the option to expand, the option to defer, and some strategic options in competitive environment are studied within the theme park context. Real option valuation is found to be superior to the traditional NPV approach since it is found to be able to increase the upside potential as well as to reduce the downside risk.

The method adopted by Leung and Hui (2002), the binomial stochastic numerical analysis, is able to handle multiple options, as opposed to most real option models that focus on valuing individual options. Furthermore, the ability to capture dividend payments in stochastic patterns, not included in the Black and Scholes model, is considered an advantage of the binomial model. The study formulates an approach for quantifying the value embedded in real estate projects and for showing the interaction of the options within and outside the development process. After taking into account different options included, the projects that may at first seem unprofitable become attractive.

### 3.4 Cases with Monte Carlo simulation

Using Monte Carlo simulation in real estate valuation has been increasingly popular in studies for the last decade. For instance Amédée-Manesme et al. (2013), Bao et al. (2012), Baroni et al. (2007), Du and Li (2008), Gimpelevich (2011), Liapis et al. (2011), Hoesli and (2006) and Loizou and French (2012) use the method in their research cases with varying opinions and conclusions.

Amédée-Manesme, Barthélémy and Baroni (2013) propose a new method for the valuation of real estate portfolio, where they use Monte Carlo simulation and options to compute the price, while including lease structure risk in the valuation process. The model considers tenant behavior with regard to cash flows and combines Monte Carlo methods for pricing the portfolio, with various market rental values.

The model by Amédée-Manesme et al. (2013) can mainly be used for reporting and risk assessments, though more robust analysis is also possible. Histograms are used in the presentation, instead of single values. In addition, the model allows the calculation of Value at Risk (VaR) of the portfolio, which is increasingly often required by both the regulators and the investors. However, according to authors, it may be challenging to find all the inputs needed for the analysis, such as the trends and the volatilities of each submarket. In the other hand, the model is very flexible and the parameters can be modified according to the needs of each investor.

The studies by Bao, Chong, Wang, Wang and Huang (2012) and Du and Li (2008) both examine the application of Monte Carlo simulation on the land and infrastructure development in China, where the growth of the real estate industry is rapid. Bao et al. find that the use of Monte Carlo simulation is truly flexible and enables investor to add internal or external factors to the model afterwards, once they can be measured as a probability distribution. Du and Li (2008) use Monte Carlo simulation to evaluate the value and the risk of a concession investment from the

developer's perspective, concerning a freeway project in China. As Du and Li emphasize, the simulation method is non-deterministic, which makes it suitable for dynamic and complex conditions. Moreover, the Monte Carlo simulation addresses the problem of the asymmetry of the probability distribution, which is ignored by the more conventional methods.

Baroni, Barthélémy and Mokrane (2007) employ Monte Carlo simulation for the measurement of a real estate asset distribution, using inputs provided by real estate indices of Paris. They use rent and price dynamics in the forecasting of the future cash flows, in order to improve the real estate valuation. Consequently, the terminal value of the property is not computed the same way as in the usual discounted cash flow approach, but is simply the actual quoted price for the portfolio in the future using the housing price dynamics.

Baroni et al. (2007) argue that, overall, the main weakness of the discounted cash flow method comes from the fact that it does not capture the distribution features of the cash flows. It is not able to serve to value contingent contracts on the real estate asset. The simulation based models are less sensitive to input variables and allow investor to estimate portfolio's price distribution for any time horizon. Finally, also Baroni et al. mention the possibility for VaR computations, when simulation based models are used.

Gimpelevich (2011) presents the simulation-based excess return model (SERM), which is based on an application of Monte Carlo simulation to real estate project risk assessment, combined with the discounted cash flow method. SERM is able to correct significant shortcomings of the discounted cash flow methodology by incorporating stochastic tools.

According to the author, it is essential to find an objective way to determine, what kind of return is sufficient to compensate for the risk taken in undertaking a project. Previous methods only allow comparison of the projects to one another, whereas SERM offers an objective metric of

sufficiency for a given project. Nevertheless, SERM model has also its limitations, such as its ability to model individual projects, but not so well the real estate portfolios. Further, if the probability spread used for vacancy and rent is exceedingly optimistic, the model will fail to account for extreme movements and lead to skewed results. (Gimpelevich, 2011)

Hoesli, Jani and Bender (2006) apply Monte Carlo simulation to a Swiss institutional real estate portfolio with 30 properties, the hedonic estimates of which are compared to the simulation-based values. All in all, these values are found to be close to each other, with simulated values being slightly lower. The risk metrics provided by simulation are found to be useful and superior to the original discounted cash flow results.

Hoesli et al. (2006) remark as one of the most significant shortcomings of the discounted cash flow method that the value of the property is needed in order to calculate the discount rate. Furthermore, the rate is assumed to be constant during the whole holding period, and no uncertainty is taken into account. These problems are addressed in the model developed by Hoesli et al. (2006). The discount rate is assumed to be time-varying and dependent on the market interest rates. It is calculated based on the assumption that the rate is higher than the risk free rate but lower than the historical return on stocks.

Loizou and French (2012) discuss the appropriateness of using Monte Carlo simulation as a risk assessment method in real estate development. Firstly, as they remark, development appraisals are extremely sensitive to the precision of the inputs. A small change in, for instance, rent, cost, yield, time, or interest rate can crucially affect the residual value and the value of the property, leading often to biased results. Even though Monte Carlo simulation can help the decision maker to be more consistent and rational in the risk analysis, several issues may become problematic. These issues may include the need to know the probability distributions for each outcome, the dubious reliability of the historical data, or the subjective nature of the estimates.

Another drawback, according to Loizou and French (2012), is the inability of the simulation based models to take account of the human interaction. Consequently, they cannot thoroughly manage the uncertainty, since the development, and the construction process in particular, should be perceived as a multitude of complex human, physical, and legal interrelationships. Moreover, the strict mathematical assumptions included in the classical financial real option methods are also present in the Monte Carlo simulation; it is without doubt challenging, if not impossible, to reflect human judgment and decision making in mechanic processes.

Liapis (2011) finds that the main shortcoming of applying Monte Carlo simulation to real estate projects is the existence of interdependencies between critical parameters, which violates the main assumption of the Monte Carlo method. According to the author, this has been strongly verified during the latest financial crisis, where a dependent increase was seen in vacancies in relation to a decrease in rents and an increase in capitalization rates.

### **3.5 Cases with modern real option valuation methods**

As discussed above, when it comes to applying real option valuation to the real estate industry, Monte Carlo simulation has been by far the most popular method in recent years. Nevertheless, many problems and shortcomings have arisen from the discussion, and other methods have been developed in order to overcome these problems.

Pfnür and Armonat (2013) continue from the basis of the simulation based stochastic processes, and develop a model, where they use heuristic simulation and genetic algorithms. In a case study it is demonstrated, how the traditional static simulation processes can underestimate the default risk of real estate investments. The researchers argue that in reality, the investor risk is greatly higher than investors have taken into account so far.

The model developed by Pfnür and Armonat (2013) is presented as a more exact way of managing investment profitability and risk, since with the aid of heuristic simulations, investment alternatives and their financing structures can be optimized. What appears to be problematic, however, is the task to gather empirical information of the stochastic dependence of the variables. Moreover, Pfnür and Armonat's model does not take into account human interaction, or the adaptability of managerial decision making, any more than Monte Carlo simulation does.

Byrne (1995) compares the Monte Carlo simulation method to the fuzzy-logic-based analysis methods and evaluates the benefits and drawbacks of the two methods, when it comes to practical application within real estate industry. For the fuzzy analysis, the researcher uses a special purpose spreadsheet package called *FuziCALC*, which uses fuzzy arithmetic to model imprecision, or vagueness, which fuzziness reflects.

The probability distributions have to always be determined if one wants to use the Monte Carlo simulation. According to Byrne (1995), this is perceived as subject to major criticism by many who doubt simulation methods and prefer fuzzy methods. Another problem of the simulation models is the transient nature of the measurement, since the probability that is subjectively measured today, can be different at another point of time. This decreases the credibility of the simulation where the analysis, based on certain observations, is repeated numerous times instead of repetitive observations made objectively over an extended period.

In the case study by Byrne (1995), it is noticed that the fuzzy analysis pushes the possible end values beyond those allowed in Monte Carlo simulation, due to a marginal extension of some state variables in the process construction. Whereas Monte Carlo suggests some values of very low probability, fuzzy model also suggests values that might be considered unbelievable. All in all, Byrne criticizes Monte Carlo simulation for mathematical complexity but argues that it may provide more information than fuzzy analysis.



Collan (2012) uses the fuzzy-logic-based pay-off method in a corporate real estate case, where vertical phasing is implied to urban construction in Chinese metropolises. Two construction strategies are compared using the pay-off method: to build all at once, or to use the vertical phasing strategy, where the second part is built in 5 years from the initial moment.

Collan (2012) finds that using a phasing strategy can provide a significant effect of risk reduction. Furthermore, the risk appetite of the investor is noted to play a role in the selection of strategies. The paper does not consider the optimization of the building strategies. The fuzzy-logic-based method is found to be useful in assessing merits of different strategies.

Vimpari, Kajander and Junnila (2014) use the fuzzy pay-off method in measuring the economic value of flexibility in a retrofit investment of corporate real estate. The research is performed as a case study at Senate Properties, as it is one of the largest property investors in Finland. Consequently, the research could also represent the category of public investments and projects, but is here placed in the category of modern methods, as the fuzzy-logic-based methodology is emphasized in the study. A seven-phase research process is used to create the three scenarios required for the pay-off method, including defining vacancy scenarios for rental agreements, calculating the potential income achievable with flexibility, estimating the cost of flexibility and valuing the real options.

Vimpari et al. (2014) remark that although real option valuation has been found to be useful in real estate and construction sector by many studies, it is problematic to determine the appropriate probabilities for different uncertainties in practical settings. Consequently, they emphasize that new applications are needed for real option valuation to break through in real estate. The main advantage of using the pay-off method is that assigning probabilities to scenarios is made unnecessary, which makes the applicability of the method into the case investment straightforward.

The main finding of the empirical case in Vimpari et al. (2014) is that flexibility investments seem profitable only when parts of the building instead of the whole building were designed flexible. The main advantage of real option valuation compared to DFC valuation is found to be the handling of uncertainty, as individual tenant risks are assessed more carefully and several sources of information are taken into account in the risk assessment. The case study provided Senate Properties with more robust numerical information when making investment decisions with limited funds for the project.

All in all, investigation into applying fuzzy logic to the real estate industry has been rather limited to date; there is a wide scope for future research in this field. Real estate has been a popular context for real option studies, especially the somewhat problematic Monte Carlo simulation, so it makes sense to apply the promising alternative of fuzzy logic here.

## **4 EMPIRICAL ANALYSIS ON SENATE PROPERTIES' SELECTED INVESTMENT PROJECTS**

This chapter presents the empirical analysis of the study. Firstly, the history of Senate Properties as a government service provider is shortly discussed and improvement needs of the current investment analysis practice are considered. Secondly, the most suitable methodology for analyzing the investment data is selected and 30 investment projects of Senate Properties are chosen to represent different business areas and client groups of the enterprise. Finally, the methodology is applied in the case projects and the results of the analysis are presented.

### **4.1 Overview of the investment valuation practices at Senate Properties**

This chapter discusses Senate Properties as a governmental service provider, taking into account its long history and the evolution of its operations. In the changing business environment, new approaches for performing even more robust and efficient investment analysis are always considered, and for this purpose, improvement needs of the current methodology are discussed.

#### **4.1.1 The evolution of government services in Finland**

In the history of the welfare society, the public sector has been seen as an almost irreplaceable actor in correcting welfare differences and inequalities in society. This view has, however, been questioned since the emergence of the New Public Management in the 1970's, which has drawn increasing interest towards redefining the boundaries between public and private sectors. Along with the wave of New Public Management, public sector has been adopting a more market-oriented approach for arranging welfare services. One consequence has been the increasing popularity of the concept of Public-Private Partnership (PPP). (Tynkkynen and Lehto, 2009)

Public-private partnerships (PPP, discussed in more detail in chapter 2.2.2) have been a worldwide trend in public infrastructure development and have also caused debate in Finland in the recent years. PPP projects change the traditional roles of the public and the private sectors, as the public sector becomes a client and the private sector becomes a service provider with a high responsibility. In Finland, PPP projects are established, for instance, in building schools, motorways or sport halls. (Tieva and Junnonen, 2009)

Senate Properties is a good example of the evolving trend of public services in Finland, as its history and tradition span over 200 years. Until 1995, the properties of the Finnish state were managed by the National Board of Public Building and its predecessors, after which the state's property was divided between 15 property units. The largest of the units, the State Real Property Agency, became a government enterprise in 1999, and in 2001 its name was changed to Senate Properties. (Senate Properties b)

The greatest reforms at the turn of the millennium have been the detachment of the construction and the maintenance costs from the state budget, and the rental agreement practice that covers the costs of premises and services. Furthermore, Senate Properties has been successful in developing life cycle thinking and energy efficiency of the construction, whereas renovation and maintenance of the protected buildings describe the company's level of corporate social responsibility and appreciation of its cultural and architectural heritage. (Senate Properties c)

These days, according to Vimpari et al. (2014), Senate Properties can be considered as a Corporate Real Estate (CRE) unit of the government of Finland. Therefore, its goal is to generate maximum additional value to the government tenants, whilst functioning as an independent business unit with economical goals. Consequently, two different perspectives of CRE management should be considered in order to measure the total success

of Senate Properties: the success of the corporation and the success of the CRE unit. To accomplish these goals, Senate Properties develops its properties to suit the needs of its governmental clients. As a result, various renovation investments have to be made into properties that have originally been designed to fit a specific tenant. (Vimpari et al. 2014)

#### **4.1.2 Improvement needs of the present investment analysis tool at Senate Properties**

Real estate investments are characterized by long life cycles, massive amounts of money, high uncertainty, and in the other hand lots of positive potential. Senate Properties is a model example of these characteristics, as its properties are often large social infrastructure investments with a long holding period. Consequently, profitability analysis can be challenging and time consuming: various kinds of input and pre-analysis are often needed, client information must be accounted for, and risk measures and post audit need to be considered. Thus more efficient ways of doing analysis are always under consideration in order to make the big picture more transparent and understandable.

The investment analysis spreadsheet used by Senate Properties, *SILK*, is a single scenario DCF-based model where the NPV and other metrics of the project can be estimated. In the case of a renovation investment, the NPV of the property with the investment can be compared to the property without the investment. The income calculations are based on rental agreements, and the level of the rent often rises according to the made renovations. After 15 years of cash flow calculations, the salvage value of the property is estimated, based on the net cash flow of an estimated average year.

The *SILK*-spreadsheet is currently under extensive renewal, as the real estate markets have changed and become generally less static over the years. The life-span of rental agreements has become shorter. In addition, the present write-off period of the buildings, 40 years, or 15 years for

technical features, appears to be too long, as the need for renovations and alterations is increasing. Consequently, the SILK-spreadsheet will face several structural changes in the near future. Furthermore, Senate Properties is currently building a tool that will gather information together from all the SILK-spreadsheets of the company. After the project finishes, it will be easier to examine the profitability of projects in different business areas or regions, or to perform analysis at the corporate level.

On the one hand, the investment analysis practice at Senate Properties is often focused on accounting-based calculations, as most comparisons of profitability are made to book value of the property. Consequently, it can be somewhat problematic to evaluate investments from the pure investor's perspective with the current method. On the other hand, it is sometimes not possible to use the fair value of the property due to the specific nature of government tenants. In the Defence and Securities business area, for instance, the book value is the only possibility, whereas for Ministries and Special Premises it highly depends on the situation. There are also various special properties that have a high market value but are not tradable. Thus they are considered to be investments where it is not appropriate to use the market value in the valuation. Nevertheless, the market value is used always when appropriate. Investment projects of Offices, for instance, are evaluated based on the fair value of the property.

It is essential to note that Senate Properties must be considered as a long-term state investor and a CRE-unit. Consequently, a pure investor perspective is impossible in the case of Senate Properties. For instance, no investments are made in properties that are to be sold, according to the investment and construction experts. The operations are based on governmental decision-making and affected by regional policy. Emphasis is more on the general interest of the state and not on individual projects – a project may be unprofitable but it can still lead to an increase in the state's general interest.

Another important observation about the SILK analysis is that the salvage value tends to be overvalued: it assumes that after a 15 year holding period the property is still in prime condition if the renovation has been made. There is, however, a possibility that there are no tenants available when the contract ends, if the property has been designed to fit the use of a single tenant. Thus the property may require heavy investments in order to transform it to fit new tenants, which may pay back only a minor price regarding the expenses. In this situation, Senate Properties should be able to prove with calculations that the investment is not likely to pay itself back in time or be profitable. Although Senate Properties may still have motives to make such investments in order to provide services to some government tenants, these decisions should be rationalized using relevant calculations and negotiated with the clients. Therefore, the continuity of the client relationship is a significant risk factor in the success of the project and it should not be omitted.

The SILK-spreadsheet already includes a risk analysis, in which such factors as buildings' technical properties, or client continuity, are evaluated. The problem is that this risk analysis is built in such way that its result is the average of the risk factors and tends to be around 2 %. This risk adjustment is added to the risk free interest rate of 5 %, and when the inflation of 2 % is taken into account, the resulting discount rate is usually close to the risk-free rate. Moreover, the risk analysis in SILK is made only once, at the beginning of the project. Consequently, possible changes in the risk level over the project life cycle are not taken into account.

One idea, suggested and supported by the experts at Senate Properties, is to build the risk assessment on properties' portfolio values. The property ratings, where six risk factors are evaluated, are reviewed every year and suitable portfolio values are given to properties. These client and property related risk factors should also be considered in the investment analysis of the projects, and it would be more consistent to use a corporation level rating system rather than individual risk analyses for each project. This

approach resembles the hedonic estimation model by Quigg (1993), discussed in chapter 3.3, where different characteristics of the building were used to determine the real option value of the property.

Notwithstanding, it is remarked that rating criteria may vary among different business areas and geographical areas of Senate Properties' operations. Another issue to consider is that the property ratings may sometimes be over-optimistic and respond to changes in the risk level with a lag; the portfolio value often changes only after the client has terminated the cooperation. Nevertheless, it is important to consider new methods in order to improve the risk assessment.

## **4.2 Data and methodology**

In this chapter, the data and the methodology used in the empirical analysis are presented. Firstly, the factors affecting the selection of the most appropriate methodology are discussed and different options are evaluated. After selecting the method, its mathematical foundations are shortly presented. Further, the selected investment projects are presented and the application process of the chosen method to a case study at Senate Properties is presented.

### **4.2.1 Selection of the method**

The main goal of this empirical analysis is to find ways to improve the risk and profitability assessment of the current investment analysis method at Senate Properties. The financial theory that most extensively takes into account the possible uncertainties in real business environment is, as discussed earlier, real option valuation. With real option valuation, the risk level and the positive potential of the future cash flows, not captured by traditional NPV analysis, can be evaluated and visualized.

There are various alternatives among real option valuation methods, but it is important to select the method that is the most suitable for the case of Senate Properties' investment analysis. The four main methods of real



option valuation are the differential equation solutions, the discrete event and decision models, the simulation based models, and the fuzzy-logic-based methods (discussed in chapter 2.1.2). As mentioned above, the three first models are based on probability theory, whereas the fourth is based on possibility theory.

In order to use a model that is based on probability theory, the data of the case study should follow the assumptions of complete markets and stochastic observations that follow a well-defined mathematical process, such as the gBm. In the case of Senate Properties, these strict assumptions do not apply. To begin with, the estimation does not happen in an institution-free world. In fact, the case environment is especially controlled by institutional agents compared to real estate markets in general. Further, the cash flows used in the analysis are not stochastic, being based on objective observations, but subjective and based on managers and experts opinions at Senate Properties.

Finally, the method for risk assessment should be as simple as possible. Performing profitability analysis on a large number of varying investments is difficult enough even without complex mathematical procedures. Thus the fuzzy pay-off method, representing fuzzy-logic-based methods, seems the best choice for the case analysis, as it does not require any simulation of the future cash flows or strict assumptions about the markets. Furthermore, the usability of the pay-off method is high and it offers a good fit, as it can be built on the already existing NPV analysis using only simple spreadsheet software. The pay-off method is a simple and understandable method that helps visualizing the risks involved in investments. (Collan 2012)

The pay-off method is a relatively new real option valuation method, firstly introduced in Collan, Fullér and Mezei (2009). It requires building a triangular pay-off distribution based on three cumulative cash flow NPV scenarios and treating it as a triangular fuzzy number. The three cash flow scenarios are formed by estimating the most likely, the minimum possible

and the maximum possible cash flows of the investment. Fuzzy numbers are part of fuzzy logic and fuzzy arithmetic, which is a mathematical system for treating imprecision in a precise way. Fuzzy logic has been used frequently in engineering applications, but also economic systems, such as asset valuation, are a natural application area for it. (Collan 2012)

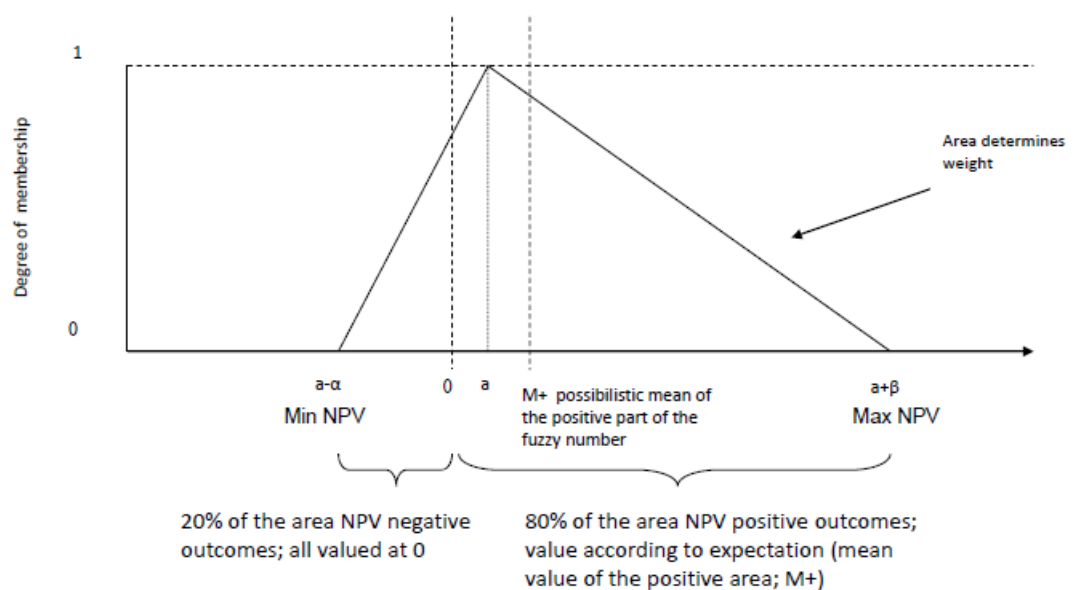
A triangular fuzzy number can be defined precisely by denoting the minimum, the maximum and the best-guess net present values of the distribution respectively as  $(a-\alpha)$ ,  $(a+\beta)$  and  $(a)$ . Further, the distance between the best guess and the maximum NPV can be denoted as  $(\beta)$  and the distance between the best guess and the minimum NPV as  $(\alpha)$ . As a result, the triangular pay-off distribution can be denoted as a triangular fuzzy number  $(a, \alpha, \beta)$ . The variables are summarized in Table 2. (Collan 2012)

**Table 2 Defining the triangular pay-off distribution as a triangular fuzzy number (Collan 2012)**

<b>Pay-off distribution</b>	<b>Fuzzy number</b>
Maximum scenario NPV	$a+\beta$
Best guess scenario NPV	$a$
Minimum scenario NPV	$a-\alpha$
Distance between best guess scenario NPV and maximum scenario NPV	$\beta$
Distance between best guess scenario NPV and minimum scenario NPV	$\alpha$

The letters (a), ( $\alpha$ ) and ( $\beta$ ) are symbols that represent numerical values that can be calculated from the pay-off distribution. The height of the pay-off distribution reflects the degree of membership of each value of the distribution in the set of possible values the NPV of the investment can get. (Collan, 2012)

The graphical presentation of a triangular fuzzy number is presented in Figure 6 (Collan, 2013).



**Figure 6 Graphical presentation of a triangular fuzzy number with definitions (Collan 2013)**

In Figure 6, the value (a), which represents the best guess NPV, is given full membership 1.0 in the set of expected values. The values outside the distribution have a 0.0 membership in the set of possible values as they are thought to be impossible. Choosing a triangular shape for the distribution gives a simplified representation of reality that is thought to have sufficiently correct results. A trapezoidal distribution, for instance, could be used in the analysis as well. (Collan, 2012) In Figure 6, ( $\alpha$ ) symbolizes the negative outcomes, all valued at 0, and ( $\beta$ ) the positive outcomes. The area of the outcomes determines the weight of the expected values, being 20 % for ( $\alpha$ ) and 80 % for ( $\beta$ ). ( $M_+$ ) represents the possibilistic mean of the positive part of the fuzzy number. (Collan, 2013)

After creating the pay-off distribution, the real option value (ROV) and other interesting descriptive numbers can be calculated for additional decision-support. First, the possibilistic mean of the positive side of the pay-off distribution,  $EA_+$  must be solved as follows (Collan, 2012):

$$EA_+ = \left\{ \begin{array}{l} (a - \alpha) > 0 \text{ then } EA_+ = a + \frac{\beta - \alpha}{6} \\ a > 0 > (a - \alpha) \text{ then } EA_+ = a + \frac{\beta - \alpha}{6} + \frac{\alpha - a^3}{6a^2} \\ \alpha + \beta > 0 > a \text{ then } EA_+ = \frac{\alpha + \beta^3}{6\beta^2} \\ \alpha + \beta < 0 \text{ then } EA_+ = 0 \end{array} \right\} \quad (7)$$

Further, the real option value of the investment can be calculated from the fuzzy NPV by calculating the probability weighted mean of the pay-off distribution, while mapping negative values to zero. The calculation is as follows (Collan, 2012):

$$ROV = \frac{\int_0^{\infty} A(x) dx}{\int_{-\infty}^{\infty} A(x) dx} \times EA_+ \quad (8)$$

where  $A$  stands for the fuzzy NPV distribution,  $EA_+$  denotes the fuzzy mean value of the positive side of the distribution,  $\int_{-\infty}^{\infty} A(x) dx$  computes the area below the whole fuzzy number  $A$ , and  $\int_0^{\infty} A(x) dx$  computes the area below the positive part of  $A$ . The definition is rather similar to the option value logic that uses probability theory, the main difference being the use of possibility theory instead of probability theory. A positive ROV indicates that it is profitable to invest. (Collan, 2012)

#### 4.2.2 Selection of the data

After choosing the pay-off method to be used for the empirical analysis, a representative sample must be picked from the investment project database of Senate Properties. Two different business areas, *Ministries and Special Premises* and *Offices* were chosen and 30 investment projects in total were selected. The projects represent different client groups of Senate Properties: *Ministries, Research institutes* and *Cultural*

*institutions* from the *Ministries and Special Premises* business area, and *Police administration* for the *Offices* business area. The main selection criteria for the investment projects included the age of the project (only projects that started in 2005 or later were selected) and the size of the project. Larger investments were favored; the original preference was to have only investments larger than 5 million euros, but due to the limited availability of data, the smallest selected investments are around 1.5 million euros. Majority of the selected projects are renovation investments, but also some new building projects were chosen. The selected projects, the investment amounts and the project periods are summarized in Appendix 1.

The client base of *Ministries and Special Premises* consists of ministries, research institutes and cultural institutions, mainly located in the Helsinki Metropolitan Area. The business area's property base is demanding, as most of the customers operate in premises classified as valuable buildings. The client base of the business area *Offices* includes various state administrative offices, such as the justice department, the police, tax administration, and employment centers. The properties are versatile: office buildings vary from 19<sup>th</sup> century properties to modern office premises, from vast office complexes of single or multiple users to smaller single offices. (Senate Properties a) The *Police administration* client group was selected to represent the *Offices* business area, as it has had several large investment projects in the recent years and it characterizes the dynamic nature of the office properties.

#### **4.2.3 Application of Pay off-method on selected Senate Properties' investments**

Since 2005, Senate Properties' real estate properties have been annually rated and divided into portfolios, ranging from A, with premium properties, to D, properties for sale. In the rating process, 6 different qualities are estimated. Regarding the riskiness of the property, experts at Senate Properties estimate the standard of services and utilities, the functional

capacity and adaptability, and the economic situation of the property. In order to determine the risk level of the client, the amount of the rental income, the location, and the client continuity are defined.

First of all, the standard of services and utilities describes how satisfied clients are with the quality of services and utilities, in what kind of condition they are, the quality of indoor climate conditions, the energy efficiency, and the need for renovation. Further, the functional capacity and adaptability illustrates how well the property supports the operations of the client, the level of the space efficiency of the property, and the ability to transform the property into use of some other clients. Moreover, the economic situation of the property expresses the level of the turnover and the profit of the renting.

The client continuity describes how long the remaining rental agreement is, how likely the client is to make a new agreement after the current one, and if the client is a strategic in-house client. Furthermore, the amount of the rental income, too, illustrates the level of annual turnover and the in-house status of the client. Finally, the location tells whether the property is situated in a national center of growth in a central location or in a declining region that does not serve the current need of the client.

Scores between 1 and 4 are given to each quality of each property, 1 standing for significant shortcomings or risk and 4 standing for excellent and stable situation. Figure 7 represents an example of property rating scores of different years for a ministry building. Until 2011, the client risk factors are not available for any data, and values for 2007 have not been stored in the property portfolio database. These missing values, however, can be averaged and estimated based on the other years' values or the risk analyses in the SILK-spreadsheets.

Project A8446	2005	2006	2007	2008	2009	2010	2011	2012	2013
Services and utilities	2	2	N/A	2	2	4	4	4	4
Functional capacity and adaptability	3	3	N/A	2	2	3	3	3	3
Economic situation	4	4	N/A	3	3	4	4	4	4
Client continuity	N/A	N/A	N/A	N/A	N/A	N/A	4	4	4
Amount of the rental income	N/A	N/A	N/A	N/A	N/A	N/A	4	4	4
Location	N/A	N/A	N/A	N/A	N/A	N/A	4	4	4

**Figure 7 An example of property rating scores of a ministry renovation project, the investment in 2008-2011**

It has been suggested at Senate Properties that portfolio values should be taken into account when performing SILK analyses, as the present risk analysis in SILK does not give very extensive picture of the client or property related risks. It is only a question of how the portfolio values should be treated in order to improve the risk assessment. Real option valuation, and the pay-off method in particular, are excellent tools for this task. The solution provided by the pay-off method requires three scenarios: maximum, minimum, and the best case scenario, and the calculation of the profitability distribution based on them. In order to turn the property rating scores into cash flow scenarios, a scorecard of some sort needs to be built.

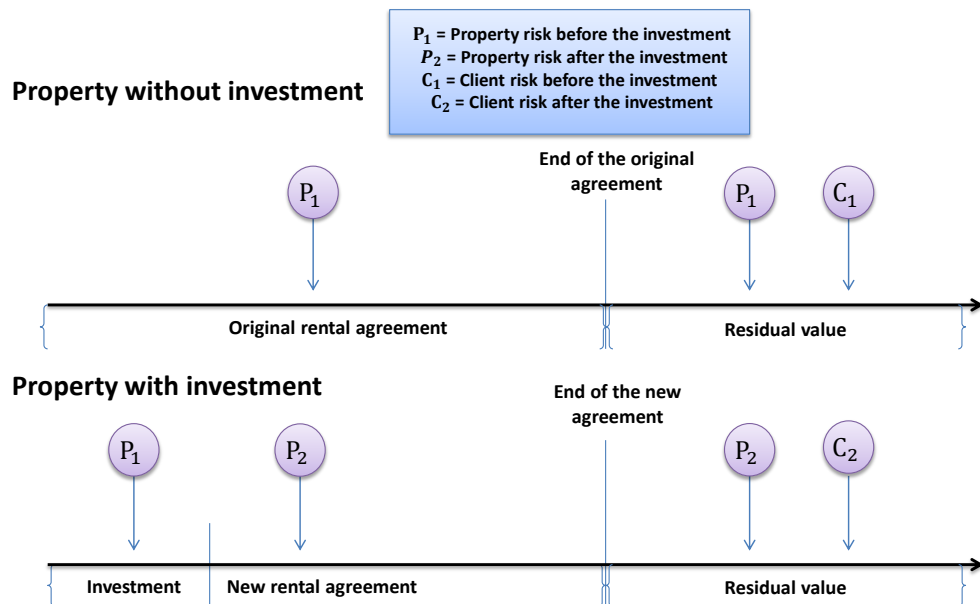
Firstly, it has to be defined, how the property and client related risks affect the project and its different phases. In the SILK-analysis, the NPV consist of annual income and cost estimates for 18 years, and a residual value based on an average year. The discount rate is formed by adding together the risk free rate 5 % and a risk factor that varies between 1 % and 3 % but is typically averaged to 2 %. This leads to a discount rate of approximately 7 %, which is neutralized by the inflation rate, 2%. The cash flows are assumed to continue into perpetuity in the future, growing at an assumed constant rate, 2 %. In the renovation SILK-model, there are spreadsheets for both the property without the investment and with the investment. Without the investment, incomes and costs are estimated based on an existing rental agreement that is to be replaced with a new agreement after the investment. With the investment, the investment costs and the new rental agreement with a possibly higher rent amount are

taken into account in the calculations. For new building projects, there is naturally only the spreadsheet for property with the investment.

It can be argued that during the rental agreement period, the client risk, which consists of the client continuity, the amount of the rental income, and the location, does not have a significant effect on the profitability of the project. This is because during the rental agreement, the client is obligated to stay and the amount of the rental income is fixed. The property risk, however, can have a slight effect on the project even during the rental agreement period, as the standard of the services and the utilities, as well as the functional capacity and adaptability, can affect the costs. If the property is in a poor condition, unexpected costs may occur, whereas if the condition is excellent, the costs may be slightly smaller than expected.

After the rental agreement has terminated, the estimated cash flows are highly uncertain and the level of the risk increases. Here, also the client risk has a significant effect on the project profitability – the client continuity and the location are important factors in defining, what kind of risks or opportunities may occur in the future. Figure 8 presents the effect of the property and the client risks on the lifecycle of a project.  $P$  symbolizes the property risk, which is a significant factor both during and after the rental agreement, and  $C$  the client risk, only significant after the termination of the agreement.





**Figure 8 Property and client risks on a project lifecycle**

In Figure 8, the difference between the two profitability analyses of the SILK-spreadsheet, the property without the investment and the property with the investment, are shown. With no investment, it can be simplified that the property and the client risks remain at the level of the moment before the investment,  $P_1$  or  $C_1$ . If the investment is implemented, the risk level may change due to the made improvements, which can be seen in the annual scores in the property rating. Thus after the investment, this new risk level,  $P_2$  or  $C_2$  will be taken into account. Nevertheless, it has to be stressed that this is a strong simplification of the reality, as the risk level does not necessarily remain the same without the investment, but can decrease or more probably increase over time.

After defining how the effects of the property and client risks fall on the project lifecycle, it has to be determined, how strong the effect of each individual factor should be. To answer this, experts at Senate Properties were asked to estimate the significance of different risks during and after the rental agreement. It was argued that neither the economic situation of

the property nor the amount of the rental income explicitly affect the risk level of the project, as these factors have been already taken into account in the best guess estimation of the cash flows. All the other factors were argued to have a significant effect on the risk level of a project, and it was pointed out that the uncertainty, especially the downside effect on the cash flows, should be remarkably higher after the termination of a rental agreement.

The client continuity was agreed to have the most significant downside effect, meaning that when the client continuity score would be 1 or 2, the minimum possible scenario would be very low. The functional capacity and the location were agreed to have also a moderate upside effect, meaning that when the score would be 3 or 4 for the both of these two factors, the maximum scenario would be rather high. Based on the discussion, the following scorecard, presented in Table 3 and Table 4, was formed:

**Table 3 Property rating weight factors on scenarios during the rental agreement**

During the rental agreement				
Score	Property risk			
	Services and utilities		Functional capacity	
	Max	Min	Max	Min
1	+1	-4	+1	-4
2	+2	-3	+2	-3
3	+3	-2	+3	-2
4	+4	-1	+4	-1

**Table 4 Property rating weight factors on scenarios after termination of the rental agreement**

**After termination of the rental agreement**

		<b>Property risk + client risk</b>							
<b>Score</b>	<b>Services and utilities</b>		<b>Functional capacity</b>		<b>Client continuity</b>		<b>Location</b>		
	Max	Min	Max	Min	Max	Min	Max	Min	
<b>1</b>	+1	-40	+1	-40	+1	-50	+1	-40	
<b>2</b>	+2	-30	+2	-30	+2	-40	+2	-30	
<b>3</b>	+3	-2	+5	-2	+3	-2	+5	-2	
<b>4</b>	+4	-1	+10	-1	+4	-1	+10	-1	

As Table 3 and Table 4 show, the difference in the downside given to scenarios is large between cash flows during and after the rental agreement. For other factors, the minimum scenario for score one gets -40 % and for the client continuity, the weight is -50 % after termination of the rental agreement. The idea is that in the minimum scenario, incoming rental cash flows decrease close to zero if the property scores have for instance two 1's or three 2's after termination of the agreement. In the case of three 1's, the minimum scenario would be already clearly negative. During the contract, the score 1 gives -4 % for all the factors. After termination of the agreement, also the upside is higher for functional capacity and location, meaning +10 % for score 4. However, these values can be easily changed so that different weights can be tested or different risk factors can be added to the analysis.

In the sample case project A8446 (presented earlier in Figure 7), the property is a protected building that was built more than a hundred years ago and last renovated in the 1970's. In 2008, when the investment decision was made, the services and the utilities of the building were out of date and at the end of their lifecycle. Consequently, the whole building was renovated between 2008-2011, including modernization of the office space and renewal of the HVAC systems. Additionally, some functional improvements, required by the client, were made to the security systems and the conference rooms.

The amount of the investment in the project A8446 is around 9 M€. According to the SILK-analysis, the NPV of the property with the investment, calculated in 2008, is 8 955 000 €, whereas it would be 12 405 000 € for the property without the investment. The difference is caused by the large investment cost, although after the investment the rent could be raised from 912 000 € to 1 352 000 €. According to this calculation, it would be an irrational decision to make the investment. The investment was, however, necessary to Senate Properties as the property is protected and serves an important government client. In addition, it must be noticed that the same discount rate was used in both calculations, the property with and without the investment, though it can be assumed that the risk would be smaller after the investment. This factor, if neglected, might have a significant impact on the calculation.

Using the pay-off method, it can be examined, what kind of an effect the investment has on the risk level of the project. If the risk is reduced after the investment, compared to the property without the investment, it can be measured how valuable the benefits of the investment are in relation to the costs.

In order to perform the pay-off analysis, firstly the missing values need to be estimated based on the previous and the following years. For instance, following values could be given for the property, marked in red in Figure 9:

Project A8446										Forecasting		
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 ...
Services and utilities	2	2	2	2	2	4	4	4	4	4	4	4
Functional capacity and adaptability	3	3	2	2	2	3	3	3	3	3	3	3
Economic situation	4	4	3	3	3	4	4	4	4	4	4	4
Client continuity	4	4	4	4	4	4	4	4	4	4	4	4
Amount of the rental income	4	4	4	4	4	4	4	4	4	4	4	4
Location	4	4	4	4	4	4	4	4	4	4	4	4

**Figure 9 Estimation of the missing property rating scores**

As Figure 9 shows, the missing values for the year 2007 can be estimated based on the following or the previous year. The location score can be assumed to be stable, so value the same value 4 that has been given for

years 2011-2013 can be given also to the earlier years. The problematic part is to estimate whether the client continuity has improved over time; here it is assumed to have remained the same, as the client is a long-term government client. The score of the amount of the rental income does not affect the analysis. However, as Senate Property has estimated property rating scores for all the six factors for the last few years, this estimation would not be necessary for new analyses, but is done here in order to perform a historical case study. Additionally, the future values can be forecasted or they can be assumed to stay at the level of the latest scoring available.

In the sample project 8446, the minimum and the maximum scenarios can be automatically generated in the scorecard spreadsheet. The weight factors formed are following, shown in Table 5:

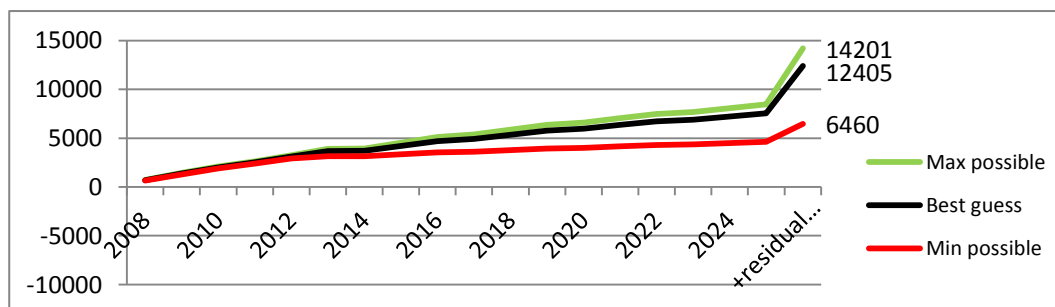
**Table 5 The property and client risk scorecard for the sample project 8446**

2007	Before the investment		After the investment		Current year
	Maximum	Minimum	Maximum	Minimum	2013
<b>During the rental agreement</b>					
Services and utilities	+2	-3	+4	-1	
Functional capacity and adaptability	+2	-3	+3	-2	
Economic situation	0	0	0	0	
<b>Property risk in total</b>	<b>+4</b>	<b>-6</b>	<b>+7</b>	<b>-3</b>	
<b>After the rental agreement</b>					
Services and utilities	+2	-30	+4	-1	
Functional capacity and adaptability	+2	-30	+5	-2	
Economic situation	0	0	0	0	
Client continuity	+4	-1	+4	-1	
Amount of the rental income	0	0	0	0	
Location	+10	-1	+10	-1	
<b>Property risk in total</b>	<b>+4</b>	<b>-60</b>	<b>+9</b>	<b>-3</b>	
<b>Client risk in total</b>	<b>+14</b>	<b>-2</b>	<b>+14</b>	<b>-2</b>	
<b>Property+Client risk in total</b>	<b>+18</b>	<b>-62</b>	<b>+23</b>	<b>-5</b>	

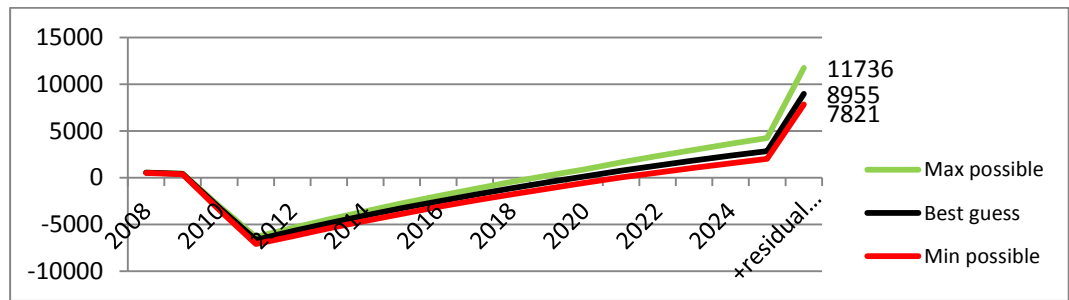
As Table 5 illustrates, the scorecard automatically looks up the property rating scores presented in Figure 9 for 2007 (before the investment) and 2013 (after the investment, the latest property rating available), and uses the weight factors of maximum and minimum scenarios presented in Table

3 and Table 4. As a result, it can be observed that the risk level decreases after the investment. Without the investment, the risk level of the project would be significantly higher after the rental agreement terminates (+18, -62), whereas with the investment the risk level is moderate (+23, -5). The biggest risk effect without the investment is caused by the property risk, as the quality of services and utilities as well as the functional capacity and adaptability is low. The client risk, however, is low and has also a moderate upside effect, because of the great location.

After the scenarios have been determined for different situations, the pay-off analysis can be performed for the maximum and the minimum scenarios based on the already existing best guess scenario cash flows in the SILK analysis. The scenarios are formed individually for the project without the investment and the project with the investment by multiplying the annual best guess estimate of the discounted net cash flows by the percentage rate generated in Table 5. It is checked, when the original and the new rental agreement would terminate, and the percentage is changed accordingly. The cumulative net cash flows are calculated, presented in Figure 10 and Figure 11:

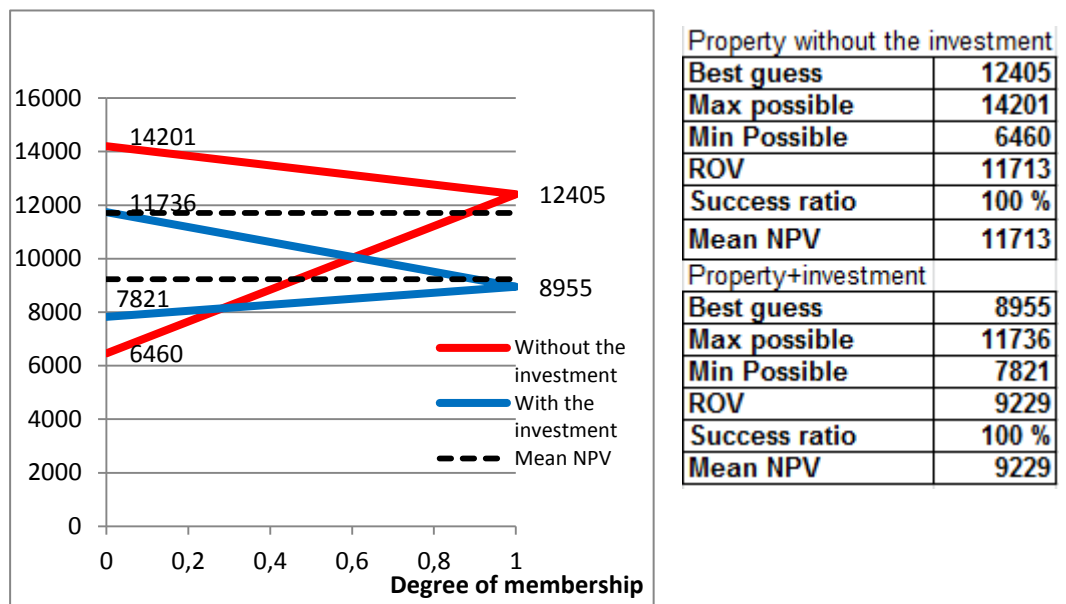


**Figure 10 Property without the investment, cumulative discounted net cash flows**



**Figure 11 Property with the investment, cumulative discounted net cash flows**

As Figure 10 and Figure 11 illustrate, the risk level is significantly higher, if the investment is not carried out. In Figure 11, the minimum scenario is higher than in Figure 10. Furthermore, the variance of the expected profits, or in other words the distance between cash flow scenarios, is smaller if the investment is carried out. From the cumulative NPV graph it can also be seen that with the investment, the project will break even around 2020, depending slightly on the scenario. Subsequently, the pay-off distribution can be formed for both cases based on the cash flow scenarios, presented in Figure 12:



**Figure 12 The pay-off distributions and key numbers of the property without the investment and with the investment**

Figure 12 visualizes the profitability distributions of the two options, the property with or without the investment. The distribution represents the overall profitability of the project, taking into account the historical property ratings and the present moment. It is obvious that although the best guess NPV is clearly higher for the property without the investment, the risk level can be efficiently reduced by implementing the investment. In the minimum possible scenario, the decision to invest would be even more profitable than the property without the investment.

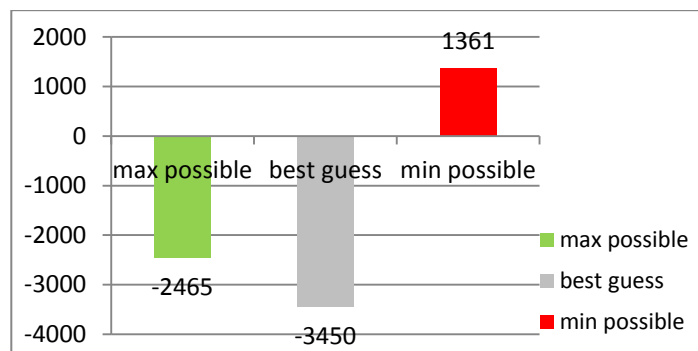
The reduction of the risk level is enabled by the improved level of the services and the utilities, as well as improved functional capacity and adaptability; it is far more likely to have clients and to earn rental income in the future, if the property is in a good condition. This fact is obvious for anyone making investment decisions, but cannot be numerically or graphically proved using the single cash flow scenario calculation that the SILK-analysis is based on. Hence, the pay-off method is in this case able to provide additional information to support the decision-making.

The key numbers presented in Figure 12 include the mean NPV, the ROV and the Success ratio, introduced in Collan (2012). The mean NPV, mathematically the possibilistic mean, can be calculated from the pay-off distribution. It is a single number measure that takes into account the shape of the pay-off distribution, including both the upside and the downside, not only the best guess scenario. The mean NPV can be compared to the best guess NPV to understand better the expectations related to the property. If the pay-off distribution is rather symmetrically distributed around the best guess NPV, the mean NPV and the best guess NPV are close to each other. If the distribution is not symmetrical, however, the mean NPV differs significantly from the best guess and can provide useful additional information. The success ratio signifies the ratio of expected positive outcomes over all expected outcomes and is calculated by comparing the area of the pay-off distribution over the positive outcomes to the total area. (Collan 2012)



Further, the real option value of the investment can be calculated from the fuzzy NPV by calculating the probability weighted mean of the pay-off distribution, while mapping negative values to zero, as presented in Formula 8. The success factor is calculated by dividing the area of the positive side of the distribution by the whole area of the distribution. In this case, the success factor is 100 % and the ROV is equal to the mean NPV, as the whole area of the pay-off distribution is above zero. If the ROV and the success factor are close to zero or negative, it is a sign of the property not having positive potential - if the price that can be obtained for the property on the markets supersedes the NPV, the sale of the property should be considered.

Figure 13 shows the difference between the pay-off distributions with or without the investment, showing the difference separately for each scenario.



**Figure 13 Difference between the pay-off distributions, property with investment – property without the investment**

Figure 13 visualizes the difference between the profitability of investing or not investing in different scenarios. The difference is the largest in the best guess scenario, where not performing the investment is 3.5 million euros more profitable than investing. In the maximum scenario, not investing is 2.5 million euros more profitable, whereas in the minimum scenario, investing is actually a more profitable option by 1.4 million euros. This result emphasizes how in this case, investing reduces the risk level.

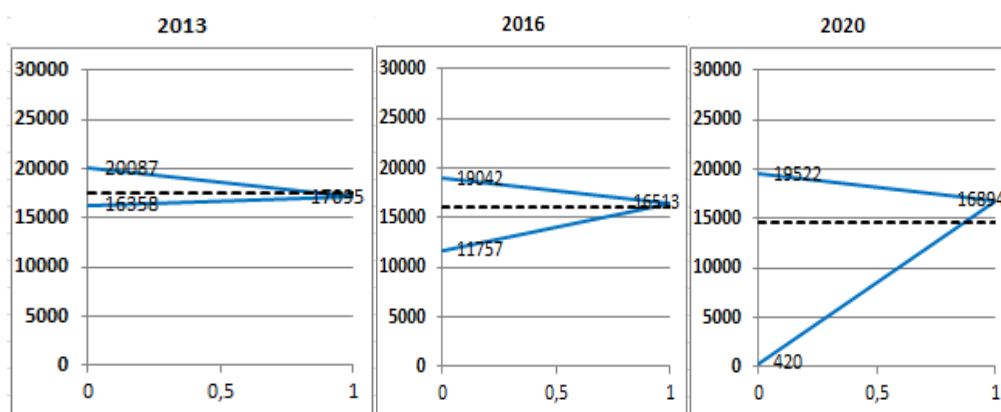
The former example examined the overall profitability of the project, taking into account the historical property ratings and the present moment. If one wants to discover how the profitability appears from this time forth, only considering the cash flows from the present moment to the future, it can be examined using the latest property rating and valuing all the previous cash flows to zero. The future property ratings could be estimated for instance as follows:

Project A8446	2013	2016	2020
Services and utilities	4	3	2
Functional capacity and adaptability	3	2	2
Economic situation	4	4	4
Client continuity	4	3	2
Amount of the rental income	4	3	3
Location	4	4	4

**Figure 14 Forecasted ratings of the sample project for 2016 and 2020**

In the example of Figure 14, the standard of the services and utilities, as well as the functional capacity and adaptability, is forecast to decline over time. In addition, the client continuity is expected to decrease as the termination of the rental agreement approaches, whereas the location is assumed to remain the same.

Figure 15 presents the pay-off distribution of the sample project in 2013, only the present and the future cash flows taken into account. Furthermore, Figure 15 presents the future pay-off distributions based on the forecasted property ratings shown in Figure 14. The future distributions can be easily examined, as the spreadsheet model was built in such way that the observable year with the forecasted property scores can be changed with a spin button and the cash flows of the preceding years will be automatically valued zero.



**Figure 15 The pay-off distribution of the sample project at the present moment and the forecasts for 2016 and 2020**

As Figure 15 shows, the expected decline in property ratings shows clearly in the profitability of the project in the minimum scenario, being approximately 16 M€ in 2013, 12 M€ in 2016 and close to zero in 2020. The minimum scenario in 2020 illustrates the possibility of not having any tenants in the property in the future. The maximum and the best guess scenarios, however, stay rather stable, as the cash flows are expected to continue to perpetuity at a constant growth rate.

The spreadsheet model for the pay-off analysis has been built in such way that it can be easily copied to any existing SILK-analysis, and only minor modifications need to be made. In this case analysis, the same pay-off analysis is repeated for 30 selected investment projects, and the main findings of the analysis are presented and discussed in the following chapter.

### 4.3 Results

In this chapter, the main findings of the pay-off analysis performed on the selected investment cases are presented and furthermore, the applicability of the method to Senate Properties is evaluated. Based on this discussion, some propositions for further operations at Senate Properties are suggested.

### 4.3.1 Main findings of the Pay off – analysis

The pay-off analysis was performed on the 30 selected investment projects, as presented in the previous chapter. In this chapter, the main findings of the analysis are summarized and discussed separately for different client groups and for renovation investments and new building investments. Finally, the findings are analyzed for all the investments together.

Firstly, the client group *Ministries* has 10 case projects, all of which are renovation projects. Summary of the pay-off analysis for the *Ministries* projects is presented in Table 6. It can be noticed that all the best guess net present values of the projects are clearly positive when the investment is carried out; the NPV is around 11 million euros on average. Without the investment, the success ratio is 100 % for 9 of the 10 projects and 99% for one project. With the investment, the success ratio is also 100 % for 9 projects and drops to 86 % for project A7423, as its minimum possible scenario is beneath zero.

Table 6 Results of the pay-off analysis: Ministries

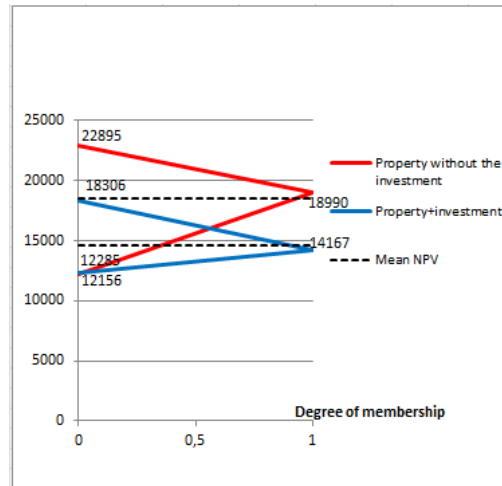
Project	A4224	A7423	A8446	A8447	A8488	A9415	A9744	A9747	A11246	A13007	Average
<b>Best guess NPV</b>	8 984	7 328	8 955	1 621	1 926	9 793	14 167	16 668	12 081	28 674	<b>11 019,68</b>
<b>Success ratio</b>											
property without the investment	100 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	<b>99,93 %</b>
property+investment	100 %	86 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	<b>98,56 %</b>
<b>(Mean NPV-best guess NPV) difference</b>											
property without the investment	-6 %	-15 %	-6 %	-3 %	-3 %	-1 %	-3 %	3 %	-3 %	-3 %	<b>-3,93 %</b>
property+investment	3 %	-24 %	3 %	5 %	7 %	6 %	3 %	2 %	2 %	4 %	<b>1,03 %</b>
<b>Difference between profit distributions</b>											
Max	22 %	37 %	-17 %	-18 %	-36 %	-17 %	-20 %	-22 %	-36 %	18 %	<b>-8,92 %</b>
Best guess	8 %	27 %	-28 %	-34 %	-55 %	-29 %	-25 %	-21 %	-40 %	9 %	<b>-18,81 %</b>
Min	83 %	-810 %	21 %	-13 %	-50 %	-6 %	1 %	-22 %	-20 %	56 %	<b>-76,05 %</b>
Mean NPV	18 %	14 %	-21 %	-29 %	-50 %	-24 %	-21 %	-21 %	-37 %	16 %	<b>-15,54 %</b>
<b>Post project calculation</b>											
Realized NPV	9 186	7 732	8 846	2 911	3 493	16 512					<b>8 113,49</b>
difference to Mean NPV	0 %	38 %	-4 %	71 %	70 %	59 %					<b>39,06 %</b>
difference to best guess NPV	2 %	6 %	-1 %	80 %	81 %	69 %					<b>39,36 %</b>
Expected investment cost	8 096	3 010	9 100	4 000	7 200	14 600					<b>7 667,67</b>
Realized investment cost	7 050	2 709	9 100	3 322	5 869	13 000					<b>6 841,67</b>
Realized/expected	87 %	90 %	100 %	83 %	82 %	89 %					<b>88,45 %</b>

As Table 6 shows, for the property without the investment, the mean NPV is on average 4 % smaller than the best guess NPV, which implies that there are pessimistic expectations related to the future profitability not captured by the best guess scenario. For the property with the investment, the mean NPV is on average 1 % greater than the best guess NPV, which, in turn, indicates optimistic expectations not included in the best guess scenario. When the profitability distributions are compared between the property without the investment and with the investment, it can be observed that on average, the option of not carrying out the investment is more profitable in all scenarios. In the maximum possible scenario, the NPV of the property with the investment is around 9 % smaller than without the investment, whereas for the best guess and the minimum possible scenarios the differences are 19 % and 76 %, respectively. The difference between the mean NPV's is on average 15.5 %. This implies that although the properties of the client group *Ministries* are profitable in general, they seem to be more profitable without the investments. Nevertheless, in 3 projects out of 10, the mean NPV of the property with the investment is clearly greater than without the investment, as Table 6 presents.

Project A9744 is an interesting example of how investing in the services and utilities of a property can decrease the risk level. It was decided that the property would be renovated in 2011-2014 in order to improve the space and energy efficiency of the client. The decision was made, although the profitability of the investment seemed rather low; the NPV of the property with the investment was estimated to be around 22 % lower than the property without the investment. This was rationalized by the importance of the government client and the client's need for reduction of the number of the office spaces.

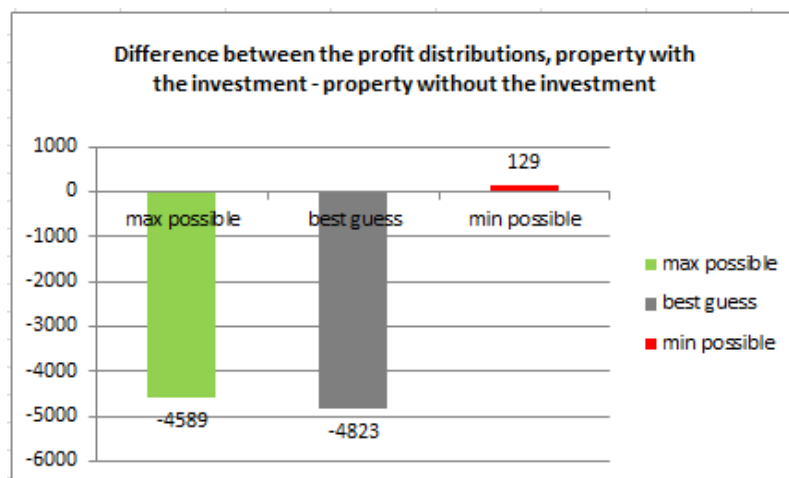
As the investment has been in progress, the property ratings have already improved: the level of the services and the utilities has increased from 2 to 3. It can also be estimated that the client continuity has slightly improved

as a result of the investment, from 3 in 2010 to 4 in 2013. Hence, the risk level has significantly decreased, which can be seen in the narrowed distribution, as Figure 16 presents:



**Figure 16** The profit distributions of the project A9744

As Figure 16 illustrates, the property without the investment seems to have more potential in the best guess and the maximum possible scenarios. In the minimum possible scenario, however, the property with the investment has even slightly higher NPV than it would have without the investment. The actual differences between the options in different scenarios are demonstrated in Figure 17.



**Figure 17** Project A9744, the actual difference between the property with the investment or without it in different scenarios

As mentioned earlier, and exemplified in Figure 16 and Figure 17, the investment may not improve the positive potential of a property, but it might still reduce the downside of the future outcomes and hedge against the risks. If the investment seems unprofitable based on single scenario NPV calculations, but still feels necessary to make, the potential benefits can sometimes be more easily illustrated using real option analysis.

The accuracy of the estimated values can be examined by comparing the post-project NPV calculations to the mean NPV and the best guess NPV values of the projects. The post-project calculations are available for 6 out of the 10 ministry projects, and they show that in 4 cases out of 6, the mean NPV value is closer to the realized NPV value than the best guess NPV is. The difference is partly due to the optimistic expectations related to the investment that were not shown in the best guess NPV but actually realized: the actual investment costs were only 88 % of the expected, on average. This result indicates that for the case of the *Ministries* client group, the pay-off analysis seems to produce more accurate results than the single scenario analysis.

Table 7 presents the findings of the pay-off analysis for the *Cultural Institutions* client group. There are 6 projects representing the client group, 4 of which are renovation projects. All the best guess net present values of the projects are positive when the investment is carried out, except for the project A9546. Without the investment, the success ratio is 100 % for 3 out of the 4 renovation projects and 23% for project A9546. With the investment, the success ratio is 100 % for 4 projects, 0 % for project A9546 and 93 % for the new building project A10546.

As Table 7 illustrates, for the property without the investment, the mean NPV is on average 1 % greater than the best guess NPV, if the abnormal NPV of the project A9546 is not taken into account. This implies that there are slight optimistic expectations related to the future profitability. For the property with the investment, the mean NPV is around 10 % greater than



the best guess NPV, which indicates clear optimistic expectations not included in the best guess estimates.

When the profitability distributions of the renovation investments are compared between the property without the investment and with the investment, it can be remarked that in 2 cases out of 4, the property without the investment is more profitable than the property with the investment in all three scenarios. For the project A8991, the property without the investment is more profitable in the minimum and the best guess scenarios, but less profitable in the maximum scenario.

Table 7 Results of the pay-off analysis: Cultural Institutions

<b>Project</b>	<b>A8399</b>	<b>A8991</b>	<b>(A9546)</b>	<b>A12101</b>	<b>A8227</b>	<b>A10546</b>	<b>Average</b>
<b>Best guess NPV</b>	3 681	165 561	- 9 788	40 505	3 930	265	<b>42 788</b>
<b>Success ratio</b>							
property without the investment	100 %	100 %	23 %	100 %			<b>100 %</b>
property+investment	100 %	100 %	0 %	100 %	100 %	93 %	<b>99 %</b>
<b>(Mean NPV-best guess NPV) difference</b>							
property without the investment	-1 %	2 %	-191 %	2 %			<b>1 %</b>
property+investment	12 %	3 %	-17 %	2 %	8 %	23 %	<b>10 %</b>
<b>Difference between profit distributions</b>							
Max	159 %	1 %	-1489 %	-12 %			<b>49 %</b>
Best guess	6 %	-2 %	-4145 %	-14 %			<b>-3 %</b>
Min	-76 %	-1 %	-652 %	-15 %			<b>-31 %</b>
Mean NPV	20 %	-1 %	-5098 %	-14 %			<b>2 %</b>
<b>Post project calculation</b>							
Realized NPV					2 897	398	<b>1 648</b>
difference to Mean NPV					-32 %	22 %	<b>-5 %</b>
difference to best guess NPV					-26 %	50 %	<b>12 %</b>
Expected investment cost					9 400	5 000	<b>7 200</b>
Realized investment cost					9 400	5 000	<b>7 200</b>
Realized/expected					100 %	100 %	<b>100 %</b>

In the case of A8399, the difference between the property with the investment and without it is exceptionally large. This is because it has been estimated in the original SILK-analysis that the property will be sold if no investment is made, as the property and its utilities are at the end of their lifecycle. Thus, in the case of the property without the investment, the cash flows are worth zero from 2010 on, when the property would be sold. The best guess NPV without the investment is around 3.5 million, the minimum and the maximum scenarios being close to its value. In the case of the property with the investment, the best guess NPV is around 3.7 million but the minimum and maximum possible scenarios differ significantly from it. The minimum possible NPV is around 0.76 million euros and the maximum possible NPV is around 9.2 million euros, as shown in Figure 18:

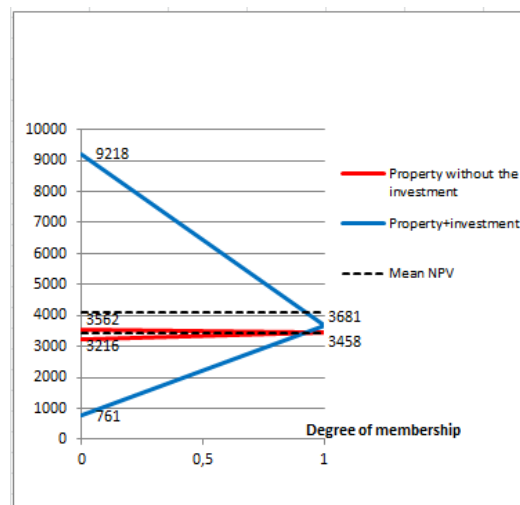
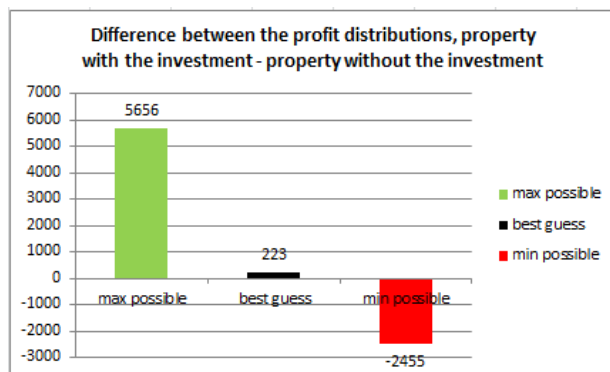


Figure 18 The profit distributions of the project A8399

As Figure 18 presents, the property without the investment has rather certain profit, which is lower than the profit of the property with the investment in the best case scenario and especially in the maximum possible scenario. In the minimum possible scenario, however, it would be clearly more profitable not to invest. Figure 19 presents the actual differences between the property with or without the investment in different scenarios.



**Figure 19 Project A8399, the actual difference between the property with the investment or without it in different scenarios**

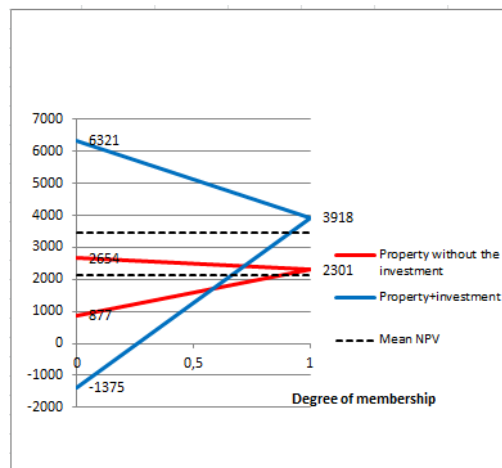
In the minimum possible scenario, the decision to invest would seem unprofitable. Nevertheless, the mean NPV of the project, 4.1 million euros, is still higher than the best guess NPV, and the success ratio is 100 %. Thus, investing seems a rational decision in this case.

For the *Cultural Institutions* case projects, two post-project calculations were available. For the project A8227, the post-project calculation shows that the realized NPV is 32 % smaller than the mean NPV and 26 % smaller than the best guess NPV. For the project A10546, the realized NPV is 22 % greater than the mean NPV and 50 % greater than the best guess NPV. Therefore, the pay-off analysis managed to provide more accurate estimates than the single scenario analysis in one case out of two. In both cases, the realized investment costs were equal to the expected ones. Table 8 presents the results of the pay-off analysis for the *Research Institutes* client group, which has 4 case projects, 2 of which are new building projects.

Table 8 Results of the pay-off analysis: Research institutes

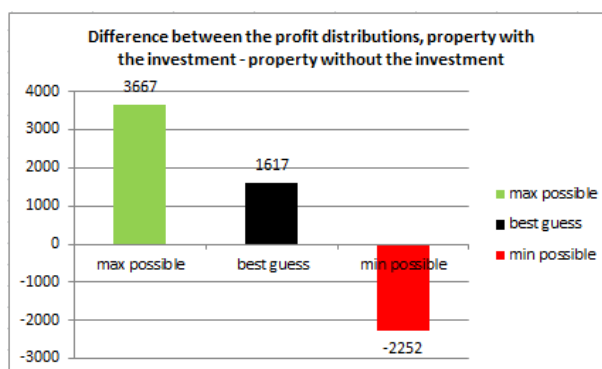
<b>Project</b>	<b>A5430</b>	<b>A5526</b>	<b>A9056</b>	<b>A9812</b>	<b>Average</b>
<b>Best guess NPV</b>	3 918	- 680	8 984	1 935	3 540
<b>Success ratio</b>					
property without the investment	100 %	100 %			100 %
property+investment	95 %	52 %	100 %	100 %	87 %
<b>(Mean NPV-best guess NPV) difference</b>					
property without the investment	-8 %	9 %			1 %
property+investment	-12 %	65 %	2 %	46 %	25 %
<b>Difference between profit distributions</b>					
Max	138 %	275 %			207 %
Best guess	70 %	-243 %			-86 %
Min	-257 %	-690 %			-474 %
Mean NPV	62 %	-145 %			-42 %
<b>Post project calculation</b>					
Realized NPV	1 617	-1 493			62
difference to Mean NPV	-53 %	-531 %			-292 %
difference to best guess NPV	-59 %	-120 %			-89 %
Expected investment cost	5 980	11 500			8 740
Realized investment cost	6 680	10 900			8 790
Realized/expected	112 %	95 %			103 %

The case project A5430 has a clearly positive best guess NPV of 3.9 million euros and a success ratio of 95 % if the investment is carried out. The mean NPV for the property without the investment is 8 % smaller than the best guess NPV, and 12 % smaller for the property with the investment. This is a clear indication of risk related to the property, especially if the investment is carried out. As Figure 20 and Figure 21 show, the property with the investment is more profitable than the property without it in the maximum possible and the best guess scenarios, but clearly less profitable in the minimum possible scenario:



**Figure 20 The profit distributions of the project A5430**

As can be observed from Figure 20, the property without the investment has a rather certain profit, whereas the risk margin of the investment is wide. Figure 21 shows the actual profit differences between the property with or without the investment in different scenarios, showing that in the minimum possible scenario, the loss of the investment would be around -2.3 million euros.



**Figure 21 Project A5430, the actual difference between the property with the investment or without it in different scenarios**

According to the post-project calculation, the realized NPV was 1.6 million euros, around 59 % smaller than the best guess NPV. Compared to the mean NPV, the realized NPV is 53 % smaller. This result indicates that in this case, the pay-off analysis was able to capture the risk of the property and provided more accurate results than the single scenario analysis. The realized investment costs were 12 % greater than the expected investment costs.

In the other renovation investment of the *Research Institutes* client group, A5526, the pay-off analysis did not have the same accuracy. The best guess NPV of the project was -0.68 million euros and the success ratio of the property with the investment 52 %. The mean NPV of the property with the investment, however, was 65 % greater than the best guess NPV, which indicates that the project would have a high positive potential. The post-project calculation reveals that the realized NPV is -1.5 million euros, even 531 % smaller than the mean NPV and 120 % smaller than the best guess NPV. The realized investment costs, however, were only 95 % of the expected ones, and thus the realized NPV, lower than expected, was due to other factors that were not captured by the property ratings and the pay-off method.

The results of the pay-off analysis for the *Police Administration* client group are presented in Table 9. It can be noticed that 9 out of 10 investment projects have positive best guess NPV's.

Table 9 Results of the pay-off analysis: Police Administration

Project	A7024	A7870	A10350	A10600	A11187	A12979	A4587	A9512	A9541	A11099	Average
<b>Best guess NPV</b>	36 004	10 547	7 783	24 081	7 101	1 894	4 498	1 740	-8 768	8 984	9 387
<b>Success ratio</b>											
property without the investment	100 %	100 %	100 %	100 %	100 %	0 %					83 %
property+investment	100 %	100 %	100 %	100 %	100 %	100 %	63 %	69 %	0 %	100 %	83 %
<b>(Mean NPV-best guess NPV) difference</b>											
property without the investment	-12 %	-7 %	-9 %	-2 %	-5 %	-28 %					-10 %
property+investment	4 %	2 %	-6 %	-2 %	-3 %	23 %	-30 %	-10 %	1 %	-9 %	-3 %
<b>Difference between profit distributions</b>											
Max	54 %	33 %	20 %	3 %	140 %	792 %					174 %
Best guess	36 %	22 %	24 %	2 %	144 %	251 %					80 %
Min	1344 %	139 %	130 %	1 %	209 %	108 %					322 %
Mean NPV	61 %	34 %	28 %	2 %	148 %	245 %					86 %
<b>Post project calculation</b>											
Realized NPV	58 610		7 868		8 392		5 260		-7 995		14 427
difference to Mean NPV	57 %		7 %		22 %		68 %		8 %		32 %
difference to best guess NPV	63 %		1 %		18 %		17 %		9 %		22 %
Expected investment cost	-35 016		1 650		3 340		27 450		39 000		7 285
Realized investment cost	-22 544		1 650		3 200		28 600		37 500		9 681
Realized/expected	64 %		100 %		96 %		104 %		96 %		92 %



As Table 9 illustrates, for 5 out of 6 renovation investments, the success ratio is 100 %, both with and without the investment. For the project A12979, the success ratio is 0 % without the investment and 100 % with it. For new building projects, the success ratios are 63 %, 69 %, 0 % and 100 %. The mean NPV of the property without the investment is smaller than best guess NPV for each project, which implies negative expectations regarding the properties' cash flows. For the properties with the investments, 6 out of 10 projects have a mean NPV smaller than the best guess NPV.

What is an interesting finding is that in the *Police Administration* client group, the profitability of the property with the investment is greater than the property without the investment in each case and each scenario. This indicates that in this client group, the investments are clearly profitable, even with the property and client risks taken into account. On average, the properties are 187 % more profitable with the investment than without it in the maximum scenario, 94 % in the best guess scenario, and even 484 % in the minimum scenario. This shows that the benefit of investing is the most significant in the worst possible case. Therefore investing seems to reduce the risk level of the properties in the *Police Administration* client group. According to the 5 post calculations available, however, the mean NPV was more accurate than the best guess NPV in 2 cases.

When the results of the pay-off analysis for the renovation projects and the new building projects are compared, it can be noticed that the best guess NPV of the renovation projects is clearly greater than of the new building projects: on average, the NPV is 20.6 million euros for the renovation projects and 2.7 million euros for new building projects. For the renovation projects, on average, the success ratio is 95 % without the investment and 97 % with the investment. For the new building projects, the success ratio is 78 % on average. For all the projects, the average success ratio with the investment is 92 %.

When the risk expectations of the renovation projects are examined, it can be observed that without the investment, the mean NPV is around 4.6 % smaller than the best guess NPV. With the investment, however, it is 4.6 % greater on average. For the new building projects, the mean NPV is on average 3.8 % greater than the best guess NPV, which implies that in general, the expectations for the investments are positive. Furthermore, on average, a property with the investment is more profitable than the property without it in all scenarios, the maximum scenario having the largest difference. The mean NPV of the project with the investment is on average 18 % greater than without the investment.

According to the post profit calculations, the mean NPV was more accurate than the best guess NPV in 6 out of 11 renovation investments and in 2 out of 4 new building investments. The result indicates that the pay-off method might be slightly more reliable when applied to Senate Properties' renovation projects than to the new building projects, although the sample size is not large enough for generalizing the results. All in all, the pay-off analysis was more accurate than the single cash flow analysis in 8 out of 15 investments.

Several studies, such as Quigg (1993), have compared the obtained real option value of an asset to its intrinsic value and market value. Thus, the latest market values of the selected properties, year 2013 (KTI, 2014), were listed and compared to the profitability distribution of the cash flows of the projects from 2013 to the future, as shown in Table 10. The future pay-off distribution can be compared to the current market price of the property in order to find out whether the property should be kept or sold. If the market price is greater than the future pay-off distribution, it is possible to gain greater profit by selling the property rather than keeping it.

Table 10 The future pay-off distributions compared to the market values of the properties

Future pay-off distributions, 2013										
Ministries	A4224	A7423	A8446	A8447	A8488	A9415	A9744	A9747	A11246	A13007
Max	22 699	13 767	23 882	7 104	11 190	32 122	19 286	20 398	15 390	35 103
Best guess	19 351	11 868	20 483	6 118	9 618	27 488	14 629	16 668	12 022	28 674
Min	18 521	-119	19 623	5 749	9 034	26 695	12 559	15 045	10 357	17 423
Market value 2013	15 489	16 209	16 411	51 300	51 300	26 812	24 085	23 970	51 300	29 807
Police Administration	A7024	A7870	A10350	A10600	A11187	A4587	A9541			
Max	118 317	16 447	10 954	29 988	11 650	47 307	26 178			
Best guess	97 761	14 189	9 682	25 900	10 135	39 754	23 558			
Min	94 532	13 324	5 370	19 020	7 089	26 238	16 579			
Market value 2013	15 489	11 545	9 542	16 965	9 750	32 571	22 673			

As Table 10 shows, the market values were found for the 10 properties of the *Ministries* client group and for 6 properties of the *Police administration* client group, as 4 of the new building projects are still in progress. For *Cultural institutions* and *Research centers* the market values are not evaluated in the annual KTI real estate index. (KTI, 2014) When the market values are compared to the future pay-off distributions in the *Ministries* client group, shown in Table 10, it can be observed that for 6 properties the market price is above the pay-off distribution. In one case the market value is between the minimum and the best guess scenarios and in one case between the maximum and the best case scenarios. This indicates that in majority of the cases of the *Ministries* client group, greater profit could be gained by selling the properties than by keeping them and carrying out the renovation investments. However, it must be noticed that the ministries are often valuable and protected buildings that cannot be truly treated as tradable assets.

In the *Police administration* client group, the market value was not above the future pay-off distribution in any of the 6 cases projects, as Table 10 illustrates. In 4 cases, however, the market value was between the best guess and the minimum scenarios, which suggests that in the worst case, the investment would not pay-off in the future and greater profits could be gained by selling the property. However, the profitability of the *Police administration* properties seems stable when compared to the market values.

#### **4.3.2 Applicability of the method**

The main objective of the pay-off method is to enable the user to calculate and visualize all the potential outcomes of the project. In order to complement the most likely cash flow scenario, the user is able to add the risks and the positive potential of the project in the estimation and thus make better-informed and more transparent investment decisions. The pay-off method is meant to be practical, understandable and simple to use.

When applied to industry, however, theoretical methods cause often various practical challenges. In the empirical case study, the pay-off method was applied to 30 investment projects of Senate Properties in order to test the applicability of the method in the public real estate environment. It was soon discovered that although the pay-off method is designed to be user-oriented and simple, the task of adapting the method to a large investment base is complicated and time-consuming.

The very first problem was that ideally the pay-off method requires forming manually at least three cash flow scenarios, based on expert opinions regarding the future incomes and costs. This does not seem feasible in the case of Senate Properties, as it would be too time-consuming for the large investment project base. As experts and management at Senate Properties had interest in using already existing property ratings in the risk assessment of the projects, it was decided to use them in forming the minimum and the maximum possible scenarios, although it meant partly compromising the original idea of the pay-off method.

When combining the pay-off method and the property ratings in the case study, several simplifications of the reality had to be made. Therefore, there are a great number of sources of error and uncertainty in the developed model, the net impact of which is difficult to estimate. To start with, it is likely that the impact of the risk factors is easily exaggerated, as they may already be intuitively included in the best guess estimate, if the person performing the original calculation is aware of the risks regarding the property and the client. Moreover, due to the limited availability of the data, property ratings were estimated for several years based on the preceding and following years and the risk analyses of the SILK calculations. This may have caused biases in the estimation of the cases.

Further, one of the most significant simplifications made was the assumption that if no investment is carried out, the property ratings will stay at the level of the year before the investment. It is clear that in reality, the property ratings would have changed but it can be argued that

estimating the change would add even more uncertainty to the model. Therefore, the comparison is actually between the property with the investment and the initial situation without it. Additionally, sometimes the last property rating before the investment period could not be used to describe the property without the investment, as it had already improved due to the anticipated investment. Generally, it must be noticed that there is no explicit, right way to use the property ratings in the pay-off analysis. Therefore, it has to be considered separately for each situation and many alterations need to be made.

Nevertheless, there are several aspects that support the application of the pay-off method in public real estate and in Senate Properties in particular. It has been discovered that it efficiently provides additional support for decision-making, making the analysis more understandable and transparent. The best guess estimate of the original SILK-analysis can only take into account a single scenario and thus it is not able to demonstrate the possible upside and the downside of the project.

Based on the empirical analysis of the case projects, the pay-off method seemed to provide more accurate results than the original single scenario model in slightly more than half of the cases. Even though the results were not always similar to the post-project calculations, the analysis still provides a useful tool for visualizing the risk level of the project and taking client and property related risks into account. It would make sense to utilize the already existing property ratings, and as a result, the risk analysis could be made more extensive and coherent. The pay-off method is one solution for combining all the information and turning it into smart analytics and graphs and most importantly, it can be performed without purchasing complicated or expensive additional software.

There are, however, also several drawbacks in the application of the pay-off method in Senate Properties at a broader level. One of the biggest disadvantages is the uncertainty of the estimation based on the property ratings, as they may be somewhat subjective and the information may not

always be timely. In the empirical analysis of the study, most of the case projects were started some years ago. For these projects, it is possible to see how the ratings have improved after the investment and to estimate how the profitability differs between the property with or without the investment, taking into account the history, the present moment, and the future. For new projects, however, performing the analysis may not be as easy, as it requires forecasting of the future property ratings. This makes the analysis more uncertain and adds potential biases. Nevertheless, the main purpose of the pay-off analysis is not to forecast the accurate future cash flows, but rather to be able to visualize the different possible future outcomes and make better-informed decisions.

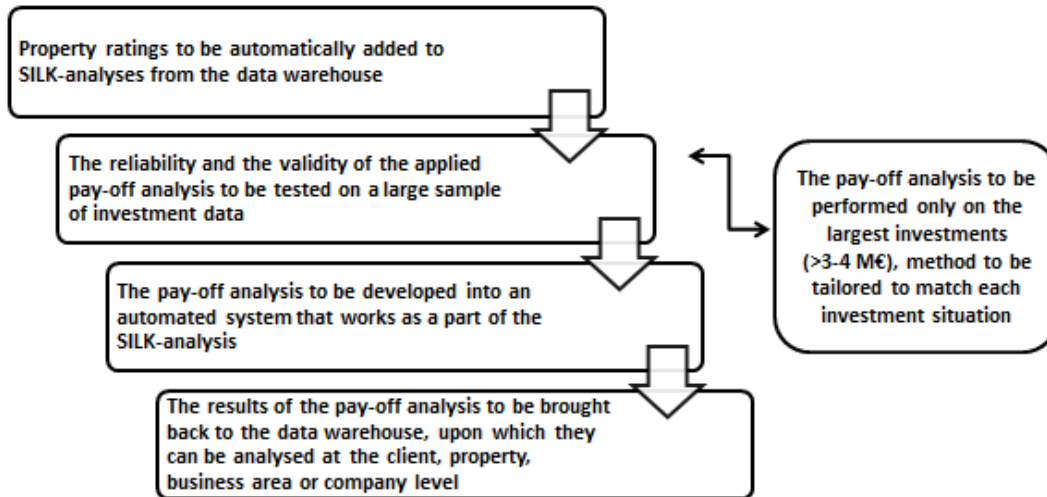
As mentioned earlier, there are also various practical issues that need to be considered before applying the pay-off method to a larger dataset. In order to perform the pay-off analysis on the whole investment project database, the model needs to be developed further into an automated system where the data would be added directly from the data warehouse, and that would create the pay-off analysis results with as little manual input as possible. Moreover, the validity and the reliability of the applied model should be tested on a large set of data and needed corrections, especially on the weights of the property rating variables, should be made.

This analysis has provided an initial idea for using the property ratings in the investment analysis and taking into account the effect of the property and the client risks on a project. Although the model itself is not flawless or ready to be used for a large investment base, it has raised some important issues that should be considered, and shown that pay-off analysis as a supplementing method to the original SILK-analysis can be valuable.

#### **4.3.3 Propositions for the future operations**

If Senate Properties has interest in using the pay-off method as a tool in the future investment analyses, there are mainly two alternative ways to proceed. The first alternative, as presented in Figure 22, is to start a

project where the pay-off analysis is turned into an automated system and performed on all the investment projects of Senate Properties.



**Figure 22 Propositions for future operations at Senate Properties**

Firstly, as Figure 22 presents, the property ratings need to be automatically brought to the data warehouse and from there to SILK-analyses. Further, the reliability and the validity of the applied pay-off analysis should be tested on a large set of data and possible improvements should be made to the variables, their weight factors, impact of the rental agreement periods, and many other factors. Moreover, the property rating data should be available for all the years and the factors, and it should be ensured that the ratings are consistent for all the properties in different client groups and business areas and truly reflect the risk level.

Further, the pay-off analysis spreadsheets that were developed during the empirical analyses could be easily added to the SILK-model. It requires no changes to the original SILK-model as the new spreadsheets are built on top of the existing information. However, all the manual input required should be minimized and it should be made easy to control, when the original replaced rental agreement and the new agreement are set to end and when the investment period starts and ends.



After this phase, as Figure 22 demonstrates, the results of the pay-off analyses could be brought to the data warehouse, where the results can be summarized and analysed at the client, property, business area, or company level. Alternatively, if this project is estimated to be too costly or time-consuming, the pay-off analysis could be used only with the largest and the most important investments. For instance, it could be added to the SILK-analysis only when the investment amount is greater than 3 or 4 million euros, as the annual number of investments of this size is feasible for the analysis. Consequently, the method could be tailored to fit each investment case more realistically and it would provide a complementing in-depth analysis when needed, in order to support strategic decision-making.

## **5 SUMMARY, CONCLUSIONS AND FUTURE RESEARCH**

This thesis has shed light upon different approaches to real option valuation in the context of the real estate industry. It has also conducted a case study to examine the topic in a practical setting. In this chapter, the key matters of this study are briefly summarized and conclusions are presented. Furthermore, the limitations of the study are discussed and some suggestions for future research based on the study are proposed.

### **5.1 Summary and conclusions**

The main objective of this study was to examine whether the risk and profitability evaluation of public real estate investments can be improved by using real option methodology. The motivation for the study arose from the fact that practitioners and managers are reluctant to adopt real option valuation to support their decision-making, despite research demonstrating that it can provide strategic flexibility and transparency.

The volatile and uncertain real estate industry has proven to be a suitable area for real option applications. Public real estate projects in particular are often criticized for inefficiency and subjective decision-making, and applications of real option valuation in the field, while limited so far, have shown promising results. Furthermore, the new fuzzy-logic-based real option methodology is based on possibility theory, not probability theory and thus it does not require stochastic cash flows. The fuzzy pay-off method promises to make the application simple and practical, providing transparent, intuitive and reliable results.

Hence, the empirical part of the thesis consists of a case study of 30 investment projects of a Finnish government-owned real estate enterprise, Senate Properties. The study aimed to determine whether the presently used investment analysis system of Senate Properties could be complemented by the pay-off method and if it would make the risk and profitability analysis more robust. In order to apply the pay-off method in the case environment, various modifications and simplifications of the

reality had to be made. The minimum and the maximum possible cash flow scenarios were built on top of the best guess scenario obtained from the present analysis system, using the existing property ratings of the company. This enabled the investment analysis to take into account the annual risk level of the equivalent property and client.

Based on the scenarios, the pay-off distributions were presented for the property both with and without the investment. Subsequently, descriptive numbers, such as success ratio and mean NPV, were calculated. The results were analyzed separately for the four different client groups and for renovation projects and new building projects. The results show that on average, when comparing the mean NPV to the best guess NPV, the risk level of the property decreased after the investment, although in some cases the property could be more profitable without the investment. The accuracy of the pay-off analysis was evaluated by comparing its results to the post-project calculations. In 7 out of the 12 available post-project calculations, the mean NPV of the pay-off analysis was closer to the realized NPV than the original best guess NPV was. Although the results of the pay-off analysis were not always precise, it still added value to the original analysis system by extending the risk assessment and presenting the profitability in a more visual, intuitive manner.

Even though the pay-off method is among the simplest and most practical real option valuation methods, many challenges were met when applying it to a real estate industry case. If one wishes to make it part of the operational investment analysis for the large investment base of Senate Properties, much work is needed in order to turn it into an automated and reliable system. Another possibility is to use it as a tailored solution for the largest and most important investment decisions. Notwithstanding, the risk analysis system should be upgraded and the pay-off method is a good solution to be considered.

## **5.2 Limitations and suggestions for future research**

Since the research is a case study, the results are very case-dependent and limited to highly specific situations. Consequently, they cannot be generalized to a broader set of applications. The greatest weaknesses of the study are the limited availability and imperfect nature of the data. As the data consists of real world investment projects, the size and the characteristics of the projects, properties and clients vary, as well as the availability of the property ratings for different years.

Furthermore, the model built in the case analysis is a rough simplification of reality and thus the results are subjective. Due to the small sample size of the case projects, the results cannot be truly generalized even at the case company level. Therefore, there are two main alternatives for future research based on this initial experiment: either with a more quantitative focus, seeking statistically significant results, or with a more qualitative focus, seeking in-depth case results.

In the quantitative focus, the pay-off analysis would be performed in a reliable and consistent manner on hundreds or thousands of investment projects in different companies. Future research could possibly find differences between public and private real estate investment projects or differences between different geographical areas or time periods.

In the qualitative focus, the research could concentrate on a single, notable investment project and gather more in-depth information from interviews with experts from different phases of the project, such as planning, construction, or accounting. Hence, the analysis and forecasts could be more realistic and accurate, based on intuitive expert knowledge.

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## Appendix 1 Summary of the investment projects

<b>Business area</b>	<b>Client group</b>	<b>Project number</b>	<b>Investment period</b>	<b>Estimated amount (1000€)</b>	
<b>Ministries and Special Premises</b>	<b>Ministries</b>	A9744	2011-2014	17 100	
		A11246	2013-2016	15 300	
		A9747	2013-2016	14 000	
		A9415	2010-2012	12 600	
		A8446	2008-2011	9 100	
		A4224	2007-2009	7 100	
		A8488	2009-2012	6 300	
		A8447	2009-2011	3 200	
		A13007	2014	3 000	
		A7423	2007-2008	2 706	
		<b>Research institutes</b>	A9056	2013-2017	32 900
			A9812	2011-2014	15 000
			A5526	2009-2011	10 850
	A5430	2006-2009	6 400		

<b>Business area</b>	<b>Client group</b>	<b>Project number</b>	<b>Investment period</b>	<b>Estimated amount (1000€)</b>
	<b>Cultural institutions</b>	A8399	2008-2012	26 600
		A8227	2008-2012	12 900
		A9546	2011-2012	10 600
		A8991	2012-2016	8 100
		A12101	2013-2015	5 500
		A10546	2010-2011	5 000
<b>Offices</b>	<b>Police administration</b>	A11099	2014-2017	31 000
		A9541	2009-2015	37 500
		A9512	2013-2016	14 000
		A7024	2006-2011	24 100
		A4587	2005-2007	27 500
		A11187	2012-2013	3 000
		A12979	2014-2017	23 000
		A10350	2011	1 500
		A10600	2011-2013	1 700
		A7870	2011-2014	1 200