EXPLOITING REAL OPTIONS AND MONTE CARLO SIMULATION IN CAPITAL INVESTMENT ANALYSIS

An Illustrative Case Study in Real Estate

Lappeenranta–Lahti University of Technology LUT

Master's thesis in Strategic Finance and Business Analytics

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Examiner(s): Professor Mikael Collan

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ABSTRACT

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Keywords: Real estate investment, discounted cash flow analysis, DCF, real options, fuzzy pay-off method, Monte Carlo simulation

This Master’s Thesis examines the applicability of real option analysis (ROA) and Monte Carlo simulation (MCS) in capital budgeting for valuing different strategies within investment and evaluating their probabilities. The aim is to find out how real option analysis and simulation can be used in connection with cash flow analysis as easily as possible, and what kind of benefits these methods can bring in relation to investment decision-making.

The literature review conducted in this thesis shows that ROA is not generally applied to real estate investments, mostly due that real options are generally perceived as complicated by the management. As the main contribution an illustrative case of a real estate investment is elaborated using fuzzy pay-off method and MCS where two alternative strategies of implementation exist. A three-part analysis of the case is constructed consisting of: i) cash flow analysis based on three different scenarios with sensitivity analysis, ii) ROA based on the net present values (NPVs) of the scenarios, and iii) simulation of the NPVs of the investment and their probabilities based on the sensitivity analysis and the ranges of the scenarios. Both strategies were analysed through these steps demonstrating how ROA and MCS can be used to evaluate complex investment with multiple uncertainties without the application of extensive mathematics.

The results of the illustrative real estate case example show that ROA and MCS can be useful to bring additional depth in an investment profitability analysis. The limitations of the study are in the uniform probability distribution of MCS, which does not allow weighting of different alternatives. The application of different probability distributions requires further research and more sophisticated software tools.

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Tämä pro gradu -tutkielma tarkastelee reaalioptioanalyysin (ROA) ja Monte Carlo -simulaation (MCS) soveltuvuutta pääomabudjetointiin eri etenemisvaihtoehtojen (toteutusstrategioiden) arvostamiseksi ja eri toteutusstrategioiden todennäköisyyksien arvioimiseksi. Tavoitteena on selvittää kuinka reaalioptioanalyysiä ja simulaatiota voidaan hyödyntää kassavirta-analyysin yhteydessä mahdollisimman helposti, sekä mitä hyötyä näistä menetelmistä voi olla sijoituksen päätöksenteon kannalta.

Työn kirjallisuuskatsaus osoittaa, että reaalioptioanalyysiä ei yleisesti sovelleta kiinteistösijoituksiin, johtuen lähinnä siitä, että yritysjohto usein kokee reaalioptiot turhan monimutkaisiksi. Pääasiallisena kontribuutiona on havainnollistava tapaustutkimus kiinteistösijoituksesta, jossa käytetään fuzzy pay-off metodia ja MCS:a, sisältäen kaksi vaihtoehtoista toteutusstrategiaa. Tapauksesta muodostetaan kolmiosainen analyysi, joka koostuu: i) kolmeen eri skenaarioon perustuvasta kassavirta-analyysistä sisältäen herkkyysanalyysin, ii) skenaarioiden nettonykyarvoihin (NPV) perustuvasta ROA:sta ja iii) sijoituksen nettonykyarvojen ja niiden todennäköisyyksien simuloinnista herkkyysanalyysin ja skenaarioiden vaihteluvälien perusteella. Kumpikin strategia analysoitiin näillä vaiheilla osoittaen, kuinka reaalioptioanalyysiä ja Monte Carlo -simulaatiota voidaan käyttää monimutkaisten, useita epävarmuustekijöitä sisältävien investointien arvioimiseen ilman laaja-alaisen matematiikan soveltamista.

Havainnollistavan kiinteistötapausesimerkin tulokset osoittavat, että ROA ja MCS voivat olla hyödyllisiä tuomaan lisää syvyyttä sijoitusten kannattavuusanalyysiin. Tutkimuksen rajoitteet ovat MCS:n yhdenmukaiseen todennäköisyyteen perustuvassa tasajakaumassa, mikä ei mahdollista eri vaihtoehtojen painottamista. Erilaisten todennäköisyysjakaumien soveltaminen vaatii lisätutkimusta ja kehittyneempiä ohjelmistotyökaluja.

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New year is coming, and it means that something old will end and something new will start. My journey at LUT has now come to an end, at least with this chapter.

In Nurmijärvi, 29th December 2022

Sinikka Niskanen

ABBREVIATIONS

ABV	[Investment’s] abandonment value
AOV	Adjusted option value
ANN	Artificial neural networks
BOP	Binomial option price
CAPM	Capital asset pricing model
DCF	Discounted cash flow
DM	Datar-Mathews
eNPV	Extended NPV
ERP	Enterprise resource planning
FPOM	Fuzzy pay-off method
GDV	Gross development value
IRR	Internal rate of return
MCS	Monte Carlo simulation
NOI	Net operating income
NPV	Net present value
PV	Present value
R&D	Research and development
ROA	Real option analysis
ROI	Return on investment
ROV	Real options value
VPGRM	Value per gross rent multiplier
WACC	Weighted average cost of capital

Table of contents

Appendices

List of Figures

List of Tables

1. INTRODUCTION

Capital investments are made long-term and the importance of them for companies is indubitable. These decisions are crucial for company managers. Often, they involve high level of uncertainty, especially when dealing with tens of years in the future. Yet, companies tend to use rigid analysis methods to model the future uncertainty that is dependent on numerous opportunities, turning points, shocks, and changes, especially in modern society where things happen very fast and new innovations emerge constantly. In this thesis, some of the most common investment analysis methods are briefly presented as a theoretical background along with the real option approach, and their application is more examined in literature review. In addition, simulation is included in the review to be later applied in the case study together with real options. After this, an illustrative capital investment case study from existing literature is conducted with a joint approach that utilizes possibilistic real option analysis combined with probability-based simulation as an additional tool to traditional investment analysis approach. The thesis aims to find out the state-of-the-art real option approach and examine if this approach, combined with simulation of the probabilities of outcomes, is useful in context of managerial flexibility and how easily the methods are to be applied. There is a specific focus of the practicality side of the methods and the main point is to test how straightforwardly this combined method could support managers' investment decision-making without tipping into the trap of too creating complicated model.

Academic research has for long suggested more flexible approaches in investment analysis to be utilized by companies. Researchers have recognized real options to be useful approach to model managerial flexibility especially in capital investment analyses although companies have been not willing to extensively apply them in practise. Thus, there seems to have been, and still being, a gap between academic research and real-life application in utilizing real options within capital investments analysis in several areas of business. Mostly, the reason seems to be that real options are experienced too complex to implement into practise, even when managers realize their potential. There are numbers of case studies where successful application of real options are demonstrated bringing concrete monetary benefits and the academic side seem to be highly confident about the benefits real options can bring to economy. Evidence of such is supported by numerous research papers and literature that are reviewed in Section 3 of this thesis.

Eventually, real options may not be complicated after all. Also, companies may be already using real option thinking, even when they do not even realize that, and some industries have adapted them into use already. There are ways to make real options simpler and several researchers have put efforts to make it possible. This thesis will utilize these findings and conduct an empirical case study to see how they can affect on capital investment analysis and how they could be creating value for decision-making process, combined with benefits that simulation can offer. Available real option valuation methods are examined, of which one is selected to be applied in the case study to model the possibilities the investment case can offer. Finally, a simulation tools is created and added to the case analysis to model the uncertainty of the case in a way it could offer a deeper insight into the uncertainty of the future.

1.1. Background

The practical profitability analysis in companies usually seems to differ from academic one as it is done with existing money, under high time pressure and people are accountable for their analyses – mistakes can cost millions. Academic analysis strives for research, often deals with highly complex mathematical models and is constantly developing new, more sophisticated methods that can sometimes be very theoretical, although some part of the research pursues to fill this gap between these two extremities.

Traditional discounted cash flow (DCF) analysis is widely used in companies (see for example Ochoa, 2004). It tells managers to invest on a project if the net present value (NPV) of its future cash flows is positive when discounted at a "correct" rate that reflects the required returns. In case NPV is negative, DCF tells not to invest. Simple, straightforward, and easy.

But when, with some uncertainty, there is a possibility for cash flows being far higher than forecasted, the forecasting turns out to be much harder: to capture a solid monetary value of such an option in an investment project, especially when the NPV has been very close to zero. If there are multiple options to proceed, how to put a price for each of them to see which one is the most lucrative one and why? Dealing with uncertainty in longer projects, as the world is constantly changing after the decision of investment has been made, is not that simple anymore. Managers are facing constant pressure to decide what route to take when there are numerous possibilities to proceed in investments along with changes during the journey. Appropriate decisions are important for the reason that managers should, and will, always pursue for the most lucrative business opportunities to exercise their most important duty, maximizing the company's and its owners' value. In some cases, if they are not, eventually it can even destroy the whole business strategy as the rivals run ahead. Managers must choose wisely and target their efforts in projects with solid business case.

Real options are one way to implement managerial flexibility in projects. Thus, they potentially provide excellent additional tool for investment analysis for valuing the uncertainty. How to utilize them in practise, is far more difficult. Several global studies point this out, such as Lander and Pinches (1998), Putten and MacMillan (2004), Block (2007), and Baker, Dutta and Saadi (2010). Some previous studies, such as Driouchi & Benett (2012), have found that further research is needed on the values of real options with practical tools considering the strategic, behavioural, and operational facets, as the use of real options is still relatively limited due to the low level of awareness and the complexity of them. For example, in real estate, several global research conclude that the application of real options in real estate projects is still at the beginning, and the challenge is moving them into practical applications in valuing investments (see e.g., Lucius, 2001; Triantis, 2005). Mao and Wu (2011) found that the common evaluation methods of real estate investment tend to fail in analysing the influence of the risk factors of a project and the real options method would be better tool for this.

Scientific research is an important part in increasing and expanding knowledge and competence. To be able to transfer them into business environment, it must be taken into account the views of the representatives of the organizations, of which the most important is the observation of complexity being the main reason why real options have not been yet utilized more. For this, the thesis intents to further apply the important findings of researchers that have examined and discussed these theories and concepts behind real options in previous studies. The aim of the study is to examine how easily the real option valuation can be brought into traditional investment analysis process and how applicable the real option analysis (ROA) method is. In addition to this, the intention of this study is to bring the risk side of the investment possibilities more visible by examining how easily the possible outcomes can be simulated and what benefits that would bring to the analysis in terms of managerial decision-making. The focus is on the practicability of the methods in ROA and simulation.

1.2. Motivation

The author's continuous interest towards financial modelling, business development and especially the practical application of different methods to see how they can be utilized motivated to examine the topic further. There seems to be some degree of consensus in academic research that the benefits offered by real options have unfortunately not yet been adopted much into use in companies, especially in context of capital investment analyses.

Collan (2011a) stated that it would be good for real option valuators to put more emphasis on the understandable presentation of results as the process of real option valuation itself contains information about real options and is likely to be of interest to the decision-makers who are often shut out of that information. Collan (2011a) also pointed out that presenting real option valuation results "as if they were coming from a black box" is not only a poor way to use the obtained results but it can also cause managers to reject the method, because managers often want to understand where these figures come from. This is supported by Kodukula and Papudesu (2006, preface) claiming there is a strong need for a focus on the real-world application of real options tools because several practitioners are taking a "black box" approach to real options solutions, and this causes management resistance due to thetheoretical complexity where transparency is missing. While, for example, Čirjevskis and Tatevosjans (2015) tested Black & Scholes and binomial trees methods in real option valuation, Collan & Savolainen (2020) have tested fuzzy pay-off method and a system dynamic simulation approach with a numerical example case study and suggested further research about investigating whether these models are usable also in practice.

Mintah & Baako (2019) also pointed out the practitioners' scepticism about the value of embedded flexibility in real estate properties because legislation requires independent valuers to do valuation for investment properties. Vimpari and Junnila (2016) argued that DCF analysis do not incorporate enough information on physical asset characteristics leading to loss of competitiveness.

These notifications point out a good reason to conduct this study. Testing how real options could be taken to practise may help organizations to adapt more easily these methods in business environment, hence help managerial decision-making in today's fast-pacing, constantly evolving surroundings where digitalization and artificial intelligence are bringing new innovations faster than ever. This changing organizational environment may represent an unrealized potential for companies to utilize and combined with rapid innovations there might be a growing demand for being able to have more flexibility in investment decisions, and thus having more flexible valuation tools. Borison (2005, 257) mentioned real option analysis (ROA) to be most sophisticated method for valuing managerial flexibility in theoretical point of view. Finding a way to adapt the real option methods easily might be a different story. That being said, real options may be powerful assistance if they can be found simple enough for companies to adapt. In this thesis, a case study is established for the testing purposes in which most suitable real option analysis is applied along with simulation of the investment outcomes. A real estate investment example is used in the case study, as real estate investments are of particular interest to the author.

There are also previous theses (Tuhkanen, 2004; Lyytikäinen, 2006; Penttinen, 2021) about the subject from which an interesting perception can be observed. These theses mainly find that the use of real options seems to increase the value of investment projects, but real options are not likely to be used in companies in the near future. For example, Tuhkanen (2004) found in Finland that the logic of real options does not replace established evaluation tools with new ones with complex mathematical equations but incorporating the real option value into the project evaluation invariably increases the total value of the project. Then, Lyytikäinen (2006) concluded that Finnish listed companies have been considered option-based investment evaluation commissioning but do not apply real option thinking due to having found the method too difficult. Back then, Lyytikäinen (2006) stated that the application of real option thinking in the future seems unlikely, as the companies do not see real option thinking as a significant benefit for them. Then, 15 years later Penttinen (2021) found that the use of real option method in Finnish companies is still not likely in the next few years, as companies are satisfied with the current methods, such as DCF, because they are simple and easy, even though companies realize their limitations. According to Penttinen's (2021) thesis the complexity of the real option method in real-life investments, difficulty in understanding the parameters, lack of understanding of the theory and its implications among users, and the difficulty in valuing real options are the key reasons why real options are not used in the organizations that were interviewed. Based on these theses it seems like there is a gap to fill between academic study and companies to utilize these inventions. The same is reflected from literature in Section 3 where several research paper demonstrate same type of findings from large, global companies. Therefore, this thesis is not trying to eliminate DCF method but rather flavour it with additional tools in such a way it could be easily adapted into companies with regards to capital investment analysis. In other words, the model must remain as simple as possible.

Another important part of this study is the risk side, the uncertainty about the future, that is always related in investment cases. For this purpose, this thesis also explores the application of risk modelling with simulation using Monte Carlo simulation method. Simulating possible outcomes of the future is one way to approach this side. Monte Carlo simulation, originally invented by John von Neumann and Stanislaw Ulam to improve decision making under uncertain conditions, is a method is widely used in many areas, for example in context of risk analysis (IBM, 2020).

The higher the possible gain, the higher the risk when it comes to investment projects. Managing those risks in business is essential. Real options can bring flexibility to projects, which can also be seen as a method to manage risks in projects – instead of taking one shot one may be able to execute multiple options depending on the changing situation. Added with simulation within predefined range of effective variables, allowing managers to see the possible outcomes and probabilities of the results of a decision, managers may experience it easier to make those decisions on investment projects.

1.3. Research objectives and questions

The objective of this thesis is to contribute to filling the gap between business and academic side in use of real options, added with Monte Carlo simulation. This thesis aims to examine whether there may be a more value-adding, yet easily adaptable investment analysis combination that managers could use in capital investment activities in real estate field compared to the traditional discounted cash flow (DCF) analysis. In more specific, the goal is to investigate whether adding real option valuation into traditional net present value (NPV) method combined with the use of Monte Carlo simulation bring concrete benefits in capital investment analysis, and how easily these could be adapted in managerial decision-making process. The thesis seeks to answer the following questions:

1) According to the literature, what are the state-of-the-art real option methods that are both easy to use and coherent in terms of managerial flexibility?

2) How to apply the state-of-the-art real options methods with Monte Carlo simulation into an illustrative real estate investment case and what would be the main benefits compared to traditional discounted cash flow method?

The thesis introduces real options as an additional tool to DCF valuation combined with Monte Carlo simulation to be able to simulate various predefined sources of uncertainty that effect on the value of the investments. These sources, variables, that have the most crucial impact in investment case, are usually recognizable via DCF method, in which usually a sensitive analysis is also performed. These variables can have different ranges that help creating multiple scenarios easily. This way, the method would be able to model the risk (uncertainty) regarding the investment case based on probability estimation.

The main point of this thesis is to examine and test the utilization of real options and Monte Carlo simulation via illustrative case study that utilizes quantitative data to gain a comprehensive insight into the topic and relies on a capital investment case in real estate field. The intention of this study is to choose suitable option valuation method to be applied in a practical real option valuation case. The thesis is eliminating especially those methods that may be more difficult to understand and thus might be difficult to base decisions on. In business environment there may be very limited time to try and learn complicated, highly sophisticated models in everyday life. Managers need to clearly understand on what the valuation is based on and how it works, in a fast-paced environment. This could be interpreted, for example, from Penttinen's (2021) thesis in which real estate managers in Finland were interviewed about the use of real options.

Managers are constantly required to make decisions in highly uncertain environment. Modelling uncertainty in such ways it serves the business goals and eases managerial decision-making in ever changing situations can help enabling managerial flexibility, which refers to the ability to make decisions based on current or anticipated market conditions rather than preconceived notions. To do this, one needs the solid idea behind the theory and the tools to make it work. Here lies the common thread of this study all along.

1.4. Limitations of the research

This study considers only two types of real options: the option to postpone an investment decision (wait until the uncertainty has resolved), and the option to expand business at a later stage. These both are considered as call options. The option to close down, abandon or sell a business or its assets (put options) are not considered in this thesis due to the usually negligible exercise prices. Also, there are several methods in valuating real options, but this study focuses only on one selected real option valuation method that is found most easy to use which serves the goals of this thesis. The chosen valuation method for the case study will be the fuzzy pay-off method that is presented in more specific in Section 2.5.1.

With regards to Monte Carlo simulation method, it must be noticed that generally Monte Carlo simulation may be used on many occasions, for example also in valuating real options, but in this study Monte Carlo simulation method is used only in context of modelling risks related to the investment case example, nothing more.

The investment valuation process includes DCF calculation, sensitivity analysis and determination of NPV. The sensitivity analysis brings the most sensitive factors, risk factors, of the investment case visible that are then used in Monte Carlo simulation to model the distributions of NPVs based on these risk factors affecting the investment case ‘s outcome.

1.5. Structure of the research

This thesis introduces theory and background of real options and some of the real option valuation methods in general in Section 2. Then the thesis focuses on going through a fuzzy pay-off method in more detail, which is perhaps one of the most user-friendly real option valuation methods and therefore chosen here to be applied. Also, capital budgeting method is introduced briefly by which the value of a potential investment project can be determined, and in which the widely used NPV is determined. Finally, Monte Carlo simulation method is introduced in context of risk analysis.

In literature review in Section 3 the thesis summarizes and discusses earlier findings about commonly existing investment analysis methods in real estate field and how real options are currently used. In empiric part (Section 4) of the thesis an illustrative case study is prepared in which the fuzzy pay-off method and Monte Carlo simulation method are applied and tested as additional tools to capital budgeting process with regards to real estate investment. The findings are discussed in results part (Section 5) of the thesis. Specifically, the feasibility of the model and process in business environment is analysed and judged. Conclusion and further discussion are presented in Section 6 of this study.

2. THEORETICAL BACKGROUND

This chapter briefly presents the key concepts within capital investments, specifically real estate and property investments, and the valuation methods, or the ideas behind each concept. It's worth mentioning, that there are numerous different methodologies and approaches in defining the value of investment projects, but only the most relevant ones considering this study are presented here. In addition, there are several different meanings for term "property" depending on the continental, or even country, and without going into more detail, for clarity reasons in this thesis the term "property" refers to any commercial income producing land (including ownership and usage rights) and building such as shops, industrials, offices, and hotels, and also the residential property.

2.1. Capital investments

Capital investments are highly important for not only for companies, but for the whole economy in short and long period. Increase in capital investments by companies raises the current level of gross domestic product (GDP) and requires manpower, which reduces unemployment. These investments will generate revenues for the businesses in the long term, raising tax income and increasing the economy's overall productive capacity, allowing economic growth in short- and long-term. This enables an increase in income, which improves the general standard of living.

For companies, capital investments refer to the acquisition of physical assets, such as machinery, plants for manufacture, and real estate, in order to generate more earnings, increase operational capacity or gain larger market share. These expenditures are used to fund a company's long-term growth. Also, capital investment in the form of a share in another company's supplementary can also be used for the same purposes. The money to finance these investments may come from several sources, such as cash, loans, venture capital deals or issuing stocks, depending on size of the investment project.

According to Fuchs, Hatami, Huizenga and Schmitz (2022), the world will see a unique wave of capital spending on physical assets in projects to decarbonize and renew critical infrastructure between this very moment and 2027, amounting to roughly $130 trillion.

2.2. Real estate investment

Real estate investment means purchasing, managing, selling, or renting a real estate, or a part of it, in order to achieve financial benefit through either the property's value increase or rental income, or both. Revenue is generated by renting (net operating income, i.e., rent profits minus ongoing expenses) and capital appreciation, taking into account any tax shelter offsets. Tenants pay the rent to landlords of real estate properties in exchange for using the property. Tax shelter offsets mean depreciation and any losses that reduce the tax liability on the same type of income source, including any tax-related credits. Equity is accumulated when tenants pay the maintenance costs and the value of the real estate property can increase, for example, by improving or renovating the buildings or due to the development of the surrounding region. If the source of debt service payment is the income gained from the real estate property, the equity accumulation can be treated as revenue because the cash flow is positive. Capital appreciation will be realized as a positive cash flow not until the real estate property is sold and this cash flow can be very unpredictable unless it is part of the development strategy of the real estate. (Glickman, 2014.)

Property valuation is the key preliminary step before making the real estate investment in the market where information asymmetry is commonplace, i.e., one party may have more information about the real value of the real estate property than the other. Several valuation techniques are used prior to purchase. In addition, for the purpose of standardizing property valuation there are many real estate appraisal associations in the world, such as the Appraisal Institute in USA, the Royal Institution of Chartered Surveyors (RICS) in UK and the International Valuation Standards Council in UK. (Morri & Benedetto, 2019.)

Diversification in real estate investments may be often small in terms of geographically and timely, as the large capital requirements often tend to limit it. Investing in a certain industry is dependent on the demand of the industry in question which may also increase the risks. Staying on schedule within the investment project can also be considered a risk, as it is often affected by many external factors and delays typically bring surprising extra costs to the investor.

2.3. Investment analysis methods in real estate

There are several different methods that are applied to real estate investments prior to the decision making whether to make the investment or not. All of them can be considered justified but they show different perspectives from the possible investment target, and eventually it is the decision-maker who has to judge the feasibility of them. It may be also very common to piece them together for having more versatile opinion.

Very common methods are the discounted cash flow-based net present value (NPV), the internal rate of return (IRR), payback period and return on investments (ROI). Also, added shareholder value may be estimated along with different versions, or extensions, of NPV. Multiples can be used as well, however, bearing in mind the heterogeneous nature of real estate market meaning that typically, the comparable investments cases are similar, not identical.

In NPV method, all payments related to the investment – investment expenditure, net income accumulated at different points in the future and possible income from the residual value of the investment – are discounted to the present value with a selected discount rate, such as cost of financing the investment or the minimum return requirement rate. These are deducted by the present values of future expenses related to the particular investment, resulting NPV. Positive NPV is a signal to invest as it means the investment is profitable and from all possible investment cases the one with highest NPV "wins". NPV equation is:

$$NPV = -C_0 + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i} \tag{1}$$

where C_0 is the initial investment, C_i is cash flow at time i, r is discount rate and T is time.

The internal rate of return (IRR) is the discount rate that makes the NPV equal to zero. It may be a quick and simple check point to compare to any threshold rate of return the investor may have for determining if the investment process should move forward. Payback period is the amount of time required for the cash flows received from the investment to pay the cost of the original investment and thus, it provides a quick insight into the liquidity of the investment while not considering the possible cash flows after the payback period. Neither of these two methods (IRR or payback period) should not be sufficient alone, most heavily due to the reason that they do not consider the size of an investment, and thus are unequivocally too narrow as a method.

ROI can be calculated by dividing the net profit on investment by the costs paid for the investment. However, this method is not considering the time frame of the investment meaning that again, alone it is a poor method. With leverage, ROI value can increase very much as investors are using (partial) debt financing which lowers the costs spent on the investment.

Professional investors may have different techniques they use. For example, in Penttinen's (2021) thesis companies in Finland replied to be using metrics such as direct capitalization (NOI yield, where net operating income (NOI) is divided by the value of property) and the market value method which assumes that real estate prices are determined by the market. Here, the comparative trades of similar properties that have recently been made (or are available in the market) are competed with the investment target being evaluated. Market value can be determined also by dividing NOI with the required rate of return. Further discussion on investment analysis methods and time value of money is provided in e.g., Quantitative Investment Analysis (2015) by DeFusco, MacLeavey, Pinto and Runkle.

According to Pagourtzi, Assimakopoulos, Hatzichristos and French (2003) valuation methods can be grouped into traditional (regression models, comparable i.e., market, cost, income, profit and contractor's method) and advanced (artificial neural networks (ANNs), hedonic pricing method, spatial analysis methods, fuzzy logic and ARIMA models), from which the latter ones are not that commonly adapted into use yet. These advanced methods are, however, studied in academic research and found to improve the efficiency of the process of predicting. For example, Abidoye, Junge, Lam, Oyedokun and Tipping (2019) suggested that property valuation stakeholders should synergise and transform the property valuation practice in a bid to promote the awareness and adoption of the advanced methods such as ANN, hedonic pricing model, expert system, and fuzzy logic system among property valuers.

From the real estate operator side, Carl Hoemke (2021) has capsulized the most common methods that are used in the real estate field, from which five of them are presented next. The market approach and the sales comparison approach are here combined due to sometimes mixed terminology in academic literature.

2.3.1. The income approach

The income approach determines value based on the present value of the future generated (lease) cash flows. The future expected revenue minus estimated future expenses are discounted into the current value with a discount rate (demanded rate of return) comparable to the risk associated with the expected income. Naturally, higher risks are associated with higher discount rates. For example, the lease agreements affect on this – the existing tenants with long-term lease agreements are less risky than any uncertainty regarding having the property rented to solvent tenants. (Hoemke, 2021.)

2.3.2. The sales comparison / market approach

The sales comparison, or market approach, looks at the comparable transactions in the same area. The selling price of these past transactions will determine the value of the property taking into account the needed adjustments for key differences such as size, location, condition and construction type. The market approach compares the property to other, similar properties available in the market ensuring it is priced accordingly. No one (rational investor) will buy the property if it is priced much higher than the other properties around it, or on contrary, it will be purchased very quickly is it was mispriced significantly under other similar properties taking into account adjustments in terms of size, age, renovations, land, building rights, functionality and other significant qualities that create value. (Hoemke, 2021.)

2.3.3. The cost approach

The cost approach is based on the principle of substitution, and it creates a ceiling on the market value of a specific property. It assumes one would have to first purchase a property of similar quality and in, or near, the same location and factor the needed construction costs: no one (rational investor) will buy the property if one is able to build a similar new property in the same are that would generate the same revenue or value in economic terms. (Hoemke, 2021.)

2.3.4. Value per gross rent multiplier

The value per gross rent multiplier (VPGRM) indicates the value to the maximum annual rent, i.e., gross rent of the property. The gross rent is compared to other similar market transactions as in the sales comparison approach. For example, if a similar property, assumed all key differentials accounted, with a €2 million gross rent sold for €20 million, it has sold for 10 times the gross rent. From here, a similar property with the same gross rent will have a basis for the valuation. (Hoemke, 2021.)

Based on academic literature, first two or three of these methods seem to be most relevant and widely used in the real estate field (Ventolo and Williams 2001, 152–272; Abidoye et al. 2019; Morri & Benedetto 2019, 59–88; Royal Institution of Chartered Surveyors (RICS) 2019). Abidoye et al. (2019) studied Australian area and mentioned residual method as most common one in addition to the first two. Also, Morri & Benedetto (2019, 90–94) and RICS (2019) include this. RICS (2019) determines it as the following:

> “The residual method is based on the concept that the value of a property with development potential is derived from the value of the property after development minus the cost of undertaking that development, including a profit for the developer. Put simply: gross development value (GDV) - total development costs (including profit) = residual land value.” (RICS 2019, 24.)

Market, income, and cost approaches are recognized also by the International Valuation Standards Council (2011, 65–68) that is an independent, non-profit organisation maintaining a valuation framework to serve the public interest. In addition, the organization emphasizes the need to understand the legal framework affecting the interest being valued before undertaking a valuation of a real property interest.

2.4. Capital budgeting

According to Damodaran (2010) corporate finance first principles are investing in projects that yield a return greater that minimum acceptance hurdle rate i.e. minimum acceptable rate of return (investment decision), choosing a financing mix that maximizes the value of the projects taken (financing decision) and return the cash to the owners when there are not enough such investments (dividend decision) – all aiming at the very centre purpose of maximizing the value of the firm and its owners. The planning procedure of these investment decision expenditures on long-term income-producing fixed assets, that will generate cash flows longer than one year, is called capital budgeting. Budgeting means a detailed plan of the projected cash flows (inflows and outflows) over the particular future period. All these cash flows are discounted at the cost of capital of the project (or sometimes with other required rate of return that company decides, e.g., a firm's weighted average cost of capital, WACC, which is the expected return by company's investors) and summed, providing the NPV that was discussed earlier. (Gitman, 2010; The Balance, 2020.)

2.4.1. DCF analysis

The cash flows that will be generated from the investment project in the future are discounted back to a certain point in time, usually to the current date. The reason for the discounting process is the theory of the time value of money, that assumes that money today is worth more than money in the future as money today can be invested in order to earn more money. The weighted average cost of capital (WACC) represents the average rate that a company pays to finance its assets, thus WACC consist of all of the company's sources of capital (debt and equity), weighted by the proportion of both of the components. The cost of equity is generally higher than the interest rate of debts due to higher risks that equity investors carry, according to the Capital Asset Pricing Model (CAPM) (see Appendix 18). Therefore, an increase in a company's debt as a portion of the total capital results in lower WACC, as well as lowering the financing rates. Nevertheless, many companies use WACC as a reference rate to decide whether to invest as it represents the minimum rate of return at which a company produces value for its investors. WACC can also represent a company's opportunity cost, meaning that if a higher rate of return cannot be found elsewhere, the company should buy back its own shares. (The Balance, 2020.)

In DCF, a forecast of the future cash flows is generated using typically either a growth-based forecast where a basic year-over-year growth rate can be used, or a driver-based forecast that requires disaggregating revenue into particular drivers (for example, price, volume, market share, and external factors). Here, a regression analysis is often in determining the relationship between the drivers and the revenue growth.

Also, a project's terminal value must be estimated and included in the NPV. Terminal value is the cash flow value beyond the explicit forecast period, and it is a critical part of the financial model, as it can make a large percentage of the total value of the project. There are two approaches to the DCF terminal value formula: perpetual growth, usually used by academics, and exit multiple, usually used by industry professionals. Selecting the appropriate discount rate and multiple, or growth rate, for the risk profile of the project, is very important in determining the most correct NPV. The NPV is very sensitive to these, meaning that even a little change in these values can cause immense change in NPV. (Gitman, 2010; CFI, 2022c.)

NPV can also be sensitive to certain model-related drivers, such as price, cost-factors, and volume. Therefore, a sensitivity analysis is often prepared as a part of the process to determine how the project value changes if certain drivers or assumptions in the model change. It is important part of decision-making to understand the key variables in the project that will mostly affect on the profitability of the investment project. A break-even analysis is typically prepared as well, as it demonstrates the point when a project will be profitable. It is used to determine the number of units or revenue needed to cover the project's total costs (both fixed and variable).

All investing expenses and project funding must be completed at the point when an investment decision is made. In addition to the financial figures companies may also take into consideration certain quality factors, such as how well the project fits into the company's values, strategy or vision. Especially, ESG and green values are highly important today for many companies and unsustainable-profiled projects may get abandoned nevertheless the positive NPVs. Thus, eventually investment decisions are often a holistic package than cold numbers for managers that are trying to maximize the company’s value.

2.5. Real options

The term “real options”, coined by Stewart Myers in 1977, refers to application of option pricing theory into the valuation of non-financial investments (“real” investments) with certain flexibility, e.g., multi-stage research and development before making a decision. Since then, a number of research papers are published on both theory and applications. Attention from industries, such as oil and gas, was gained as a potential tool for valuation and strategy. Later, management consultants and internal analysts began to apply real options to major corporate investment issues. (Borison, 2005.)

2.5.1. Brief history and introduction to real options

Black, Scholes and Merton developed the first formula solution for financial option pricing in 1973 (Black & Scholes, 1973). Few years later, Myers (1977) defined real options as “opportunities to purchase real assets on possibly favourable terms” and proposed (Myers, 1984) that DCF tends to understate option value when business grows and even if DCF would be properly applied it may fail in strategic applications. Kester (1984) discussed about growth options in capital budgeting. Since that an increasing number of research papers were made about the subject (see e.g., McDonald and Siegel, 1986; Trigeorgis and Mason, 1987; Pindyck, 1991; Dixit, 1992; Trigeorgis, 1993) until Dixit and Pindyck (1995) provided the first detailed suggestion of the new theoretical approach to capital investment decisions that recognizes the option value of waiting for better information. Since that many researchers have examined real option analysis (ROA) and recognize its potential in investment analysis but indicated that especially the application of ROA is problematic due to the complexity of its different methods (see e.g., Lander and Pinches, 1998; Oppenheimer, 2002).

Then, Collan, Fullér and Mezei (2009) proposed fuzzy pay-off method (FPOM) which was based on possibility distribution derived from different NPV scenarios. The real option value was calculated using probability of success and the possibilistic mean of the positive side of fuzzy number. Borges, Dias, Neto and Meier (2018) demonstrated that the calculated option value may be below project NPV (without real option) which is inconsistent with financial theory. This nonuniformity stemming from probability and possibility approaches used at the same time was solved based on findings of Luukka, Stoklasa and Collan (2019), and presented by Stoklasa, Luukka and Collan (2021) showing that the probabilistic part can be omitted from the formula, making it consistent with financial theory. Thus, today, real option analysis with FPOM can be applied with lower complexity.

A real option is a right but not an obligation to take an action on an asset (such as expanding, contracting, abandoning, or deferring its purchase) at a particular cost (treated as exercise price) during the lifecycle of the real option (Copeland & Antikarov, 2001, 5). Real option analysis (ROA) is from theorical point of view likely the most sophisticated method to value managerial flexibility. In ROA, an investment opportunity is regarded as a real option and it has the same payoff structure than a financial option where valuation is tied to following parameters: the expenditure to acquire the asset, the length of time during the investment decision is available, the risk-free rate, the volatility (risk) of the cash flows, and the forgoing free cash flow if the investment opportunity is not started immediately, or at all (Scialdone, 2007, 257–258). However, managers cannot measure uncertainty in terms of volatility, but instead they must rely on their perceptions of uncertainty unlike in financial options – thus, ROA is distinguished from financial options, as it takes into account uncertainty about the future evolution of the parameters that determine the value of the project, coupled with managers' ability to respond (Piesse & Van de Putte, 2004; Damodaran, 2005).

As with financial options, real option can be also categorized in call and put options: a call option gives the holder of the option the right (but not an obligation) to buy the underlying asset at a certain fixed price (strike or the exercise price), at any time prior to the expiration date of the option (American options style) or at the expiration date (European style). For this possibility, the holder pays a price. If at expiration, the value of the asset is less than the strike price, the call option will not be exercised, thus it expires worthless. A put option gives the holder of the option the right (but not an obligation) to sell the underlying asset at a fixed price, again called the strike or exercise price, at any time prior to the expiration date of the option, or at the expiration date (American versus European option). Again, the holder pays a price for this right and if the price of the underlying asset will be greater than the exercise price, the put option will not be exercised and will expire worthless. (Damodaran, 2005.)

Real options are typically available only for a limited time. In business, there are sometimes situations where a company must decide whether to act or not if an opportunity comes available. The risk is that the rival company will act first and win the competition. Unless "exercising" the option makes sense (it makes more money or saves money) the real option is not used. Obviously, real options are most valuable when uncertainty is high and managers have the flexibility to change the course of the project, when needed.

There are several types of real options (CFI, 2022a):

1. Option to expand (make an investment or undertake a project in the future to expand the business operations).
2. Option to abandon (cease a project or an asset to realize its salvage value).
3. Option to wait (defer the business decision to the future to have more information).
4. Option to contract (shut down a project at some point in the future if the operating conditions are unfavourable).
5. Option to switch (shut down a project at certain point in the future if the operating conditions are unfavourable and resume it if the conditions are again favourable).

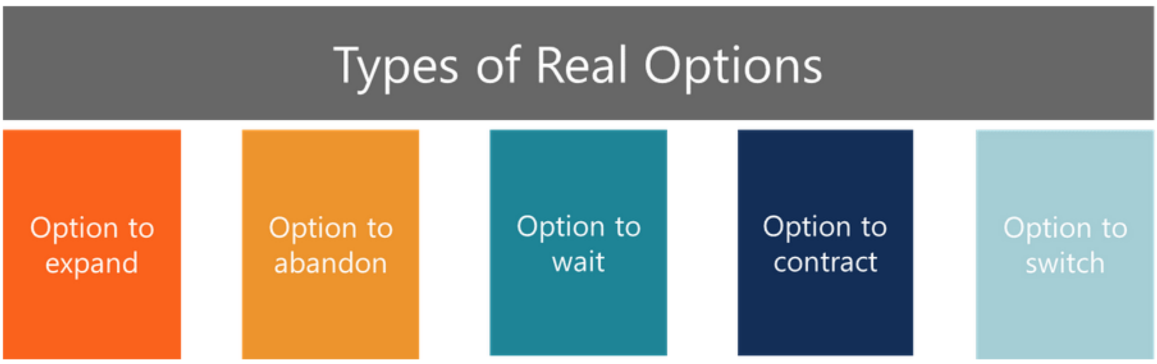


Figure 1. Types of real options (CFI, 2022a).

From these examples one may realize that these real options are already used in certain way in companies, perhaps not even realizing it. For companies, real options are valuable if their existence is recognized, available real options are found either from current projects or in future investments, and they are actively managed. This requires companies to discuss about real option thinking and skilled employees for real option mapping, valuating them and providing the needed software solutions, such as the needed enterprise resource planning (ERP) system integrations. Thus, managers must be equipped with real option mindset and fully seeing the benefits of ROA in business. After all, the real option mindset does not differ far from “normal” business leadership and management expectations.

In general, real options are widely studied subject in many fields. For example, in strategic management research Trigeorgis and Reuer (2017) identified several challenges and opportunities in real options and concluded suggestions of the needed future research to take more of an implementation perspective focusing more on aspects of option management and exercise, than a detached valuation or purely strategic reasoning one. However, there is survey evidence suggesting companies being slow in adopting real options even there is findings about their benefits (see for example, Graham and Harvey 2001; Brounen, de Jong and Koedijk 2004; Ryan and Ryan 2002; Block 2007; Baker et al. 2010). That being said, it is noteworthy to point out, that, according to Baker et al. (2010) there are many surveys that provide limited justification for the low popularity of real options, as they only report the percentage of firms using real options.

Instead of seeing real options as an alternative method to the widely used traditional DCF technique many surveys consider the identification of the use of real options specifically as an additional tool for DCF analysis. For example, Triantis and Borison (2001), and Copeland (2002) suggest using real options to complement the existing evaluation methods, such as DCF. McDonald (2006) even argues that the differences between the ROA and DCF approaches are not as large as many seem to be believing and according to Guerrero (2007) real options are an important extension to DCF analysis.

While traditional DCF approach assumes a single decision pathway with fixed outcomes, and without the ability to change and evolve overtime, the real options approach considers multiple decision paths as a result of high uncertainty and the flexibility of management to choose the optimal strategy as new information becomes available (Mun, 2002). In comparison with the DCF, or the NPV method, the differences between the NPV approach and the ROA approach can be summarized as following: in NPV, risk is measured indirectly through the rate of return while ROA measures risk by assigning probabilities to the expected future payoff. The expected normal distributed cash flows in NPV approach are predetermined without the flexibility to change them after starting the project while in ROA future actions are modelled in response to the revolution of uncertainty aiming to skip the negative outcomes and thus an unsymmetrical distribution is assumed in results. NPV also requires one starting time while ROA calculates one optimal starting value, but no false mutually exclusive alternative is being laid off. (Scialdone, 2007, 43).

2.5.1. Recognizing real options

Having a real options mindset is the key to recognize real options and it is part of management methodology. Basically, it means following how the world changes and understanding how the changes will affect the business, keeping track of the available real options and thinking about what options company should have, establishing solid communication in place in the organization, and seeing “new” as an opportunity and embrace it (adapting the ”entrepreneurial” way of thinking).

> “One of the problems in learning how to use real options is that we often don’t know how to recognize them in real-life managerial settings.” (Copeland & Keenan 1998, 41.)

Real options can be found anywhere where one can find uncertainty, but they must be identified and documented: the possibility (choice), source of uncertainty, terms under which the real option can be exercised, the exercise price (cost of real option), and type (operational or strategic) (McKinsey, 1997). Operational real options are such that companies have in their operational business currently or in the near future (e.g., investment projects). Strategic real options are such that companies must prepare for the long-term future (e.g., patents or R&D projects).

NPV method as such does not consider the value of managerial flexibility to adapt according to changing circumstances. If the market grows faster than anticipated, managers must seek for options to expand the operations. If technology or digital innovation brings unforeseen applications available, managers must evaluate the options to utilize it. Real options may bring the needed addition to NVP calculation – the flexibility to enter a market with options to grow, scale down or abandon, and the value to wait before undertaking a major investment or new market (CFI, 2022a) – and Monte Carlo simulation may offer more insight into decisions when the probabilities of outcomes can be estimated and made visible.

2.5.1. Valuating real options

There are several different methods for valuating real options and numerous examples of the applications. Mayer and Schultmann (2017) discussed and presented a brief overview of the option valuation methods they think are the most relevant, considering analytic, numeric, and stochastic approaches. They continue that depending on the parameter under investigation, different methodological recommendations can be derived regarding the valuation of real options.

The valuation methods are often adapted from techniques for valuing financial options (see for example, Borison, 2005). For example, Black–Scholes model (differential equation solution) for European styled options, binomial lattices (discrete event and decision model) for American styled options, and Monte Carlo simulation (simulation-based method) for both types are very commonly adapted. However, due to the required extensive mathematical sophistication these methods can be considered too heavy for high-dimensional situations. Cash-flow scenario using methods, such as Datar-Mathews method and fuzzy logic-based fuzzy pay-off method, do not contain restrictive assumptions similar to those underlying the closed form. Decision trees analysis method combines cash-flow scenario with decision points clarifying the connection between future decisions and uncertain circumstances, although it is challenging to apply in practice when multiple sources of uncertainty are present. In this method (see e.g., Borison, 2005 and Mills, 2006), every point of decision and the options at that point must be identified along with their aspects of uncertainty, range of alternative outcomes, probabilities of events, results from actions (costs and possible profits). The net present value is then calculated for each point, node, based on the chosen course.

Mayer and Schultmann (2017) presented the following visualization of the (real) option valuation methods that highlight the variety of them (see Figure 2). For more understanding about the different methods in detail, see e.g., Wilimowska & Lukaniuk, 2005; Mathews, Datar & Johnson, 2007; Carlsson & Fullér, 2003; Street & Santhanakrishnan, 2011; Collan et al. 2009.

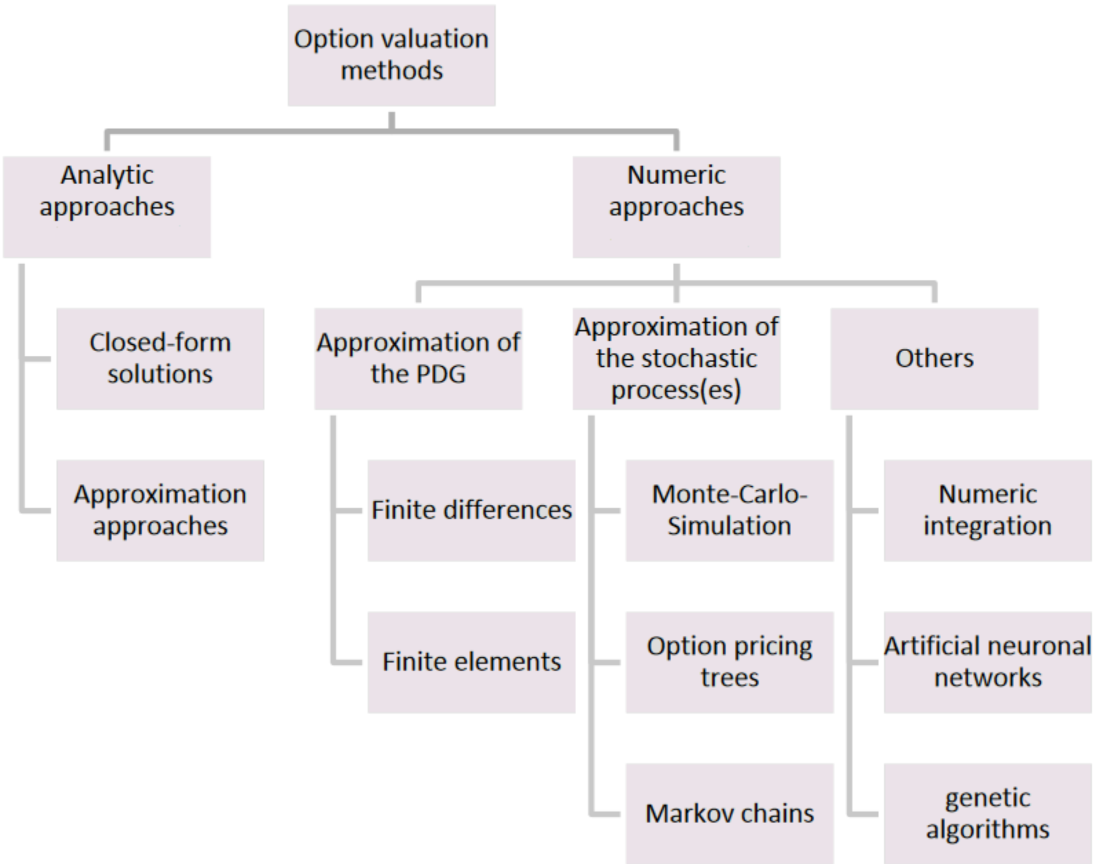


Figure 2. Visualized tree of some of the real option valuation methods (Mayer and Schultmann, 2017).

There are various analytical approaches that have been proposed to calculate the real option value for a potential investment. They differ in terms of their applicability (what the value represents), assumptions and mechanics. For example, the classic approach (Amram & Kulatilaka, 1999) is based on a traded replicating portfolio, and building data from that portfolio, and is connected to standard option pricing from finance theory. It assumes capital markets are complete. The mechanics uses the Black-Scholes algorithm, where the following factors are used to determine the option value of the project: strike price, share price, time to maturity, project volatility and the risk-free rate, which is proposed to calculate the real value of the potential investment. The subjective approach (Luehrman, 1997; 1998) is very much the same the classic approach but not all: it is based on a traded replicating portfolio, but it is built on data that is subjectively assessed. Here, the price and volatility of the underlying asset are subjectively estimated before applying Black-Scholes model. (Borison, 2005; Mills, 2006.)

The next one, marketed asset disclaimer (MAD) approach (Copeland and Antikarov, 2001) is not relying on a traded replicating portfolio and the data is completely subjective except for the discount rate. The same assumptions that may be used to justify the application of net present value (NPV) in capital investments analysis are used here to justify the application of real options analysis. The mechanics is based on building a cash flow model of the underlying asset using subjectively evaluated inputs and calculating the NPV using a CAPM-based beta, then subjectively estimating the uncertainty associated with the inputs and running a Monte Carlo simulation of the model to obtain the resulting distribution, that is then used to construct a risk-neutral binominal lattice. The value of real option is then estimated using this lattice. (Borison, 2005; Mills, 2006.)

The revised classic approach (Dixit & Pindyck, 1994; Amram & Kulatilaka, 2000) is based on the view that there are two different types of business investment, each of which requires its own approach: real options analysis (ROA) should be used if the investment is dominated by market-priced (public) risks, and dynamic decision analysis if company-specific (private) risks dominate the investment. Here, for market-priced risks, the classic approach is applied and for corporate-specific risks, the decision analysis is applied by using decision-tree analysis that represent the investment alternatives, their probabilities, and values by subjective judgement. Then a cash-flow model is applied at each of the tree points, calculating the NPV using the appropriate weighted average cost of capital (WACC) rate. The decision tree is then rolled back to determine the optimal strategy (based on the associated values). (Borison, 2005; Mills, 2006.)

The integrated approach (Smith & Nau, 1995; Smith & McCardle, 1998) recognizes that most investment problems encountered in practice involve both kinds of the risks described above. Unlike the four previous approaches, that are based on finance, the origin of this approach is in management science. It establishes a goal of making investment decisions to maximizing the utility of owners and managers. The mechanics is very much the same as in revised classic approach but with some exception: the decision-tree is applied considering both types of risks where market-riced risks the replicating portfolio is identified, and "risk-neutral" probabilities are assigned. (Borison, 2005; Mills, 2006.)

For more information about the strengths, background, usability and weaknesses, see e.g., Borison (2005) and Mills (2006) who very much refers to Borison's (2005) previous work.

There are numerous research papers of application of different real option valuation methods. For example, Čirjevskis and Tatevosjans (2015) tested real option application in real estate development project aiming to valuate managerial flexibility with the use of real options and valuating them in three different methods. They used term "extended NPV", "eNPV", and decided that in case of expanding project its NPV is positive, the option to sell the project should not be considered as it is inefficient. Ďurica, Guttenova, Ľudovít and Svabova (2018) performed a case study presenting a practical application of the real options in investment valuation using binomial trees in calculating three values for the potential managerial interventions in real estate investment, and confirmed that the traditional NPV approach significantly undervalued the case because it did not consider the flexibility of managerial interventions in the project. It is noteworthy, though, that both of these studies' attention is more on the valuation methods and the implementation into practise to be used by companies is not dealt. Also, these valuation methods can be considered rather complicated. More examples are provided in literature review in Section 3.

2.5.1. Fuzzy pay-off method

Fuzzy pay-off method (FPOM) is at this point rather new method for investment analysis. It was originally brainstormed by Mikael Collan between 2007–2008, based on specifically the realization of the complexity of the Black-Scholes model and that the calculation had to be simplified for real options and profitability analysis, and later proposed by Collan, Fullér and Mezei in 2009. The method is based on Datar-Mathews (Datar & Mathews, 2007) real option valuation method that uses simulation to generate a probability distribution of project outcomes from project cash-flow scenarios, calculates the probability weighted mean value of the positive outcomes and multiplies by the probability of the positive outcomes (%) over all of the outcomes. (The pay-off method, 2022.)

Fuzzy pay-off method “extends” this idea further: it used fuzzy numbers and possibilistic approach instead of probabilities. The pay-off distribution of a project value (calculated with fuzzy numbers) is called fuzzy NPV. The mean value of it is a possibilistic mean value of the positive fuzzy NPVs. Thus, real option value calculated from the fuzzy NPV is the possibilistic mean value of the positive fuzzy NPVs multiplied with the positive area of the fuzzy NPV over the total area of the fuzzy NPV. This can be done without simulation (or it can also be done with simulation as well). Basically, this means that the real option value can be derived from the fuzzy NPV. These are the blocks that jointly form the fuzzy pay-off method for valuing real options. (The pay-off method, 2022.)

Fuzzy numbers are fuzzy sets that satisfy certain conditions and derive from fuzzy set theory (Zadeh, 1965) using fuzzy logic in which different propositions (scenarios) have a degree of membership in a certain set. This degree of membership can be either 0 (complete non-membership), 1 (complete membership) or a value between 0 and 1 (an intermediate degree of membership). A very simple example of the application can be presented from everyday life, e.g., related to a question about the current weather conditions. If one asks, is it hot outside when the outdoor temperature is 19°C, the answer depends on many things, such as the location. In South Pole area, where temperature is always below zero, it is definitely considered hot (1, complete membership) but in somewhere near equator area that might be considered quite warm but not exactly hot (value between 0 and 1, an intermediate degree of membership), as it also depends on the time of the year, along with many other factors. This highly simplified example illustrates conveniently the complexity of real life, in which real option analysis is applied. Even the forecasting is difficult, due to uncertainty of real life, exact accurate numbers are used to give uncertain estimates, thus highly simplifying the reality. For this purpose, the fuzzy logic, a “tool” that enables to treat uncertainty and imprecision in a precise way, was introduced by Zadeh in 1965. For further discussion about fuzzy set theory see e.g., Dubois & Prade, 1980, and about possibility theory see e.g., Dubois & Prade, 2001.

Based on the work of Collan et al. (2009), Luukka et al. (2019), and Stoklasa et al. (2021), in short, a fuzzy set A on the universe U is defined by $A : U \rightarrow [0, 1]$. For each $x \in U$ the value $A(x)$ is called the membership degree of the element x in the fuzzy set A. A(.) is called a membership function of the fuzzy set A. A fuzzy number is a normal convex fuzzy set on R (with bounded support). A triangular fuzzy number A on [r,s] ⊂ R is a fuzzy number, whose membership function is

$$A(x) = \begin{cases} 0 & \text{for } x \leq a - \alpha \\ 1 - \frac{a-x}{\alpha} & \text{for } a - \alpha \leq x \leq a \\ 1 - \frac{x-a}{\beta} & \text{for } a \leq x \leq a + \beta \\ 0 & \text{for } a + \beta \leq x \end{cases} \tag{2}$$

In FPOM, using fuzzy logic, three cash flow scenarios (i.e., three NPV scenarios) are applied: minimum, "best guess" or best estimation (most likely scenario, which is typically used in investment analysis) and maximum. Then, these scenarios are treated as fuzzy numbers that form a triangular shaped fuzzy NPV pay-off distribution. This represents graphically the range of the possible future investment pay-offs (see Figure 3). In this distribution, best guess scenario has a complete membership (1), the minimum and maximum scenarios have complete non-membership (0), and other scenarios between have intermediate degrees of membership (a value between 0 and 1). The triangular shape of the pay-off distribution is assumed for simplicity reasons (it may naturally be something else), and it is "a graphical presentation of the range of possible future pay-offs the investment can take". (Collan et al., 2009; Luukka et al. 2019; Stoklasa et al. 2021.)

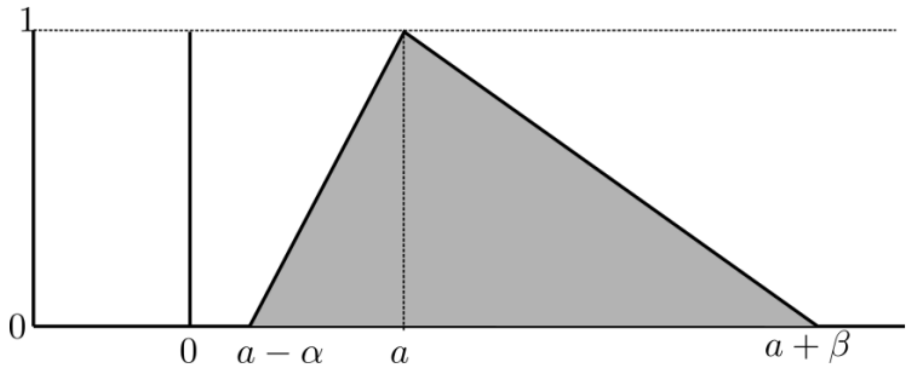
For more detailed description of the method and mathematical equations, see e.g., Collan et al. (2009), Luukka et al. (2019), and Stoklasa et al. (2021). Next, equations of real option value (ROV) are presented. These following equations and their background information are based on the work of Collan (2019).

The real option value (ROV) is defined as the possibilistic mean of the positive side of the fuzzy NPV distribution. There are four different equations for the calculation of ROV:

1. When the pay-off distribution is treated as a fuzzy number, and the whole fuzzy NPV distribution is above zero, it can be calculated with equation

$$ROV(A) = a + \frac{\beta - \alpha}{6} \tag{3}$$

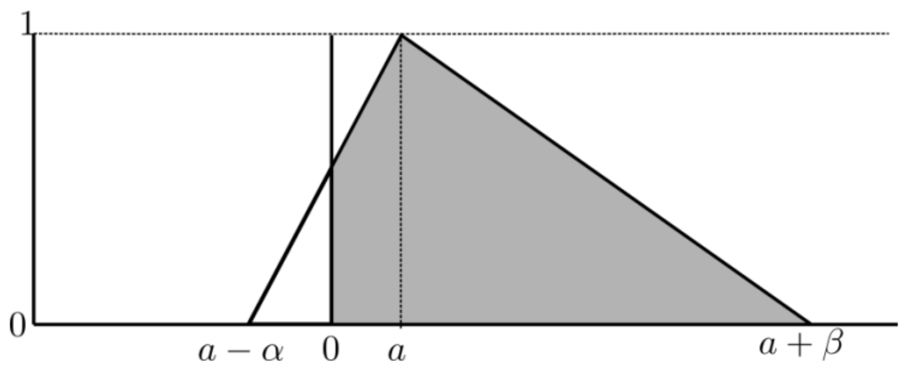
and graphically illustrated by:



2. When the pay-off distribution is treated as a fuzzy number, and the fuzzy NPV distribution is partly above zero (zero is between the minimum possible NPV and the best guess NPV), it can be calculated with equation

$$ROV(A) = -\frac{a^3}{6\alpha^2} + \frac{a^2}{2\alpha} + \frac{a}{2} + \frac{\beta}{6} \quad (4)$$

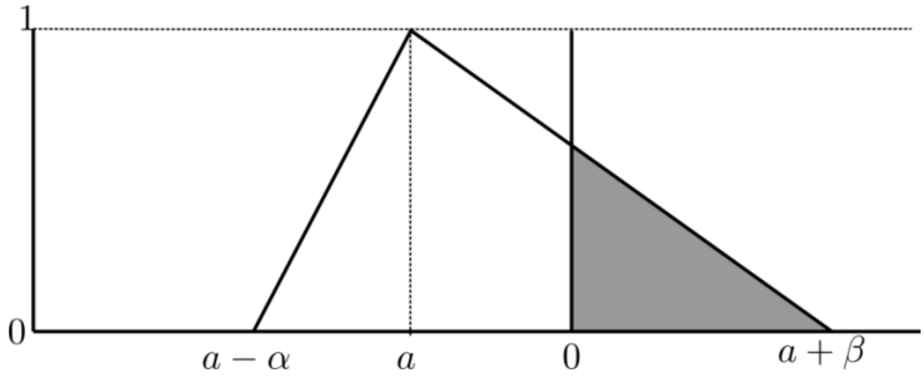
and graphically illustrated by:



3. When the pay-off distribution is treated as a fuzzy number, the fuzzy NPV distribution is partly above zero (zero is between the best guess NPV and the maximum possible NPV), it can be calculated with equation

$$ROV(A) = \frac{a^3}{6\beta^2} + \frac{a^2}{2\beta} + \frac{a}{2} + \frac{\beta}{6} \quad (5)$$

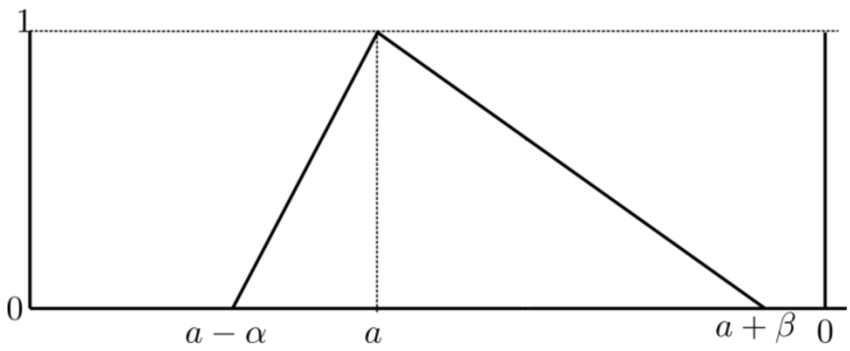
and graphically illustrated by:



4. When the pay-off distribution is treated as a fuzzy number and the whole pay-off distribution is below zero, the equation is simply

$$ROV(A) = 0 \tag{6}$$

graphically illustrated by:



Thus, ROV for a fuzzy set A is

$$ROV(A) = \begin{cases} a + \frac{\beta-\alpha}{6} & \text{for } 0 \leq a-\alpha \\ = -\frac{a^3}{6\alpha^2} + \frac{a^2}{2\alpha} + \frac{a}{2} + \frac{\beta}{6} & \text{for } a-\alpha \leq 0 \leq a \\ \frac{a^3}{6\beta^2} + \frac{a^2}{2\beta} + \frac{a}{2} + \frac{\beta}{6} & \text{for } a \leq 0 \leq a+\beta \\ 0 & \text{for } a+\beta \leq 0 \end{cases} \tag{7}$$

where

a = the best guess scenario NPV;

α (alfa) = the distance between the minimum and the best guess scenario NPV;

β (beta) = the distance between the maximum and the best guess scenario NPV. (Collan 2019.)

The graphical triangular shape can be placed to visualize real numeric cumulative NPV scenarios (see Figure 3 below).

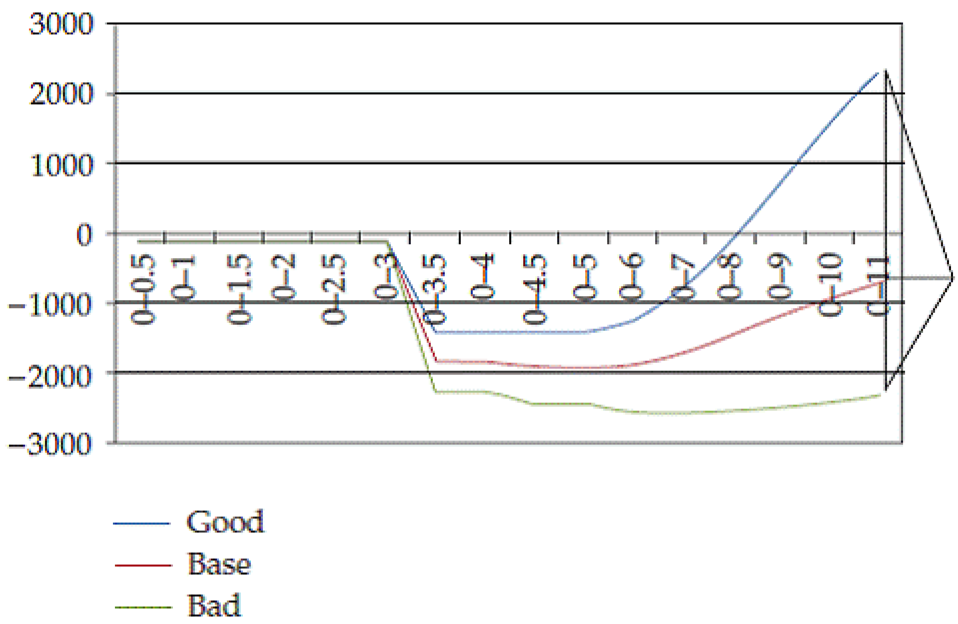


Figure 3. Example of cumulative NPV scenarios and graphical triangular shaped pay-off distribution (The pay-off method, 2022).

The usefulness of this model lies in the fact that there is no need for determining the volatility of the asset. Instead, projection of uncertainty can be done based on expert opinion and other relevant data available which applies excellently in the real estate industry where there is often insufficient data available for calculating the volatility. Also, the model uses available cash flow-based data that is very commonly used in companies, and it is suitable for several analysis tools, including the most commonly used simple analysis tool in companies, Microsoft Excel, based on Visual Basic programming language. Thus, the model does not force companies to ultimately change their entire work processes. (The pay-off method, 2022.)

2.5.2. Application of real options in practice

In short, according to Collan (2019) application of FPOM for real option valuation is creating three cash-flow scenarios, calculating NPV for each scenario, establishing a fuzzy NPV (pay-off) distribution and obtaining the ROV. To calculate the (expected) fuzzy NPV the present value of the lowest cost estimate is deducted from the present value of the highest revenue estimate, and the present value of the highest cost estimate from the present value of the lowest revenue estimate. (Collan, 2019.)

The fuzzy NPV (pay-off) distribution is represented by fuzzy number:

Table 1. Fuzzy number representations (Collan, 2019).

Value	**Fuzzy number**
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	β
Distance between the best guess scenario NPV and minimum scenario NPV	α

The height of the fuzzy NPV distribution reflects the degree of membership of each value to the distribution in the set of possible values for the investment NPV. Based on fuzzy logic theory, the best guess scenario is the most likely one, and maximum and minimum possible scenarios are used as upper and lower bounds of the distribution. The three scenario NPVs are then used in the creation of the pay-off distribution, which in this case is assumed as triangular (as there are three scenarios). (Collan, 2019; The pay-off method, 2022.)

This fuzzy pay-off method for real option valuation has been integrated, for example, into a management information system for valuating of research and development projects of a large company. In addition, the method has been applied to several types of problems, such as valuation of large industrial investments or patents, and analysis of mergers and acquisitions. (The pay-off method, 2022.)

2.6. Monte Carlo simulation

Simulation is an analytical method imitating a real-life situation. It can be useful especially when other analyses are too mathematically complex to reproduce. Monte Carlo simulation (MCS) is a type of simulation which randomly generates values for uncertain variables to simulate a real-life situation. MCS selects values of variables that have a known or estimated value range, but whose value is uncertain for a specific time or event (e.g. interest rates, inventories, or discount rates) to simulate a certain model. A simulation calculates several scenarios of a model by repeatedly picking values from the probability distribution for the uncertain variables and using those values for forecasting future events. Simulation is highly useful, for example, to avoid "the flaw of averages" (that is, trusting the average value when the range of absolute values vary enormously) that sometimes severely mislead managers to make wrong decisions. The distribution can be pre-set, such as normal, triangular, uniform or lognormal, or non-parametric where the historical data itself is used. (Mun, 2002, 102–103.)

Monte Carlo simulation enables a simulation of several thousands of possible project scenarios, calculation of the project NPV for each scenario using the DCF approach and analysing the probability distribution of these NPVs. The uncertainty must be reflected in choosing the appropriate discount rate. The risk-free interest rate corresponds to a riskless investment, but when dealing with project investments, it is almost impossible to find cash flow streams with absolutely no uncertainty – thus the question of what discount rate is appropriate for a cash flow stream with no uncertainty may only be academic. (Papudesu, 2006, 21, 40.)

2.6.1. Use in risk analysis

In practice, Monte Carlo simulation method is a computerized mathematical technique that allows one to quantitatively account for risk in forecasting and decision-making. The method uses random parameter samples to examine the behaviour of a complex system and it is applied to a wide variety of problems in different fields to understand the effects of risks and uncertainty. It offers several advantages over predictive models with fixed inputs, such as the ability to perform extreme sensitivity analysis or calculate the correlation of inputs. In forecasting, the method takes risk, uncertainty and variability into account. Project managers and decision makers can use Monte Carlo simulation to estimate the impact of certain risks on a project's cost or timeline to easily find out what will happen to the project's schedule and cost if one of the risks occurs. (Palisade, 2022.)

In Monte Carlo simulation, the values based on the selected factors are taken randomly from the input probability distribution. Each set of samples is called an iteration, and the result of the sample is recorded as the result of a probability distribution of possible outcomes. There are different types of probability distributions to use and choosing the correct one depends on the situation to be modelled. Some of the most commonly used are normal distribution (the uncertain variable is more likely to be in the vicinity of the mean rather than further away), triangular distribution (values near the minimum and maximum are less likely to occur than those near the most-likely value), uniform distribution (all values between the minimum and maximum occur with equal likelihood), custom distribution (data is let to define the distribution without forcing any distribution on the data), lognormal distribution (when values are positively skewed and cannot fall below zero), binomial distribution (only two mutually exclusive outcomes are possible, and the trials are independent), discrete uniform distribution (related to the uniform distribution but the elements are discrete, not continuous), poisson distribution (describes the number of times an event occurs in a given interval, where the average number of occurrences must remain the same), and exponential distribution (describes events recurring at random points in time, when time has no effect on future outcomes). See Figure 4 for visualization. (Palisade, 2022; Real Options Valuation, 2022.)

Compared to static analysis Monte Carlo simulation provides a number of advantages, such as a comprehensive view of what may happen and how likely it is to happen. Graphical results of different outcomes and their chances of occurrence based on the iterations are easy to create which is essential in communicating findings with other stakeholders. Also, with Monte Carlo simulation, it is easy to see which inputs have the largest effect on the results. This is useful for identifying and mitigating factors that cause the most risk. Different combinations can be tested easily which enables flexible scenario building in the analysis process. In addition, it is possible to model interdependent relationships between the input factors, i.e., variables. (Palisade, 2022.)

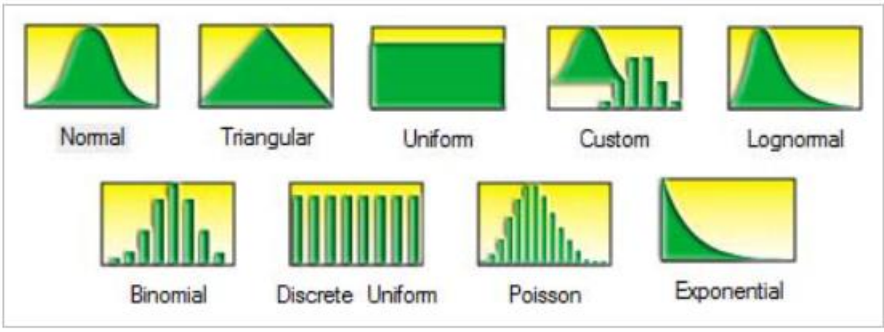


Figure 4. Commonly used types of probability distributions (Real Options Valuation, 2022).

For example, with uniform distribution type all values in the simulation will have an equal chance of occurring, and the user only defines the minimum and maximum (because there is no knowledge of which values are more likely than others) (Palisade, 2022). In practice, future sales revenues for a new product is an example of the variable that could be uniformly distributed. For more detailed information, see Palisade (2022) and Real Options Valuation (2022) that both offer well-arranged further descriptions on the matters.

3. LITERATURE REVIEW

This section concludes a review of the literature of the commonly used valuation methods in the real estate field. In addition, the chapter discusses how real options and Monte Carlo simulation have been applied previously in the real estate field and what possible notification have been risen from previous research. The review includes four topic-related books and selected academic research articles.

Articles selected for the review were found mainly from Elsevier Science Direct, JSTOR and Emerald Journals databases using targeted keywords, such as “real estate valuation”, “real estate investment”, “real estate”, “real options” + “real estate”, “real estate” + “Monte Carlo”, “fuzzy pay-off”. The search was limited to peer-reviewed journal publications and mainly papers published during the 21st century were accepted with some relevant exceptions. The search provided numerous articles related to the topics, from which 32 were selected for closer examination based on the titles and abstracts. A summary table of these articles and included books is presented at the end of this chapter.

3.1. Real estate valuation approaches and discount rate

Ventolo and Williams (2001) find income approach as the most important in valuing income-producing property and note that it is the most heavily relied in final value conclusion. In addition, the approach is separated by two: direct capitalization and yield capitalization. They conclude the direct capitalization is the most convincing method for value estimation assumed the rate used is supported adequately by comparable sales in the market. This means either comparing the net income figures and sales prices of comparable properties or breaking down the rate’s component parts to estimate each separately. The yield capitalization means considering the present value of the fixed future returns of the invested amount and its interest using the expected rate of return in comparable properties as a discount rate. (Ventolo and Williams 2001, 267.)

Hoesli and MacGregor (2013) discuss a lot about these differences and about the different models for valuation, for example especially when comparing UK (in context of law and construction, housing separated) to USA and mainland Europe (in context of finance including housing). In addition, they underline that the property investments require consideration of the wider context of the capital markets, especially when many investors are holding a portfolio of different properties and benchmarking them with market performance. Hoesli and MacGregor (2013) see the income approach, more specifically discounted cash flow (DCF) technique, the most relevant one when it comes to income-generating property valuation. In short, according to them, this means the estimated future cash flows of the holding period and the exit value of the property are discounted to the present value with the discount rate that is most suitable for the case. This being mentioned, one may already see where lies the highly uncertain, i.e., risky variable – that is the discount rate and how to be able to define it properly. Their approach is to link return forecasting, risk assessment and depreciation in a process where via DCF analysis, the NPV of cash flows is calculated based on market risk level (discount rate) and then calculated the internal rate of return (IRR) to be compared with the required return (Hoesli & MacGregor 2013, 77).

Eventually, the choice of an appropriate discount rate for an income-producing property is somewhat subjective. This means there is not necessarily a right or wrong answer, but one must choose the rate based on market data and investor requirements. It should and must be supported by logic, i.e., it must be understandable and justified. Companies often using WACC as a discount rate is understandable, but technically this is just an averaged number that does not likely reflect correctly the risk factors of the particular investment case (surely also the financing form needs to be taken into account). Typically, the valuation is not quite accurate then, but it is the company policy who sets the limits. Graham and Harvey (2001) also pointed out that more than half of the respondents in their study would use their firm's overall discount rate to evaluate a project in an overseas market despite that the project likely has different risk attributes than the firm and indicated that practitioners might not be applying the CAPM or NPV rules correctly. This could be true, but – as simply put – the fact is business is busy in doing business. One approach to discount rate determination would be to use Capital Assets Pricing Model (CAPM) approach (see Appendix 18) in which rate of return on equity for investment depends on the equivalent market return level and the risks associated for the specific investment.

Pagourtzi et al. (2003) found the comparable method to be accurate and reliable according to existing European (UK) and North American (US) literature, however they underline the importance of recognizing the key variables. What they mean by comparable is the same method with different name as the beforementioned market approach. Pagourtzi et al. (2003) find it useful in situations where there is lack of data allowing one to focus on selection, evaluation and registration of the elements that bring value considered important in appraisal. Sayce, Smith, Cooper and Venmore-Rowland (2006) mention, regarding mostly UK based valuation methods, for example the comparative method, investment method based on discounted cash flows (for income-producing property) and residual method (for redevelopment properties financed with 100% borrowed money when no comparable market prices available).

Hoesli and MacGregor (2013) discuss about discounted cash flow (DCF) techniques in context of determining whether the investment is correctly priced and find the comparison methods, used in the property market, rather implicit. Hoesli, Jani and Bender (2006) see the discounted cash flow method useful, generally accepted and widely used method for income-producing real estate in many countries but underline that it suffers from limitations such as the discount rate is assumed to be constant during the holding period and the uncertainty is not explicitly taken into account. Amédée-Manesme, Baroni, Barthelemy and Dupuy (2012) also point out the DCF method along with other traditional methods – the cost of construction, the comparables, the yield capitalization and the asset present value – suffering from numerous limitations but particularly, not appropriately taking the risk into account while also being too sensitive to some parameters, such as infinite growth rate.

3.2. Real options in real estate valuation

Real option approach is hardly mentioned as a commonly accepted valuation method in real estate field operators. In fact, for example Baker et al. (2010) noted that direct evidence from decision makers on a range of issues related to real options is largely lacking in the literature. On contrary, real options are widely studied by academics in valuation of real estate properties. Trigeorgis (1993) applied real option valuation to a construction project and concluded that there was 7% value of flexibility to switch of the project’s gross value. Ashuri (2010) performed a ROV model for valuating flexible leases. Yao and Pretorius (2014) tested American call option pricing model for valuing development land. Mintah, Higgins, Callanan and Wakefield (2017) studied a deferral option embedded in Australian residential project. The optimal phasing of a property investment project and the valuing flexibility to wait, enabled by ROV approach, have been also studied widely (for example see Guma, Pearson, Wittels, de Neufville and Geltner 2009; Ott, Hughen and Read 2012; Vimpari 2014).

Graham and Harvey (2001) found that real options ranked eighth among 12 considered capital budgeting techniques based on the responses of 392 CFOs, of which 26.59% indicated using them either always or almost always (NPV 74.93% and IRR 75.61%). Regarding ranking and use of real options, Brounen, de Jong and Koedijk (2004) found similar results in their study of 313 European CFOs. Ryan and Ryan (2002) found that real options ranked last among 13 considered capital budgeting tools in their survey of 205 Fortune 1000 CFOs, of which 11.4% reported utilizing real options. According to Teach (2003) the real options utilization rate was only 9% in the survey of a Bain and Company in 2000 in which 451 senior executives from 30 industries took part regarding their management techniques. Thus, real options ranked at the bottom.

With a focus on real options and capital budgeting exclusively Block (2007) found that only 14.3% of respondent managers (40 out of 279) in Fortune 1000 companies used real options and of that the respondents came mainly from industries, such as energy and technology, where sophisticated analysis is rather the norm. Baker et al. (2010) found that the lack of expertise or knowledge is the key reason for firms that are not using real options and the ones using real options are more often companies in industries such as gas, oil and mining. This study showed that only 16.8% of the 214 responding managers in Canadian firms are using real options in making capital budgeting decisions and that it ranked last among 9 considered capital budgeting techniques.

Scialdone (2007, 258–259) suggested to separate the task of recognizing the real options in real world business case and the task of mathematical modelling of the real option valuation problem due to the complexity within the latter. As an example, this suggestion demonstrates well how complex the approach to practical real option application can be for practitioners (business side) and may be also the key reason why real options are not yet applied more widely in several business areas: if manager cannot understand the modelling side of the real option valuation, there is very limited possibility to adopt the method in practise because managers need to know what they are based their decision on.

Borison (2005) analysed five different approaches to real options analysis and concluded a summary illustrating something that "could be called the unfortunate state of confusion in the state of real options analysis": all five studied approaches produced fundamentally different results which means that only a little, if any, of value can be obtained there. Out of the five studied approaches (classic, subjective, MAD, revised classic and integrated) the classic, subjective, and MAD approaches found to be easy to use but all of them have significant problems with inaccurate and inconsistent assumptions that make them effectively unacceptable for corporate investments. Then, the revised classic approach overly simplifies the world producing only approximate results, and lastly, the integrated approach was found to be based on solid foundation but requires more effort as a result meaning that it is not easy to adapt. These approaches are presented briefly in Section 2.5.1.

Smith and McCardle (1999) stated that although there are all options in business, embedded options are often overlooked in the evaluation of decision problems, even when uncertainties are modelled. They pointed out that to properly evaluate the downstream decisions of business decisions (when using decision trees method, see Section 2.5.1) in terms of modelling the managerial flexibility, one must model not only the downstream decisions, but also the information available at the time those decisions are made. This immediately brings excess complexity to the use of real options in practise. They suggested risk-adjusting the probabilities for market risks, using a risk-free discount rate and solving the models using standard dynamic programming techniques in taking the real options approach to project valuation. Specifically, they saw the real options approach useful in incorporating market information into project valuation.

3.3. Concerns of real options

Putten and MacMillan (2004) pointed out a serious concern of many CFOs seeing real options overestimating the value of uncertain projects, hence encouraging to overinvest in them as "a license to gamble with shareholders' money". While hearing these managers' concerns, they stated that abandoning real options as a valuation model would be just as bad as companies relying only on DCF analysis for valuing their projects as they end up underestimating the value and hence not investing enough in uncertain but highly promising opportunities. Putten and MacMillan (2004) suggested adopting DCF valuation and real options as an integrated approach in order to make valuations that reflect the reality – and complexity – of their projects. What is noteworthy here, they discussed about projects being in the “option zone” when the DCF value of a project is only modestly positive, or somewhat negative – here the option value can provide the needed information and logic to support the investment.

Putten and MacMillan (2004) also suggested to not to waste time on projects that are clearly carrying a large negative DCF value as they are clearly considered too risky. In this situation, one shouldn’t even bother to add option valuation to the project. In addition, they suitably discussed about the dilemma of project’s costs being highly uncertain but with different volatility than project’s revenue’s volatility, addressing also a practical method of properly adjusting the option value (to be added to NPV obtained from DCF analysis) to solve this dilemma. However, they surprisingly concluded that option valuations only makes sense when applied to projects that can be terminated early at low cost which leaves very little room for different perspectives to utilize real options in valuations. For example, this does not consider a situation when one has an option to change something the project while keeping the project viable instead of just abandoning the project.

As an approach, combining DCF (NPV) with real option valuation is at this point widely studied by researchers. What is thin here though, is, that there are quite few studies to be found considering the practical side of applying real options in some detailed real-world cases or the results of these studies seem somewhat mixed. For example, Michailidisa, Mattasb and Karamouzisb (2009) concluded an illustrative case example of applying the real options approach in comparison with a DCF technique (NPV criterion) in which NPV illustrated the investment case to be economically feasible, but the real option approach revealed the same investment not being feasible. These kinds of empirical results may cause confusion in managers rather that courage them to adapt the real option approaches. On the contrary, there are examples of very promising adaptations as well.

3.4. Demonstrated applications of real options

Krychowski and Quélin (2010) demonstrated and discussed about Mobitel’s successful strategic decision in which the company managed to enter the market at perfect timing by utilizing real option analysis. This was a case about whether the 3G network rollout should start immediately (and thus being ahead of the rival Comptel) or be deferred by one year (including fear of long-lasting decrease in Mobitel's market share, the loss of high-end customers and reduction in revenue per unit) back then when the market was not yet mature. Due the high uncertainty surrounding the success of the new technology and the irreversibility of the investment, the Mobitel managers decided to apply the use of real option of deferring the rollout decision until there were more clear signs that the technology would be profitable even that the NPV calculation supported an early market entry. Real option approach suggested to pay greater attention to alternative migration paths, for example to deploy EDGE instead of 3G and then leapfrog to 3.5G if 3G were abandoned. Therefore, Mobitel ended up deploying 3G in the most densely populated areas and EDGE in the rest of the territory, taking full advantage of the flexibility offered by waiting. (Krychowski and Quélin, 2010.)

Also, Yasseri and Mahani (2009) viably demonstrated in detail how the real option approach can be practically applied to the investment decision and concluded that the real option thinking should be included to the practical measurement of the value of flexibility.

Then, sometimes the research is viable, but the initial set-up can be somewhat confusing. For example, Smith, Driver and Matthews (2018) found a three-step valuation method of recombining binomial lattice and the simpler discrete decision nodes useful. Here, the research is presented as an alternative approach to DCF, but eventually the demonstrated methods required calculating NPV and thus eventually it is rather combing the two approaches.

3.4.1. Managers' point of view

Managers need to lead by knowledge and facts. The ever-changing environment requires the tools of acquiring the knowledge to be flexible, fast to use, justified and understandable. Many managers may have already recognized the limitations of the traditional, widely used net present value (NPV) method for valuing new business projects to make investment decisions. Krychowski and Quélin (2010) pointed out how managers are facing the constantly increasing level of uncertainty and discussed about the highly volatile environment when it comes making investment decisions, and how most corporations are, despite of this, basing their investment decisions on static approaches such as NPV and IRR. Michailidisa et al. (2009) also conclude that NPV is the most widely used method, as well as many other research papers (see for example Ochoa, 2004).

These DCF based methods are very fundamental and easy to understand, therefore highly justified and very important for managers on many occasions. However, when it comes to the practical business life situations, it leaves not much room for occurring changes related to constantly varying situations as it does not capture the value of remaining flexible or provide assistance on any timing issues, such as optimal market entry. This is because the traditional NPV assumes that the decision to start or abandon a possible project has to be taken at once, and that this decision is irreversible. Krychowski and Quélin (2010) even stated NPV to be biased in favour of early market entry as it takes into account the risk of waiting but not the rewards of waiting i.e., the reduced uncertainty.

NPV assumes a manager to act “now or never”, without changing or postponing the decision later, or executing a pilot phase to test something. In reality, this is not at all the case, especially in today’s business world. Many decisions can be changed or postponed by managers, and managers may request further analysis or additional research and development, or a pilot project before proceeding to launching a project into production. Managers may also decide to abandon a project’s operations at a later stage, for example, due to changed circumstances and re-evaluation. In practice, managers are specifically needed to remain flexible to changing market conditions instead of following a pre-determined plan blindly while executing a strategy which involves making a sequence of major business decisions on the way business and its surroundings are progressing. Deciding not to take active initiatives in a certain sector may be changed at a later stage, for instance because the market conditions have later improved. These all can be considered as some of the fundamental qualities of a modern leadership.

3.4.2. Real option vs. DCF

Many researchers state, for example Mintah & Baako (2019), that flexibility is important to be considered across all economic sectors due to the pace at which changes and their direct impact on businesses occur. According to Guthrie (2013) DCF model underestimates the flexibility of delaying project phases which can add value to real estate projects. Along with Guthrie (2013), Baldi (2013) evaluated a real estate project with binomial option pricing method. Baldi (2013) resulted that the real option valuation derived higher values than the DCF model in two separate phases (before construction and after second stage). Also, Mintah et al. (2017) applied binomial model to real estate project and found that the main tool, DCF analysis, is unable to capture the flexibility value embedded in the active management of projects such as a project deferral until uncertainty is resolved. In their study, the real option model provided a value associated with the project that was missed by the DCF model. Therefore, Mintah et al. (2017) suggested that property developers and analysts should acknowledge the value of waiting to invest in decision making and they seemed to wonder why developers and property practitioners do not acknowledge the value of flexibility in their project analysis.

One reason for this could be the limited capability for practitioners to adopt such model as already discussed earlier. For example, this particular study does not discuss the tools with which to apply the model, the methodology is described only briefly in theoretical point of view and the sample data presented in the study remains somewhat vague for a reader as it is such decentralized. Academically, such a study seems correct and justified, but from practical side, it is not easy to approach this level of information, or findings, when it comes to applying it into utilization. Eventually, many researchers have called for further study to be applied in the use of real options. For example, Mintah and Baako (2019) suggested further work to be done to improve ROA methods proposed for the valuation of flexibility.

3.4.3. Sensitiveness of DCF

As the beforementioned academic literature acknowledges DFC based method the most relevant regarding income-producing real estate property valuation, there are weaknesses as well which many researchers and practitioners recognize. Basically, the risk of determining the incorrect discount rate and method's sensitivity to it remain the crucial ones. Also, for example, Sayce et al. (2006) criticize the sensitivity of a multiplier regarding the future rents, risks and growth characteristics considering the investment method which is an important notification. Eventually, is it likely impossible to determine a perfect model to estimate any future events but whether there are higher or lower rates, or multipliers, the idea behind the DCF method remains constant. For this, one of the most nearly perfect situations in investment purpose might be if one knows exactly the level of required rate of return one must pursue, and then utilizes modelling the uncertainty to see different outcomes. It is still obviously not perfect, or “correct”, but it would keep things simple and ease the decision process to see what is likely to happen, how likely it is to happen and what this estimation is based on.

3.5. Utilizing simulation in Real Option problems

With the use of Monte Carlo simulation (MSC) one can possibly add value to discounted cash flow-based methods. One argument would be that as long as the input assumptions are relevant (based on sensitivity analysis done for DCF calculation) MCS can be used in calculating probability of achieving targets of returns, measuring variability and helping to visualize return distributions. Here the knowledge and expertise of real estate industry is very useful as industry experts are capable of analysing the historic market and adjusting the parameters according to the changes in the market. This makes MCS possibly a useful additional tool to DCF analysis that can be implemented with relative easily.

Some theses have been made about MCS, for example Suhonen (2014) studied the use of Monte Carlo simulation in supporting a retail real estate investment decision and suggested that in the future research the potential underlying within unused building rights could be assessed in real estate investment analysis process by utilizing real option thinking in addition to the traditional discounted cash flow (DCF) calculation – which basically means defining NPV – and Monte Carlo simulation. Suhonen (2014) used normal distribution in probability distribution, as according to French & Gabrielli (2004) it best describes the nature of variables that lie around a proposed mean and are uncertain within some expected range. This is a limiting factor in the application of the model, as it may be useful to be able to determine different values for how likely it is that a certain risk factor will materialize, i.e., how likely it is that, for example, inflation would rise to a certain level affecting the development of prices, which in turn will affect the NPV. On the other hand, there must be evaluated also the need for simplicity in capital budgeting process – too complex processes will not be implemented, as it already has been found in many studies before.

Mathews, Datar and Johnsson (2007) stated that the more strategic approach would be to stimulate discussions around the various scenarios reflecting different market conditions that could be encountered at the launch. According to them, this is something called “real options thinking,” and it is in contrast to the NPV approach reducing all to one single most-likely scenario. Mathews et al. (2007) refer to the Datar-Mathews method (DM method) having the potential to extract significant value from scenario planning by providing a structure that lends itself to quantitative analysis. The DM method is based on the probabilistic approach in which real option value is defined as a risk adjusted expected mean of the simulated randomized variables (inputs). Here, a payoff distribution is created – the negative side of the resulting outcome distribution is mapped as zero (because the option is not an obligation to exercise anything negative) and the positive side is weighted on the success ratio. The real option value, therefore, is the mean of the resulting pay-off distribution. (Kozlova, Collan & Luukka, 2015.)

DM method uses simulation in determining the real option value (Mathews et al. 2007). The model has been compared to the fuzzy pay-off method even the latter is not based on simulation. However, there are studies that demonstrate similar results in numerical examples. For example, Kozlova, Collan and Luukka (2016) performed a comparative analysis of the methods which revealed that the fuzzy pay-off method simplifies the analysis and offers sufficient precision for the analysis of problems with low complexity. According to them, the DM method was able to treat more complex problem structures but required more computational time and specialized software.

3.6. Fuzzy pay-off method

Fuzzy pay off-method seem to be considered in existing literature as a modern approach in the analysis of updated cash flows and ROV. Since it was suggested in 2009, many research papers have examined and developed the model further. For example, Mezei, Collan and Luukka (2018) suggested an extension of the method for real option valuation using interval-valued fuzzy numbers using triangular upper and lower membership functions as the basis to account for a higher level of imprecision. The method has been applied in many areas, such as valuing patents, forest investment, R&D investment, and giga-investment (see Collan, Fuller, Wang & Mezei, 2011; Hassanzadeh, Collan & Modarres, 2012; Tohmé, Broz

& Rossit, 2014; Collan, Fedrizzi & Luukka, 2017; Stoklasa et. al, 2021). These six last mentioned papers are excluded from the summary section because they are out of scope of this literature review.

Historically, fuzzy approach and fuzzy numbers have been examined already earlier in several contexts. For example, Byrne (1995) discussed about fuzzy approach for dealing with aspects of risk and uncertainty in real estate analysis, Muzzioli and Torricelli (2001) used triangular fuzzy numbers in modelling vagueness of the price on an asset, extending the standard binomial option pricing model and Siniak (2001) discussed about the use of fuzzy numbers in research of real estate market, finding that fuzzy numbers allow to get model for the property valuation. In context of real estate, fuzzy pay-off method has not yet been widely applied. Vimpari, Kajander and Junnila (2014) stated that literature, especially in the real estate and construction industry, has called for new applications of real options analysis in a practical setting, and noted that measuring economic value of flexibility is not straightforward. To add to that request, they explored how fuzzy pay-off method can be used for valuing flexibility in Finnish office building retrofit investment case. In their evaluation of the empirical usability fuzzy pay-off method was found straightforward because assignment of probabilities into different uncertainty scenarios was unnecessary. In the empirical case, Vimpari et. al (2014) found that flexibility investments were profitable only when only parts of the building were designed flexible.

Giudice, Paola and Cantisani (2017) applied fuzzy logic in real estate investment, stating that there is a wide theoretical background in literature on real estate investment decisions, but a lack of empirical support – in other words a gap between theory and practice. The case study concerned a purchase of an office building using fuzzy logic, resulting that operators and investors are able to improve investment decisions in terms of quality, while reducing the risk arising from the uncertainties of inputs.

In 2020, Collan and Savolainen presented new results in academic literature: they applied fuzzy pay-off method and simulation-based approaches to analyse the effects of phasing a construction project. The idea was to offer practitioners two usable methods: quick one, and more complex one for deeper analysis. Both methods resulted to have a good fit with the information typically available for construction project analysing. The fuzzy pay-off method resulted to be a simple and usable tool in this context and fully supported with the most commonly used spreadsheet software in companies. (Collan & Savolainen, 2020.)

3.7. Summary of the literature review

The literature review shows that within the context of real estate investing real options are not widely used in real life investment analyses. The methods applied to numerically solve real option problems are versatile and typically considered quite complex to be applied in practice. However, the research has been recently developing less complex models. Based on the literature review, Datar-Mathews method and the fuzzy pay-off method can be considered as the state-of-the-art ROA methods based on their good results and convenient application process. The FPOM, specifically in its current form, is likely the most promising one from all ROA methods examined as, compared to DM method, it does not require simulation and it is based on a theory where probability estimation process can be excluded.

There is a summary of the articles and books included in the literature review below in Table 2. The content is listed in order of publishing year.

Table 2. Summary of articles and books in literature review.

Authors	Content of article	Findings
Trigeorgis (1993)	A comprehensive review of the existing real options literature and application, as well as the principles of quantifying the value of real options.	These papers took one of the first steps towards expanding the real options literature to identify different interactions with financial flexibility and illustrate how in practice one can analyze managerial flexibility in the case of different types of both real options, recognizing that these option values can interact.
Byrne (1995)	A demontration of fuzzy logic applied to real estate problems, a discussion of methodology of fuzzy analysis and a comparison of fuzzy procedures with “conventional” risk analysis approaches.	Providing a study about the use of fuzzy logic in the field and raising most questions for the years to come.
Smith and McCardle (1999)	A tutorial on option pricing methods, focusing on how they relate to and how they can be integrated with decision analysis methods, and describe some of the lessons learned from using these methods to evaluate some real-world oil and gas investments.	Option pricing and decision analysis approaches are equally capable of modeling flexibility. In both approaches, evaluation models correspond to the construction of a decision tree or a dynamic programming model, which describes the sequence of decisions to be made and the resolution of uncertainties over time. Option pricing and decision analysis techniques should be seen as complementary modeling methods that can be nicely integrated.

Graham and Harvey (2001)	Survey of 392 CFOs on capital costs, capital budgeting and capital structure.	Large companies rely heavily on present value techniques and the capital investment pricing model, while small companies are relatively likely to use the payback criterion. A surprising number of companies use enterprise risk instead of project risk when evaluating new investments. Companies are concerned about financial flexibility and credit ratings when issuing debt, as well as the dilution of earnings per share and the recent strengthening of the share price in connection with the issue of shares. There is some support for the pecking order and trade-off capital structure hypotheses, but little evidence that managers are concerned about asset substitution, asymmetric information, transaction costs, free cash flows, or personal taxes.
Muzzioli and Torricelli (2001)	Combination of the standard binomial option pricing model with a fuzzy representation of the option's payoff.	The method provided an intuitive way to look at the future price of an asset while incorporating the results of a standard binomial model, allowing for different levels of market knowledge.
Siniak (2001)	Discussion of using fuzzy numbers in different spheres in real estate researches, investments and valuation.	Using fuzzy logic technique and more criteria the real estate market of any country can be estimated.
Ventolo and Williams (2001)	(BOOK)	
Ryan and Ryan (2002)	A survey of the Fortune 1000 CFOs about capital budgeting tools.	Net present value is the most popular tool compared to internal rate of return and other capital budgeting tools. While most CFOs use multiple tools in the capital budgeting process, these results better reflect an academic and business perspective. 205 usable responses were received, with a response rate of 20.5 percent, which is comparable to similar surveys.
Pagourtzi, Assimakopoulos, Hatzichristos and French (2003)	A brief overview of the methods used in real estate valuation.	Traditional real estate evaluation methods include regression models, comparability, cost, yield, profit and contractor's method. Advanced methods include ANNs, hedonic pricing method, spatial analysis methods, fuzzy logic and ARIMA models.
Brounen, de Jong and Koedijk (2004)	An international survey of 313 European CFOs on capital budgeting, cost of capital, capital structure and corporate governance.	Large companies often use present value techniques and the equity pricing model to assess the feasibility of an investment opportunity, but small business CFOs still rely on the payback criterion. In capital structure policy, financial flexibility seems to be the most important factor in determining the amount of corporate debt. Corporate financing practices seem to be mostly influenced by company size, to a lesser extent by shareholder orientation and least by national influences.
Ochoa (2004)	Discussion on how ROA is based and specifically complements the DCF approach passive NPV	ROA corrects the estimates of the passive NPV approach in two ways: a) by taking into account the real alternatives, it increases the value of the project by introducing asymmetry in its cash flows and b) while the passive NPV does not recognize the "strategic value" of the project due to its interdependencies for future, further investments and competitive interactions, ROA takes these interdependencies into account, which generally results in higher estimates than those based on NPV. Empirical evidence shows that ROA explains actual prices better than DCF approaches. There is no doubt about it from a theoretical perspective, ROA is a a more attractive concept than passive NPV. However, it has been accepted by practitioners was very slow, mostly due to difficulties in understanding and applying option pricing theory.

Putten and MacMillan (2004)	Presentation of integrated approachh of DCF and real options.	The integrated approach allows senior executives to make more aggressive investments while fulfilling their fiduciary responsibilities. The valuation formula for the option area is NPV + corrected option value + surrender value. The framework is particularly useful when the discounted cash flow value is modest, as the option value can provide evidence to support or refute the manager's intuition, and should be tested in pilot projects that can be terminated early at a low cost if things do not go well.
Borison (2005)	A critical review of five well-established real options widely documented in the academic and professional literature.	Although the "Classical Approach" and the "Revised Classical Approach" focus on investment flexibility and shareholder value, they are based on fundamentally different assumptions, use significantly different techniques, and can produce dramatically different results. The revised classical approach seems to be best suited to cases where either "market risk" or "private" risk dominates, where approximate results are acceptable and resources are limited. An integrated approach is best suited to cases where there is a mix of market risk and technical risk and where accuracy and a management roadmap are critical.
Hoesli, Jani and Bender (2006)	Adjusted Present Value (APV) method with Monte Carlo simulations for real estate valuation. Empirical data was used to extract information about the probability distributions of different parameters and to propose a simple model for calculating the discount rate.	Empirical results suggest that the central values of our simulations are mostly slightly lower than the hedonic values. The confidence intervals are most sensitive to the long-term equilibrium interest rate used and the expected growth rate of the terminal value.
Sayce, Smith, Cooper and Venmore-Rowland (2006)	(BOOK)	
Block (2007)	A surveys of Fortune 1,000 companies about use of real options to complement traditional analysis.	Out of 279 respondents, 40 currently used real options (14.3%). Although the percentage is small, the number is higher than in previous studies. Somewhat encouragingly, clearly more than half of non-users consider using real alternatives in the future.
Scialdone (2007)	(BOOK)	
Guma, Pearson, Wittels, de Neufville and Geltner (2009)	Demonstrating the potential value of significant vertical phasing as a valuable real estate development option, especially in terms of corporate real estate strategy.	Vertical expansion seems to have significant organizational and logistical advantages for business developers, and the ability to expand vertically is a reasonable way for business developers to have convenient expansion space while limiting their risk, as long as the possibility of vertical expansion is built into the original design.
Michailidisa, Mattasb and Karamouzisb (2009)	Extension of irrigation dam evaluation techniques in Northern Greece comparing the real options approach with the traditional approach, discounted cash flow.	The results clearly show that the irrigation dam can be classified as a profitable investment using traditional discounted cash flow analysis, while applying the real options approach, the project cannot be classified as profitable. Taking uncertainties into account, the real option approach reveals that investment can be postponed and decision makers can keep the investment opportunity open. Sequentially discounted cash flow analysis together with a real option approach facilitates decision making and improves investment evaluation analysis.
Yasseri and Mahani (2009)	A demonstration of how the real option approach can be practically applied to investment decision making in jack ups, consideration of flexibility, strategic growth opportunities and idle time, and a discussion of the applicability of real option valuation to investment decision making.	ROA provides a better tool to guide investment decisions in the context of uncertainty and flexibility. In practice, managers understand that the value of investment timing is significant given the rapidly changing market conditions and uncertain business environment. A key contribution of the analysis is to understand the complexity of projects in order to determine their interdependencies, how one project can be leveraged to initiate other projects, and its impact on projected business benefits.

Ashuri (2010)	A model is presented that uses a real option valuation approach and determines a lease flexibility value, or option premium, which is the maximum amount of money a lessee is willing to invest to include a specific flexible feature in the lease.	The model takes into account the uncertainty in the rental market and the uncertainty about the workspace needed by the company in the integrated valuation framework, but according to the author, it may be too easy to apply to complex, real-world decisions to make situations. However, this study is the first work in a series of studies understand the meaning of innovation workspace strategies in corporate real estate and property management in the 21st century in companies.
Baker, Dutta, and Saadi (2010)	A large sample of Canadian companies to learn if they use real options, what real options are used, and why companies don't use them.	Only 36 of 214 respondents (16.8%) reported using real options, which ranks last among the nine capital budgeting techniques. The reason for using real options is to provide a management tool to help form a strategic vision. The most commonly used real options are growth options and deferral options. Lack of expertise and knowledge prevents the use of real options. The use of real options seems disproportionate to their potential as a capital budgeting tool.
Krychowski and Quélin (2010)	An examination of the applied investment decision in the telecommunications industry in order to highlight the most important advantages related to the use of real options and a discussion of the theoretical problems raised by real options.	The most important contribution of real options is the recognition that investment projects evolve over time and that flexibility has value. RO is useful both for evaluating the investment project and for determining the optimal investment time. Traditional discounted cash flow methods often lead to recommendations that conflict with strategic analysis because they do not take into account the value of the growth opportunities created by the project. Because the analogy between financial options and real options is imperfect, RO creates implementation problems. Case-based Mobitel RO analysis provides an informed decision on optimal investment timing, is a useful tool for dialogue between decision makers and enables a more efficient decision-making process.
Amédée-Manesme, Baroni, Barthelemy and Dupuy (2012)	Shows that the accuracy of real estate portfolio valuation and real estate risk management can be improved by simultaneously using Monte Carlo simulations and option theory.	Combining Monte Carlo simulations of market prices and rental values with an optional model that accounts for rational tenant behavior. Simulated cash flows that take options into account are more reliable than those usually calculated using the traditional discounted cash flow method, which also provides interesting metrics such as the distribution of cash flows.
Ott, Hughen and Read (2012)	Conducting an extention of real options framework to concurrently estimate optimal phasing and inventory decisions for large-scale residential development projects.	In economic environments such as Atlanta, Las Vegas, and Orlando, land developers have been found to build in large lots and hold significant amounts of inventory, despite their ability to mitigate risk by phasing home production. Interactions between several variables show that full development, smooth stepwise development, and lumped development can all be optimal under different market conditions, and each pattern affects inventory levels and lot pricing.
Baldi (2013)	Proposing a conceptual framework as a practical aid in identifying and understanding some frequently repeated combinations of options (such as postponement and extension options). Based on the definition and classification of real estate options available in the real estate market, a valuation tool is developed to quantify the value of the options included in the real estate development project.	Based on the static land value of EUR 34.7 million, the waiting period (postponement option) in the early stage of the property's development constitutes 16 percent of the project's expanded land value, and the expansion's share of this value is 8 percent. option. The real option valuation of the real estate developer's available option portfolio enables the value of the project to increase by 31.1% compared to traditional DCF analysis. According to financial options theory, the values of real options increase as volatility increases. The added value of management flexibility is ignored in DCF/NPV techniques. The theory of option value is suitable for the evaluation of real estate assets (a portfolio approach is crucial when there are several real estate options) and flexibility in real estate development can create added value that allows real estate developers or funds to react to market developments.
Guthrie (2013)	Demonstration of the practical application of real option analysis to the evaluation of multi-phase projects, as an example commercial real estate development.	ROA can be implemented in a spreadsheet and only one parameter – the volatility of the price of the completed project – needs to be evaluated in addition to the parameters required for the static DCF analysis. With the help of the described approach, the project can be evaluated at any stage of development, which is especially useful when considering the suspension of partially completed projects.

Hoesli and MacGregor (2013)	(BOOK)	
Vimpari (2014)	Examining the possibilities opened up by ROA in real estate investment analysis and decision-making, as well as showing the real option value in some current areas of real estate investment.	ROA can enhance the analysis and decision-making of real estate investments and identify value elements that are overlooked by conventional valuation practices. The life cycle performance of real estate assets can be improved through real estate options and ROA can produce results that can encourage the investments necessary for the long-term success of the real estate industry. The calculated values of real options in the different demonstration cases were an 8.8% premium in the case of green construction certification, a range from €8/square meter to €195/square meter in the construction flexibility case, a 6.6% premium in the residential real estate portfolio case. and an added value of 1,580,000 euros in the case of public-private partnerships.
Vimpari, Kajander and Junnila (2014)	An exploration of how real options analysis can be used for valuing flexibility in a real retrofit investment case.	The fuzzy pay-off method can be used to estimate the monetary value of flexibility, and the applicability of the method to a practical investment case was felt to be straightforward, because assigning probabilities to different uncertainty scenarios was unnecessary. In the empirical case, flexibility investments were profitable only when only part of the building was designed to be flexible.
Kozlova, Collan and Luukka (2016)	A comparative analysis of Datar-Mathews and fuzzy pay-off methods.	The fuzzy pay-off method simplifies the analysis and provides sufficient accuracy to analyze simple problems. The Datar-Mathews method could handle more complex problem structures, but required more computation time and specialized software.
Giudice, Paola and Cantisani (2017)	Applying fuzzy logic in real estate investing to evaluate real estate market situations with imprecise and vague information.	The results showed that by correctly applying fuzzy logic, operators and investors can improve their investment decisions. By providing a range of results for changes in inputs, the results arguably represented a more flexible response to uncertainty problems.
Mintah, Higgins, Callanan and Wakefield (2017)	First application of the certainty equivalence approach to the binomial option pricing method to evaluate an Australian housing case study project.	The main tool for financial evaluation of real estate projects (DCF) could not get hold flexible value embedded in the active management of projects, such as the strategy of deferring until uncertainty is resolved. By applying the real option method, the potential related to the projects could be comprehensively evaluated for better decision-making in real estate development. Here, the true option value of A$290,000 was found to be associated with the project, which was missed in the DCF model.
Smith, Driver and Matthews (2018)	A demonstration of real option analysis using the recombining binomial lattice.	Use of real options with appropriate method should help management proceeding with confidence in project decision. Fundamental analysis (DCF), random walk theory application with discrete simulation and backward induction to value the option nodes using risk-neutral equation should be more palatable for analysts who have had difficulty conveying complicated valuation methods to upper management.
Mintah & Baako (2019)	A conceptual model is developed to describe flexibilities/real options and is linked to the real estate development process to determine the precise steps in the real estate development process where real options can be embedded to preserve opportunities to exploit future positive benefits of uncertainty.	The model can serve as a practical tool and visual aid for real estate development professionals and stakeholders to determine the exact stages of the real estate development process in which the real options sink and the different types of options. It will also help deepen operators' understanding of real estate development opportunities and further increase potential acceptance and adoption in the Australian real estate industry. Getting involved in the real estate development process can make it easier to identify flexibilities/real options at different stages of the real estate development process.
Collan and Savolainen (2020)	Application of fuzzy pay-off method and simulation-based approaches to analyzing the effects of phasing of a construction project.	Both methods are well suited to the analysis of a construction project with information typically available and suitable for the task. The fuzzy pay-off method was found as a simple and useful tool in this context and was fully supported by the most commonly used spreadsheet software. The simulation found the optimal investment time for the second stage investment if a two-stage strategy is chosen, and demonstrated clearly whether it makes sense to invest in stages or not.

As a last side note, it is worth mentioning that when dealing with property valuation, it’s important to realize that the ultimate value of the property may include intangible elements that investors are willing to pay, for example, in hope for higher lease revenues. Thus, one shouldn't attribute the value of intangible elements to the tangible asset, that is ultimately taxable. There are also several different purposes for which the valuation is needed, such as sale, tax assessment, expropriation, inheritance, or transfer. This thesis considers only the purpose of income-producing investment.

It can be concluded from the literature review that on academic side there are clear empirical evidence of the usefulness and value of real option application in real estate investment projects where various real option valuation methods are tested successfully. Simultaneously, it is clear that on practitioners’ side real options are experienced too complicated and thus very few companies use them in real estate projects, even when they realize there could be benefits. Traditional investment analysis methods, such as DCF analysis, are widely applied and trusted among companies while realizing its weaknesses. DCF analysis is considered the most common analysis tool in this context, based on the review.

4. DATA, METHODOLOGIES AND APPLICATION

As presented in theoretical background and literature review, there are numerous real option methods that offer methodology for real option valuation, depending on the perspective. The last mentioned, the fuzzy pay-off method (FPOM), developed by Collan et al. (2009), has been applied by several authors (e.g., Collan, Fúller, Wang & Mezei, 2011; Vimpari, Kajander & Junnila, 2014; Collan, Fedrizzi & Luukka, 2017; Collan & Savolainen, 2020) in the evaluation of real options embedded in real estate projects as well as other areas. Due to its relative simpleness of use, easy justification, and ability to reach a single quantification to support the decision-making process along with the NPV based graphical presentation, the FPOM is the methodology used in this study as it serves the cause of the study well. The idea is to model the possibilities in the case study, and to find a single numerical value representing the real option value (ROV). Another methodology is the Monte Carlo simulation (MCS), which intends to model the risk side via probability distribution and present the expected NPV value of each of the strategies.

Before applying either of the methodologies, the DCF analysis is conducted along with sensitivity analysis which provides the needed factors for simulation purposes. The data for DCF analysis will be retrieved from existing peer evaluated literature where Collan and Savolainen (2020) analysed the value of phasing in a construction project with FPOM and Monte Carlo simulation. The latter method was used from different perspective (to dive deeper in analysing the value of the project) than in this study, thus it is important to state that the data is retrieved specifically from the FPOM part of the research paper, and then used for further application in this study. This process is described next in sections.

4.1. Case description

The empirical section of this study examines a case example from the literature, where Collan and Savolainen (2020) examined two different strategies for the construction of a 10,000 m² office complex. More specifically, they looked at whether there is value in phasing the construction, if the construction was done in two parts: 5,000 m² now (phase 1) and 5,000 m² in 5 years (phase 2), instead of the whole 10,000 m² at once. The valuation was based on experts' cash flow analyses, consisting of three different scenarios (maximum, representing the optimal scenario, best estimate, representing the realistic scenario, and minimum, representing the pessimistic scenario).

4.1.1. Introduction of the original case

In the research paper of Collan & Savolainen, 2020, two different valuation perspectives were used: "quick and dirty", where the fuzzy pay-off method based on real option theory was used to get a clear general understanding of the effects of phasing on project cash flows and NPV, and a more precise system dynamic simulation for deeper analysis in the matter (e.g., for optimal timing matters). In the study, Collan and Savolainen (2020) managed to demonstrate how the effect of phasing on the value and the risk of construction investments can be analysed with the two different methods.

Considering the fuzzy pay-off method of the study of Collan and Savolainen (2020), the numerical value of phasing (real option to phase the investment) the construction was illustrated by calculating the difference between the expected mean NPV of the two alternative strategies (with and without phasing). It is noteworthy to mention that the research paper included also an illustration where it was numerically demonstrated what would happen for the minimum cash flow scenario if the second phase of 5,000 m² office complex was not built in the situation where the project was found unfavourable after the phase 1. The benefits included visualizing the effect on the risk profile of the project, although it was stated that the real option to phase did not seem to be very valuable by the measures of the mean NPV, or possibly the best estimate NPV (one can argue which is more suitable in one's intentions).

However, it is worth mentioning that the analysis did not include the alternatives to the maximum and best estimate scenarios, thus it does not perfectly reflect the alternative situation where neither in the maximum or the best estimate scenarios include the costs of the construction of phase 2 and both scenarios do include 50% less revenue is leases (both short-term and long-term). In more specific, the analysis only included scenario of "minimum 2" but not scenarios of "maximum 2" and "best estimate 2".

If it did, the NPVs for scenarios maximum 2 and best estimate 2 could have been included, and therefore the mean NPV in such situation would have been different. See Table 3 (Collan & Savolainen, 2020) and Table 4 where this difference is illustrated. Table 3 shows the comparison of original study's FPOM part and Table 4 shows the alternative situation where the scenarios of maximum 2 and best estimate 2 would have been included.

Table 3. Two strategies (one phase and two phases) illustrated in figures added with third one in which after first 5,000 m² construction phase the project is ended (two phases 2). The differences between these strategies illustrated in right where * means preference of strategy one phase (Collan & Savolainen, 2020).

	STRATEGY ONE PHASE	STRATEGY TWO PHASES	STRATEGY TWO PHASES 2	DIFFERENCE ONE - TWO	DIFFERENCE ONE – TWO 2
Optimistic NPV	608	355	355	253*	253*
Best estimate NPV	140	142	142	2	2
Pessimistic NPV	-136	-209	-34	73*	102
Mean NPV	172	119	148	53*	24*
"Risk factor"	152	115	80	37	72
"Risk factor, %"	88 %	97 %	54%	N/A	N/A
"Success factor"	91/100	78/100	98/100	13/100*	7/100

As can be seen, the maximum and best estimate NPVs do not change due to the lack of scenarios maximum 2 and best estimate 2 in the original analysis. The comparison is illustrated in between "two phases" and "two phases 2". In Table 4, it is demonstrated how the comparison changes when scenarios maximum 2 (to calculated optimistic NPV) and best estimate 2 (to calculate best estimate NPV) are included:

Table 4. Illustration of the comparison when scenarios maximum 2 and best estimate 2 are included (based on the study of Collan and Savolainen (2020) and modified for illustrative purposes).

	STRATEGY ONE PHASE	STRATEGY TWO PHASES	STRATEGY TWO PHASES 2	DIFFERENCE ONE - TWO	DIFFERENCE ONE - TWO 2
Optimistic NPV	608	355	309	252*	298*
Best estimate NPV	140	142	176	2	36
Pessimistic NPV	-136	-209	-34	73*	102
Mean NPV	172	119	163	53*	24*
"Risk factor"	152	115	70	37	82
"Risk factor" %	88 %	97 %	43 %	9 %*	45 %
"Success factor"	91/100	78/100	98/100	13/100*	7/100

As now can be seen, the highest best estimate NPV is now in strategy of two phases 2, which is not to construct the phase 2 at all.

Nevertheless, the point of the findings is not changing, and the authors clearly state that the fuzzy pay-off method and the simulation-based analysis, used within the context of the particular research paper of Collan & Savolainen (2020), must not be compared among themselves as the latter offers much deeper analysis that the first one, although this illustration now shows the same idea of the maximum NPV, which is to not build the phase 2 at all, that now has the highest best estimate NPV.

The simulation part of the study (Collan & Savolainen, 2020) consisted of three additional sub-models, making it in total of five “strategies”. The simulation-based analysis showed that the highest best-estimate NPV can be found from the strategy 5, which is the strategy to build only the first phase of a two-phase construction while all five strategies gave a 100% success factor. See Table 5 for more details that shows the comparison from the simulation part of the original study of Collan and Savolainen (2020):

Table 5. Five strategies in simulation illustrated in figures (Collan & Savolainen, 2020).

STRATEGY	1	2	3	4	5
Optimistic NPV(*)	313	206	312	312	324
Best estimate NPV	225	149	219	236	284
Pessimistic NPV(*)	134	92	119	152	237
Positive NPV Mean	225	149	219	240	284
Success factor, %	1.00	1.00	1.00	1.00	1.00
Risk factor, %	0.31	0.47	0.32	0.29	0.24

(*) with 1% probability

From this it can be seen that the strategy 5, not to construct the phase 2 at all, has the highest best estimate NPV. Now, both analyses support the same strategy which will even increase the reliability of these analysis methods, however it remains to argue whether best estimate NPV or the mean NPV is the “correct” value to examine as Collan and Savolainen (2020) state.

Next, this case will be used as an illustrative example case for this thesis, but it will be slightly modified. The changes and final case are explained more specifically in the next section.

4.1.1. Modifications and final case description

For the purposes of this thesis the case was modified. The changes are listed in the below Table 6, after which the final case is described in more specific.

Table 6. The differences between the original case of Collan and Savolainen (2020) and the final case used in this thesis.

Subject	In original case	In this thesis	Possible issue	How is tackled in thesis case
Strategy one (strategy1)	10,000 m² office complex built now at one phase.	10,000 m² office complex built now at one phase.	The costs are the same but the absolute cash flows may differ slightly.	The NPV value is the same in both cases (in original and this thesis) if calculated with the same discount rates.
Strategy two (strategy2)	5,000 m² office complex built now (phase 1) and 5,000 m² office complex in 5 years (phase 2). This causes extra cost of 15% divided equally between phase 1 (7.5%) and phase 2 (7.5%).	5,000 m² office complex with flexible construction parts built now (phase 1) and 5,000 m² office complex with flexible construction parts in 3 years (phase 2). This causes extra costs of 25% divided the following: 10% for the first phase and 15% for the second phase .	Office complex with flexible construction parts add costs 10% higher compared to the strategy 2 in original case and 25% compared to the strategy 1 in both cases.	Flexible construction parts are more expensive but they offer tenants the possibility to adjust the space according to their business needs that is in demand. This mean higher revenues. Also, it offers the project managers a possibility to extend the business into new area if the office rental market is decreasing in 3 years.
Strategy two 2	Only 5,000 m² office complex built now (phase 1).	-	-	-
"Plan B" if the market declines or things go wrong	-	Managers prepare in advance to change the course if pessimistic scenario will realize (option to expand the business).	With flexible construction parts managers can change the business away from office complex into almost any new rental market, e.g. hotel property. This option have extra costs of 25% in total compared to the costs in strategy 1.	-
Strategies 3 - 5	Used in simulation part.	-	-	-
FPOM	Used for ROV.	Used for ROV.	-	-
Simulation	Used for deeper analysis where three additional sub-models (strategies) were used. Applied in total of 5 strategies.	Used only for risk analysis without adding any sub-models / strategies. The simulation part from the original paper is not applied in this thesis. Instead, simulation is used in different purposes.	The model in the thesis only included uniform distribution of NPVs.	Uniform distribution is suitable for the contex because every outcome in the sample is considered here as equally likely. For more sophisticated model this issue must be covered to enable e.g., different weighting in the possible outcomes.

ROV	The difference between the expected (possibilistic) mean NPV of the two alternative strategies (with and without phasing).	The difference between the expected (possibilistic) mean NPV and/or ROV of the two alternative strategies (with and without phasing + flexible parts).	There is room for interpretation: one can decide to use either possibilistic mean NPVs or calculated ROVs for comparison.	In the thesis, strategy 1 (without phasing + flexible parts) had possibilistic mean NPV = ROV and strategy 2 (with phasing + flexible parts) had possibilistic mean NPV ≠ ROV. One can compare each one as long as one understands what the value represents. In FPOM, ROV represents only the "possibility part" of the NPV distribution while possibilistic mean represents the whole NPV distribution.
Real option	Phasing (option to wait/postpone up to 5 years before deciding about the second phase).	Phasing (option to wait/postpone up to 3 years before deciding about the second phase) and changing the course if market situation changes (option to extend the business into new area).	-	-
Discount rate	4% for costs and 9% for revenues.	4.81% (around 5%) for costs and revenues (nominal rate of 9% excluding estimated inflation).	-	-
Cash flows	Years 0 - 15 without terminal value	Years 0 - 15 without terminal value.	Terminal value should be included but is left out for illustrative purposes.	-
Sensitivity analysis	-	Is used to see the most sensitive factors for simulation part.	-	-

The case is a continuum of research paper of Collan and Savolainen (2020) where there was a construction project case that had two options: to build 10,000 m² office complex at once or build two 5,000 m² office complexes in two phases (assuming to pay nominal 15% higher price for this option, equally divided between the two phases). Collan and Savolainen used two different methods, fuzzy pay-off and simulation, to illustrate the analysis and valuate the option. Here, only the fuzzy pay-off version is considered (the “quick and dirty” one) where the possible second phase will start in the beginning of year 5 in the original case.

In the paper of Collan and Savolainen (2020), it was demonstrated that the phasing had value and it comes from the difference between the mean NPV of these two scenarios (alternatively, one can argue whether the value should be between mean optimistic, realistic or pessimistic scenario NPVs), however the conclusion was that the visualization of the range of possible outcomes is a proxy for risk. The numbers and the visualization demonstrated that the real option to phase the construction wasn't valuable by these measures (for the reasons discussed and illustrated in the previous section), but phasing seemed to have an effect on the risk profile which is good information for risk-averse investors.

The intention of the paper of Collan and Savolainen (2020) was to illustrate the possibilities that these models can offer (mitigating risk and optimizing value via phasing strategy) in construction investment analysis process and thus, it did not include any more specific reasons or alternativities for, for example, what to do if the strategy of phasing the construction was taken and then realized the market for office rental market has evolved according to pessimistic scenario. In other words, what is the "plan B" if things go wrong. In real world, managers should always be on the top of maximizing the value of every investment case, and realistically, usually there are other options than just to abandon the project, or at least such alternatives should always be retrieved. The idea now is, that the project managers are very attentive to the changes in their operative environmental trends and weigh different possibilities even before deciding to make an investment. In other words, they already think in advance what "plan B" would be if things evolve badly (according to pessimistic scenario).

Therefore, now the original case is changed in a way that in case of pessimistic scenario, the managers of this project will prepare themselves to change the course in the project. Good managers are aware of the surrounding world and open-minded to act when needed. Managers of the project have investigated the market beforehand and are aware that the most frustrating factor in company facilities is their inflexibility meaning that companies are unable to scale the size of the premises it rents (see Jones Lang LaSalle,2018). Also, hybrid working models and sustainability matters are setting their own demands for office buildings (see Jones Lang LaSalle, 2021). Applying all these findings would increase the construction costs on short-term but they are large factors that have an impact on companies (the office tenants), especially in the future.

The idea of the original 10,000 m² office complex will remain the same, but the other strategy (strategy 2) is adjusted in a way that project managers have to option to build two 5,000 m² office complexes in a way that the materials are constructed flexible in the first one.

Managers are willing to see how the market evolves in the next three years (instead of five that was in the original case) and how the flexible office complex is accepted in the market before they make the decision how to build the next one. This way managers have the flexibility to decide to change the course after three years when the construction of the second 5,000 m² office complex is about to start.

By preparing this way, the second office complex can be changed, e.g., either to serve better the needs of business travellers or tailored to better fit for any other groups in the future before renting it for businesses. It can be even easily altered into a hotel building due to the adjustable walls and other adjustable (flexible) parts of the building. Especially the fast-pacing technology changes are bringing uncertainty to the investment because managers want to be able to offer modern tools that the market is requesting but currently it is very unsure how the market will accept them. For example, office automation control systems with automated heating, lighting, and air conditioning need built-in sensors that can adjust the environment based on the number of people in the office, allowing to provide the optimum working environment, or digital visitor management solutions must be taken into consideration already in construction phase to make the space functional. In addition, the difficult-to-predict economic situation, rising construction costs – current construction cost index is 9.7% (Rakli, 2022a) – and the uncertain availability of building materials and products are worrying the project managers.

The additional cost of phasing 10,000 m² complex into two 5,000 m² complexes was 15% in the original example. Now, the additional cost will be 25% due to flexible construction parts, such as movable walls and multifunctional fittings. This 25% additional cost is divided the following: 10% for the first phase and 15% for the second phase which is three years after the first one. The cost is 5% higher in the second one because an extra budget is needed for the possible additional adjustments after the results of phase one are visible, although with careful planning from the start they can be well mitigated. Compared to the original Collan’s and Savolainen’s (2020) example, the additional cost of phasing (without the flexible office model) was 15%, divided equally between the two phases, making it 7.5% additional cost for each in that case.

4.1.2. Revenue and business model

As according to the original case of Collan and Savolainen (2020), the project has two sources of revenues, 70% of the rented spaces consist of long-term leases (10-year contracts) and 30% of short-term leases. The long-term leases are assumed to create a stable revenue with a low risk of having unoccupied spaces. The short-term leases are assumed to be minimum one-year contracts that command a 10% higher rental income per square meter. However, they include a risk to cause more empty periods between tenants. The rent is assumed to have a 3% annual growth trend.

The project experts are forecasting the potential cash flows in three scenarios: optimistic (maximum), realistic (best estimation) and pessimistic (minimum). It is estimated that if everything will go as planned it will be possible to achieve the maximum cash flow estimation. This means that project will not be delayed, it will not face any extra costs during construction and the short-term tenants will stay or are replaced immediately after the previous one, thus leaving no empty months in between. The pessimistic scenario is prepared as if everything would go badly and produce minimum cash flow estimation. In cash flow forecasting, basic procedure of NPV calculation is performed with DCF method.

In the original case, as the NPV calculation theoretically requires the assessment of the costs' and revenues' risk levels for the derivation of proper discount rates, a separate discount rates of 4% and 9% were used for the costs and revenues. In this thesis instead of using two discount rates, a single discount rate is used for simplified illustrative purposes. Even that it is theoretically justified to use risk-based discount rate for different cash flows, many companies prefer using only one that reflects the companies' required rate of return.

Prices are known to rise in the construction industry. For example, in Finland, according to Rakli-KTI business space barometer currently the required return level for prime offices, is only 3.7% (Rakli, 2022b) and in summer 2022, inflation was expected to rise to 5 percent this year and fall to 2-3 percent next year in Finland (Rakli 2022a) but was 8.3 percent in October 2022 (The Finland Chamber of Commerce, 2022). The inflation is thus very high at the moment and includes high level of uncertainty. The total return on direct real estate investments currently being 9.2 percent (Rakli, 2022a) it is decided that the required rate of return for this project is 9% including inflation. Inflation is estimated to be exceptionally high 4% for the next 15-year period which will make the real-term discount rate around 5%, or 4.81% in more specifically (calculated as ((1+9%)/(1+4%))-1).

4.1.3. The initial setup of the case

First, the estimated cash flows for each scenario from the original example of strategy 1 (see Collan & Savolainen, 2020, Appendix 1) are plugged in into a spreadsheet software. Then, the discount rates of 4% and 9% are both changed into around 5% (according to the calculation equation above) to get the new NPVs for each scenario. After this, all these numbers are adjusted in a way that only the original cost cash flows remain the same (i.e., the investment) and the NPV of 15-year cash flows remains the same for each scenario, however discounted at around 5% and thus being different in absolute terms. The revenue cash flows (behind NPV) will change completely due to the application of capital budgeting illustration example (see Appendices 12–17) that is created behind these numbers for each scenario for later simulation purposes. The capital budgeting process means that the model includes inputs, factors, that will create such outputs in the calculation as income or expenditure streams and cash flows. Later, according to the sensitivity analysis some of the most sensitive factors are chosen for simulation to better see the probabilities of different outcomes. Another purpose is to test the suitability of traditional capital budgeting process. All cash-flows are estimated excluding inflation which is already accounted in the around 5% discount rate.

In capital budgeting process some relevant costs are accounted in the project as an example, such as maintenance costs and taxes. A small amount of working capital investment is accounted for the two starting years due to high marketing costs which is released back after first two operating years. More specific illustration of each capital budgeting calculation are in Appendices 12–17. As in the original example (Collan & Savolainen, 2020) in the maximum scenario, it is assumed that the construction is finished according to the schedule and the revenues start to accrue faster than in the two other cases, where the construction is finished late. Visual presentations of the cumulative net present values for both construction strategies in each scenario are presented later in Figures 8 – 13 and jointly in Figure 7.

Regarding strategy 2 (build in two phases with flexible construction parts), constructing flexible office complexes in two phases, the process is different compared to the original case, as mentioned earlier. The initial investment costs are now calculated based on strategy 1 (build with one phase), added with 25% increase for each of the three scenarios divided as described earlier (10% for phase one and 15% for phase two). Then, the timing of the initial investment costs are estimated along with other relevant factors in capital budgeting process.

NPVs for each scenario are based purely on the individual forecasting of the future cash flows, otherwise same principles of capital budgeting process are applied. It is assumed that in this strategy there will be more facilities for tenants due to the flexible form of the premises, accounting for higher revenues per square meter and higher overall occupancy rates in maximum and best estimation scenarios. This means that companies (tenants) can adjust their premises according to their business needs and the facilities can serve several different types of businesses due to their adjustability. The location of the office complexes is in high demand, reducing the risk of empty months between tenants. Then, in the minimum scenario the risk of tenants not accepting the new, flexible facilities model is accounted by lower overall rental income per square meter.

4.2. The analysis process

In practice, the analysis process includes capital budgeting process which means preparing several spreadsheets as following:

First, a spreadsheet for the i) input factors and ii) output factors that are divided as a) income and expenditure streams and b) cash flows. The cash flows will the calculate the NPV which is the cumulative cash flow value for the period between years 0 and 15. It is important to realize that this particular calculation does not include the property's terminal value, which typically have several tens of percent of the total NPV, thus being a critical part of the DCF analysis in real life applications. The reason for this is simple: the original case did not mention it and seem not to include it, based on the original figures in the DCF analysis, probably due to the illustrative purposes of the need of having a negative NPVs. For the illustrative purposes with this case example, it serves the cause well in strategy 2 (build in two phases with flexible construction parts) where the NPV will be negative value in pessimistic scenario. This would have not been the case if the terminal value would be included (added as an additional cash flow beyond the initial forecast period) in the analysis.

In real life applications, terminal value is an essential part of investment analysis process. That being said, eventually it is only an attempt to anticipate the investment's value in far away in the future (after the last investment year in the analysis) where one must apply it to the present value through discounting with "proper" discount rate (d). It also includes some problematics. Usually, investors will not get rid of a well income producing asset. This means the investment should continue its operation infinitely and thus must have a proper value included in the profitability analysis. In this case, the investors should evaluate a "proper" terminal growth rate (g) that will continue infinitely and then divide the last forecasted cash flow, added with the value of the terminal growth rate, by the difference between the "proper" discount and terminal growth rates to get the terminal value of the investment: (FCF x (1 + g)) / (d – g).

Another way to model the terminate value would be to use liquidation value model to find out "exit value" with exit multiples when the investors want a return of principal. In this situation, the terminal value is treated as a bookend to close out the investment and it must reflect the net realizable value of the property after the investment holding period for which the property will be sold. Exit multiples estimate a fair price for the property by multiplying suitable financial statistics, such as sales, profits, or earnings before interest, taxes, depreciation, and amortization (EBITDA) by a factor that is used for similar properties (see e.g., CFI, 2022d). For commercial real estate cases the terminal value is often estimated by applying a terminal capitalization rate to the forecasted net operating income (NOI) at the time of sale. Capitalization rate is a real estate valuation measure that is used in comparison of different real estate investments. There are many variations of it, however, generally it is calculated as the ratio between the annual rental income to its current market value.

The difference between these two approaches is that the perpetuity growth model does not assume the company will be liquidated after the terminal year while the multiples approach accounts exactly that. Nevertheless, without the terminal value in this calculation, there exists an unreasonable, and unrealistic, projection that the investment would simply disappear and cease all operations at the end of the initial forecast period which is obviously not the case. However, due to the beforementioned reasons this particular calculation does not include the mentioned terminal value in the calculation.

Structure of the whole analysis process is the following:

- Investment valuation method: DCF calculation and sensitive analysis
- Real option analysis method: Fuzzy pay-off
- Risk analysis method: Monte Carlo simulation based on sensitivity analysis

The presented structure is in chronological order because DCF calculation must be performed first for being able to perform ROA and simulation. Regarding sensitivity analysis it is not mandatory part regarding ROA, but it is recommended for the simulation part.

4.2.1. Discounted cash flow analysis

Discounted cash flows are presented as outputs of the input factors. Both strategies are done in separate workbooks, i.e., both strategies will have its own profitability analysis calculations. The model is built as follows:

First, based on inputs, the accounting cash flows are prepared. These include the investment and the operating costs (possibly other costs as well) as negative cash flows for each operating year from 0 to 15, and rental income as positive cash flows for the same years. This results as EBITDA value, from which depreciations will be calculated for taxation purposes. The purpose of depreciation is to reduce the acquisition cost of the investment asset belonging to fixed assets during their useful lifetime from the income that is obtained through the contribution of the asset. Basically, the investment cost is converted into depreciation that diminishes the tax base in a more distributed manner. Possibly impairments are also accounted here. After this, the operating profit (EBIT) is obtained, from which the tax is deducted to get the net income value. The annual 2% growth rate of maintaining costs per square meter is accounted for operating costs.

The inputs include several factors that calculate the output results via formula. A number of relevant inputs can be included here but, in this case, only some of the most relevant are chosen, such as the total investment costs, nominal and real interest rates, inflation, number of square meters, rental income per square meter, maintenance costs per square meter, working capital investments and tax rate. Some of the relevant factors in the model could have been, for example, to use different occupancy rates for each year and well as step by step increasing rental income levels, but these interesting modifications were left out from the final model.

After the accounting side, the actual cash flows are modelled. Here, only the actual cash flows are included and thus, e.g., depreciating is excluded. The investment cost, operating costs, working capital investments and taxes are included as negative cash flows, while rental income and released working capital are included as positive cash flows. These result as free cash flows for each operating year which is then presented also as the cumulative free cash flows. These two results are then discounted with the real interest rate (discount rate) of around 5%. The final year's cumulative discounted free cash flow is the NPV of the whole investment, in this case, without the terminal value of the investment.

This process is repeated in total of six times: three times for strategy 1 (build with one phase) to model each scenario (minimum, best estimate and maximum) and three times for strategy 2 (build in two phases with flexible construction parts) to model each scenario (minimum, best estimate and maximum). All the three scenario calculations can be easily put into one workbook with a scenario tool where all the input factors are applied, and then just choose one of the three scenarios. However, two different workbooks for each strategy seem easier considering the next steps. All cash flow analyses are in Appendices 12–17 for more specific information.

4.2.2. Sensitivity analysis

On next worksheet in the same workbook, a sensitivity analysis is built with the help of Excel macros that record each calculation step with only one button click. A connection is established in the cash flows sheet to model what will happen to the NPV in each scenario if the selected factors are decreased or increased 10 to 50 percent. The selected factors are investment cost, discount rate, inflation, rental income per square meter and maintenance costs per square meter.

Sensitivity analyses reveal that the rental income per square meter has the most affect in the NPV, i.e., it is the most sensitive factor in the investment case among the selected factors.

For managers this is important information because it enables to carefully evaluate the probability of reaching the targeted level of rental income per square meter, as well as to stay focused on any changes that will affect it during the project if it is decided to proceed. Also, some extra investigation and analysis may be targeted into that factor already before deciding to proceed. For each scenario, the sensitivity analyses are in Appendices 6–11.

4.2.3. Application of Monte Carlo simulation

One possibility to evaluate the probability of reaching the targeted level of rental income per square meter would be to use Monte Carlo simulation and establish a separate workbook for that purpose. This model could be built by investigating the market and selecting the most proper factors that affect on the level of rental income. Important factors could be things such as the location, extra services offered to the tenants and the general level of office complex rents in the market. Then setting the maximum and minimum boundaries one could simulate the effects on these changes in rental level.

In this case the Monte Carlo simulation is used to estimate the probabilities of reaching an expected level of total investment’s NPV, which is the probability-weighted mean of all NPVs in the simulation run, by random values between the maximum and minimum levels of the selected factors. The selected factors for simulation are investment cost, inflation, rental income per square meter, maintenance costs per square meter and tax rate.

The model works as follows: from the separate worksheet the NPVs are stemmed into a built simulation tool where random values are tried as many times as the user sets them, the maximum level of being around 10,000 runs. The calculation is repeated every time again when the value of any the selected factors is changed, and thus the NPV is changed. The changing NPVs are recorded in background memory which is then presented as a visual histogram of the probability distribution of NPVs, and as numerical values where is the probability-weighted mean of all NPVs represent the expected NPV, the share of negative NPVs represents risk, and positive NPVs represent potential of the investment. Obviously the minimum and maximum boundaries are set according to the minimum and maximum scenario values.

The simulation is executed with the help of macros and additional coding that requires the use of for-loop to make the simulation run simple. For-loop is used to repeat a specific arrangement (a block of code) a specific number of times until certain condition has been satisfied and it is a common command for numerous of programming languages. This makes the usability of certain tasks very simple. Also, there are numerous methods of probability distributions to be applied, as is described in Section 2.6.1. Here, a uniform distribution is applied, which means that all values that fall between the minimum and maximum occur with equal likelihood, i.e., there is no emphasis on any certain values to occur more likely than others. All positive NPVs in the distribution are presented as green pillars, and the negative NPVs as red pillars. The distribution can be presented in different bins that can be adjusted according with the preference of user.

An illustrative outcome of the simulation can be seen in the below examples (see Figures 5 and 6). The expected NPV is presented on the top left and on the right side it is shows along with other relevant statistical values. These examples were run 5,000 times and are only examples, not the results of the actual case yet.

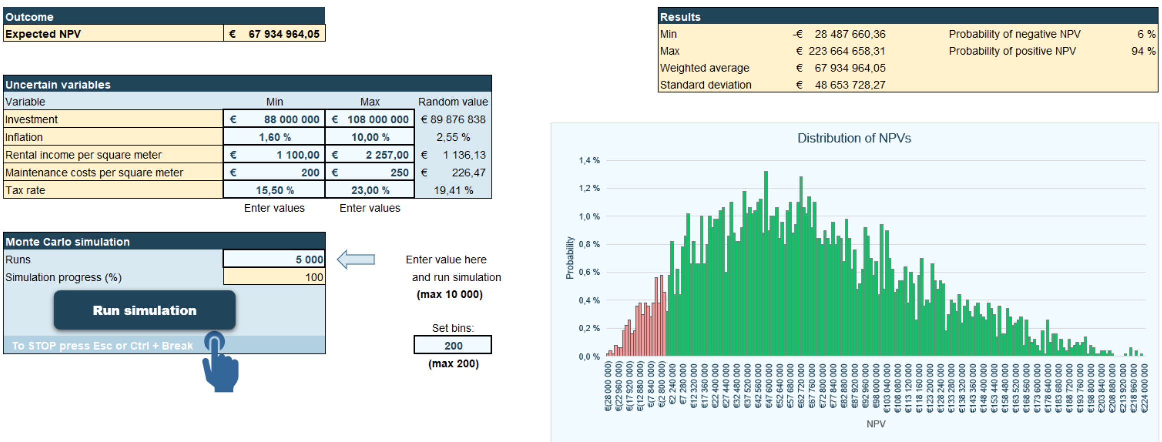


Figure 5. Illustrative example of simulation runs with a positive skewness distribution and low level of risk.

When ranges of investment, rental income and tax rate are adjusted towards more negative scenario (larger cost range with limited possibility to gain as high rental income), the distribution on NPVs will change (see Figure 6 below).

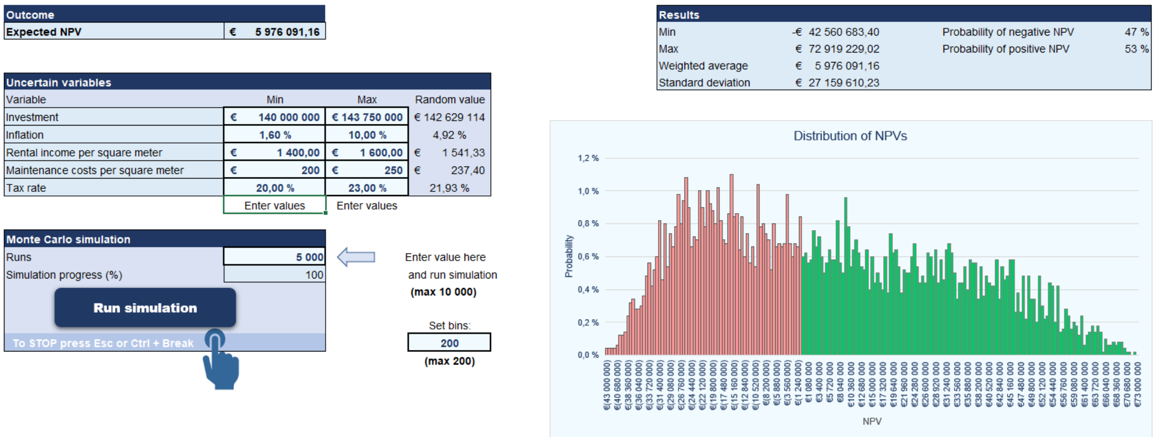


Figure 6. Illustrative example of simulation runs with a positive skewness distribution and high level of risk.

The actual case simulation results are presented in Appendices 4 and 5, and in Figures 14–17 where different numbers of bins are also illustrated. The actual simulations are done with 10,000 runs.

4.2.4. Real option calculation

Finally, the real option approach is applied to the investment case. In practice, two different real option analysis (ROA) are prepared to calculate two real option values (ROV) for each strategy.

What is important to notify here, is that on general level the risk profile of an option differs from the risk profile of the total project. Thus, discounting the project by using the project discount rate, typically WACC, is not valuing the option theoretically correctly. Therefore, options should be valued separately, and the total value of the investment is the sum of the NPV and the value of the options. This is how typically options are applied in the investment analysis. For example, Putten and MacMillan (2004) described a process where project's NPV is calculated with DCF analysis, and then looking closely at the range of costs that will incur as well as the uncertainty surrounding the terms under the investment case to estimate project's volatility. The result of this is equivalent to the adjusted option value (AOV) term in their approach (there are two different methods to calculate this). Then, considering the possibility of selling the investment, equivalent to the investment's abandonment value (ABV), the total value of the project can be calculated by adding these three together.

Here, the approach is different. As referring to Collan's and Savolainen's (2020) work, in calculation results they presented the different NPVs for each strategy and each scenario, stating that "the difference between the value of two strategies is the value of phasing", whether it is the difference between the mean NPV, or the best estimate NPV, of the project with the real option and without the real option. They seem to refer phasing as the real option in the case, which is essentially true according to the existing literature where real option is typically some additional benefit or possibility to influence the investment's profitability (see different option types in Section 2.5.1).

In this case, the same approach is taken, however, the results are interpreted from only slightly another perspective: in real life, every possibility to execute something (to have a certain strategy) can be interpreted as a real option itself. One has the option to proceed according to strategy 1 (build with one phase) or strategy 2 (build in two phases with flexible construction parts) in this case. Both of these can be practically interpreted, or treated, as real options. The point is to compare them: which one is better and why? This seems to be the idea in Collan and Savolainen's (2020) study as well.

The approach in this study is to present a simple, detailed outlook on both options. This includes the earlier performed DCF analyses along with simulation of probable outcomes that enable to model the risk side while visualizing the possibilities. This would be already quite sufficient level of information, at least for some, but there remains one specific problem: the distribution of NPVs in each scenario between the two strategies. Strategy 1 (build with one phase) has positive NPV in each scenario while strategy 2 has very much more lucrative NPVs in best estimation and maximum scenarios. And this is the place where fuzzy pay-off is allowing to calculate the absolute, monetary value for each of the strategies with theoretically stable method. This value is the possibilistic mean NPV that is representing the whole NPV distribution of each strategy. This is not the same as ROV. In practice, the calculation process is very simple. For both strategies, equation (3) can be used to calculate the possibilistic mean NPV, representing the value of each strategy.

Real option value (ROV) is then the possibilistic mean of the positive side of the NPV distribution multiplied with the positive area of the NPV distribution over the whole area of the NPV distribution. This can be calculated by applying the suitable formula from equations (3) to (6). For strategy 1 (build with one phase) it can be seen that the whole fuzzy NPV distribution of the project lies above zero, and therefore equation (3) is to be applied. This equation also represents the possibilistic mean NPV value, meaning that the possibilistic mean NPV is the same as ROV. The maximum scenario NPV represents "a + β", the minimum scenario NPV represents "a – α", and finally the best estimation scenario NPV represents "a".

Respectively, for strategy 2 (build in two phases with flexible construction parts) it can be seen that the fuzzy NPV distribution lies partially above zero, in a way that zero is between the minimum possible NPV and the best estimation NPV, and therefore equation (4) is to be applied. The possibilistic mean NPV can be calculated with equation (3) as in strategy 1 (build with one phase). In this case, the ROV is not the same as the value of the whole NPV distribution. Again, the maximum scenario NPV represents "a + β", the minimum scenario NPV represents "a – α", and finally the best estimation scenario NPV represents "a". Values of β and α can be calculated with the help of a that is known, after which the values can be applied in both equations. This way, both strategies have received an absolute value, and also a real option value (value of possibilities) that can be compared.

5. RESULTS

The numerical results of the case study are presented in the following Table 7 (in million euros) and in Appendix 1 in exact results in euros. The results are obtained from the discounted cash flow analysis, the simulation between previously mentioned selected input factors that range between optimistic (maximum) and pessimistic (minimum) scenarios, and the real option analysis that was conducted with the fuzzy pay-off method.

Table 7. Numerical results of the case study.

(in million euros)	Strategy 1 (build in one phase)	Strategy 2 (build in two phases with flexible construction parts)	*Difference*	Method from which the value is obtained
Real option value	59.61	98.37	*38.76*	ROA
Possibilistic mean NPV	59.61	98.35	*38.74*	ROA
Optimistic NPV	113.61	168.37	*54.76*	DCF
Realistic NPV	55.01	108.24	*53.23*	DCF
Pessimistic NPV	24.00	-11.22	*35.22*	DCF
Expected NPV	91.89	98.80	*6.90*	Simulation
"Risk factor"	0 %	4 %	*4 %*	Simulation
"Success factor"	100 %	96 %	*4 %*	Simulation
Standard deviation	41.74	65.45	*23.71*	Simulation
Min NPV	0.62	-34.57	*35.19*	Simulation
Max NPV	216.88	299.99	*83.11*	Simulation

From these results it can be interpreted that while strategy 2 (build in two phases with flexible construction parts) includes more risk than strategy 1 (build with one phase), the level of risk is very moderate and the strategy 2 offers highly absolute profit possibilities. This can be seen from the differences in risk and success factors, as well as the standard deviations. The standard deviation shows whether the variation of values around the average is small or large. This is hard to judge without a reference point but here the values can be compared to each other. Only a nominal difference can be found from the risk and success factors, but the standard deviation values indicate that, on average, the results are more spread out in strategy 2 that they are in strategy 1. The strategy 2 has larger standard deviation than strategy 1 which means that, on average, the results are more far away from the mean value in strategy 2.

The results also reveal that the pessimistic scenario did not manage to capture the absolute extreme worst-case scenario that simulation succeeded to do (see the differences between pessimistic NPV and min NPV). The reason for this is the static nature of the DCF analysis that could be avoided only if all the input factors in the model are built as adjustable, which was not the case here. This was intentional in this illustrative case. For example, the tax rate or maintenance costs had no ranges in DCF model as they had in the simulation part, instead they were static input values. The same happened with the maximum scenario where the different ranges of inflation level caused extreme changes in the real interest rate, i.e., the discount rate, which then affects on the NPV. It is likely not optimal to build the DCF model to have inputs between ranges as it creates unnecessary complexity in the process and thus “breaks” the idea behind it. Instead, it is likely optimal to keep the DCF scenarios as they are, and then build a separate simulation tool where one can try even the more extreme trials, for example, to see the possible, but not probable, effects of the extreme level of inflation. This kind of visibility is likely to increase the level of insight of the case when one understands the process behind it and see why the NPV changes.

According to the possibilistic mean NPVs and real option values, the difference between the values is the value of phasing (option to postpone the investment decision) and the possibility of expanding into other rental sectors (option to expand business at a later stage) in case of pessimistic scenario will realize. As mentioned in Section 1.4, these both are considered as call options. The expected NPV value then demonstrates the probabilistic part of the decision (risk) where the numerical value shows the most probable outcome with the given parameters, however this one figure is not enough as itself but requires the parameters to be used alongside when making the decision.

The cumulative discounted cash flows of all scenarios are visualized in below Figure 7, followed by individual cash flows visualizations of both strategies per each scenario.

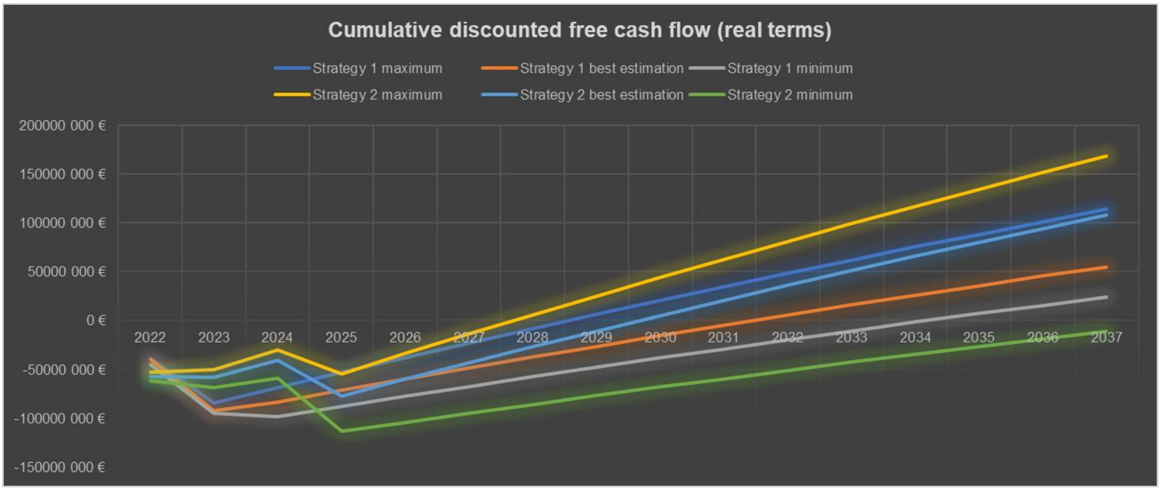


Figure 7. Cumulative discounted free cash flows (real terms) of strategies per scenario.

The Figure 7 above shows the cumulative discounted cash flows of all the total of six scenarios. The figure is for visualizing the profitability of them all in this case without comparing the figures to the original case of Collan and Savolainen (2020). The comparison of the results between the original case and this case is out of scope of this study. The next Figures 8–13 show all three scenarios of both strategies.

Figure 8. Discounted free cash flow and cumulative discounted free cash flow (real terms) of strategy 1 (build in one phase) maximum scenario.

Strategy 1 (build in one phase) shows 113.6M€ positive NPV in maximum scenario and break-even level would be reached at year 2029.

Figure 9. Discounted free cash flow and cumulative discounted free cash flow (real terms) of strategy 1 (build in one phase) best estimation scenario.

Strategy 1 (build in one phase) shows 55.0M€ positive NPV in best estimation scenario and break-even level would be reached at year 2032.

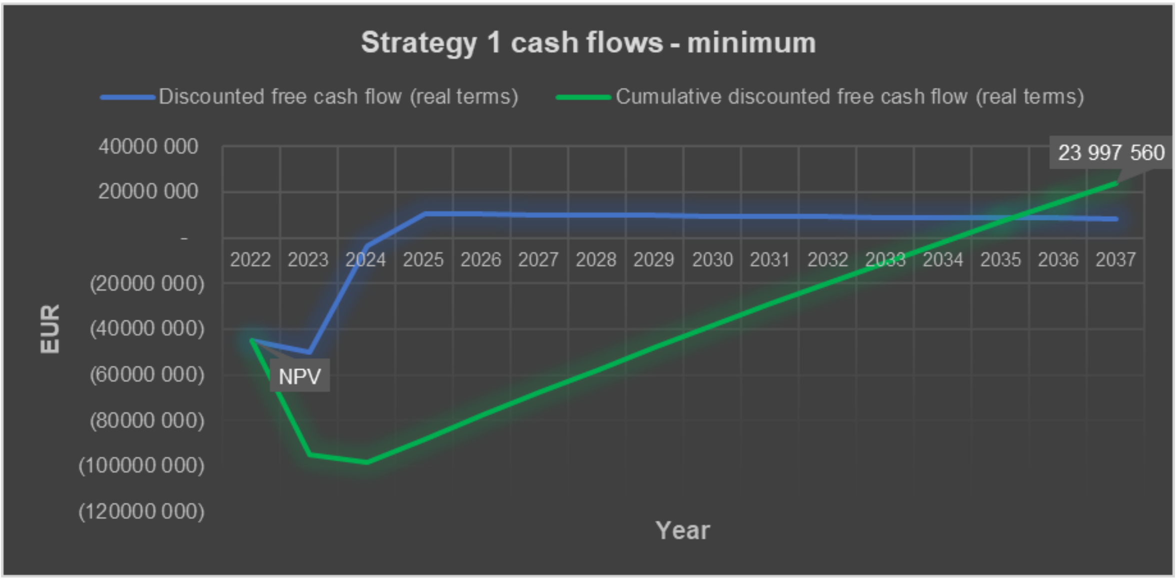


Figure 10. Discounted free cash flow and cumulative discounted free cash flow (real terms) of strategy 1 (build in one phase) minimum scenario.

Strategy 1 (build in one phase) shows 24.0M€ positive NPV in best estimation scenario and break-even level would be reached at year 2035.

Figure 11. Discounted free cash flow and cumulative discounted free cash flow (real terms) of strategy 2 (build in two phases with flexible construction parts) maximum scenario.

Strategy 2 (build in two phases with flexible construction parts) shows 168.4M€ positive NPV in maximum scenario and break-even level would be reached at year 2028.

Figure 12. Discounted free cash flow and cumulative discounted free cash flow (real terms) of strategy 2 (build in two phases with flexible construction parts) best estimation scenario.

Strategy 2 (build in two phases with flexible construction parts) shows 108.2M€ positive NPV in best estimation scenario and break-even level would be reached at year 2030.

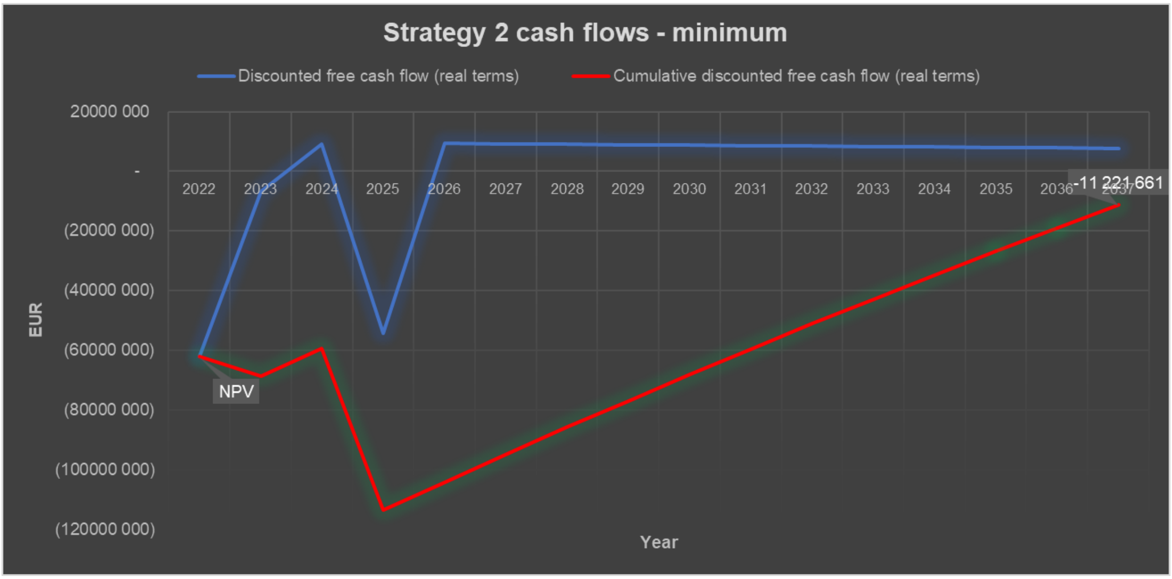


Figure 13. Discounted free cash flow and cumulative discounted free cash flow (real terms) of strategy 2 (build in two phases with flexible construction parts) minimum scenario.

Strategy 2 (build in two phases with flexible construction parts) shows 11.2M€ negative NPV in minimum scenario, meaning the break-even level would not be reached at all during the review period of years 0 to 15.

Sensitive analyses results are visualized in Appendices 6–11. Next, the Monte Carlo simulation results for both strategies are presented:

Table 8. Strategy 1 (build in one phase) numerical simulation results.

Results				
Min	€	623 256,46	Probability of negative NPV	0 %
Max	€	216 880 008,20	Probability of positive NPV	100 %
Weighted average	**€**	**91 892 581,86**		
Standard deviation	€	41 740 591,23		

Strategy 1 (build in one phase) indicates that by choosing this strategy there is 0% probability of failing the project (resulting negative NPV). After 10,000 simulation runs of the selected factors (shown below at Table 9) the expected NPV level, calculated as weighted average, is 91.9M€.

Table 9. Strategy 1 (build in one phase) simulation factors and their ranges.

Uncertain variables			
Variable	Min	Max	Random value
Investment	€ 88 000 000	€ 115 000 000	€ 97 366 874
Inflation	2,00 %	10,00 %	4,90 %
Rental income per square meter	€ 1 553,78	€ 2 287,30	€ 1 853,83
Maintenance costs per square meter	€ 200	€ 250	€ 210,30
Tax rate	20,00 %	23,00 %	20,37 %

The factors represent the factors that were found most sensitive to the investment (investment and rental income per square meter) in sensitivity analysis part, added with three other factors. One can subjectively choose the factors in the model, however it is most recommended to select the most sensitive ones to see more accurate results. The ranges of investment and rental income per square meter are derived from minimum and maximum scenarios of strategy 1. Other ranges are subjectively decided for testing.

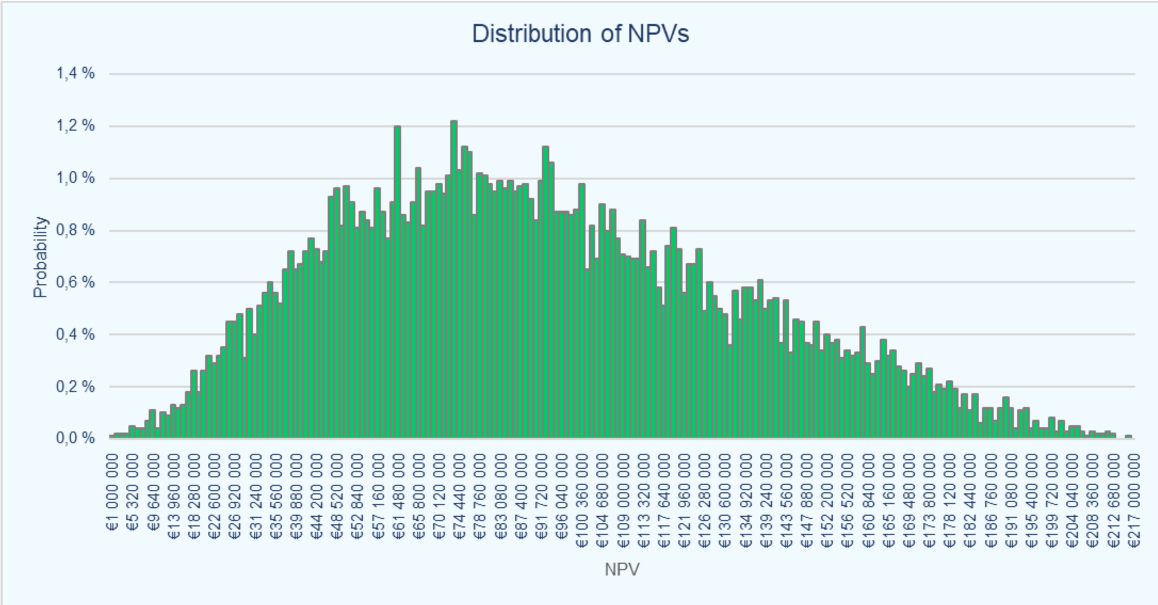


Figure 14. Strategy 1 (build in one phase) simulation results in histogram (200 bins).

The above Figure 14 shows the distribution of NPVs and their probabilities divided on 200 bins for more detailed examination. The Figure 15 below shows the same results divided only in 50 bins for more "high level" examination. From here, the probabilities in the Y-axis are easier to interpreted as a whole.

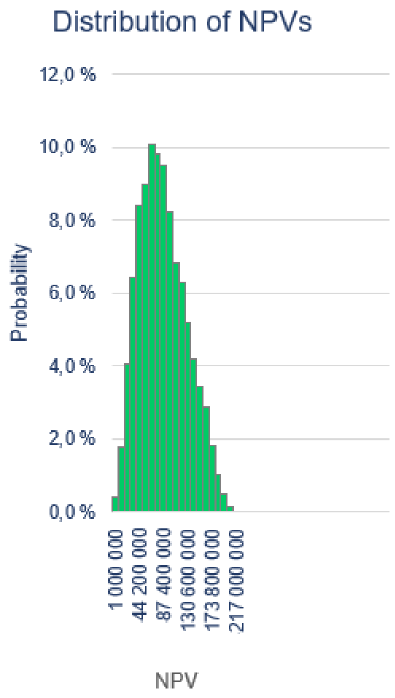


Figure 15. Strategy 1 (build in one phase) simulation results in histogram (20 bins).

Next, the analysis is presented for strategy 2 (build in two phases with flexible construction parts):

Table 10. Strategy 2 (build in two phases with flexible construction parts) numerical simulation results.

Results				
Min	-€	34 566 358,59	Probability of negative NPV	4 %
Max	€	299 987 314,59	Probability of positive NPV	96 %
Weighted average	**€**	**98 795 606,25**		
Standard deviation	€	65 451 452,20		

Strategy 2 (build in two phases with flexible construction parts) indicates that by choosing this strategy there is 4% probability of failing the project (resulting negative NPV). After 10,000 simulation runs of the selected factors (shown below at Table 11) the expected NPV level, calculated as weighted average, is 98.8M€.

Table 11. Strategy 2 (build in two phases with flexible construction parts) simulation factors and their ranges.

Uncertain variables			
Variable	Min	Max	Random value
Investment	€ 110 000 000	€ 143 750 000	€ 126 333 279
Inflation	2,00 %	10,00 %	2,28 %
Rental income per square meter	€ 1 404,68	€ 3 000,00	€ 1 944,99
Maintenance costs per square meter	€ 200	€ 250	€ 221,02
Tax rate	20,00 %	23,00 %	20,60 %

The factors represent the factors that were found most sensitive to the investment (investment and rental income per square meter) in sensitivity analysis part, added with three other factors. One can subjectively choose the factors in the model, however it is most recommended to select the most sensitive ones to see more accurate results. The ranges of investment and rental income per square meter are derived from minimum and maximum scenarios of strategy 2. Other ranges are subjectively decided for testing.

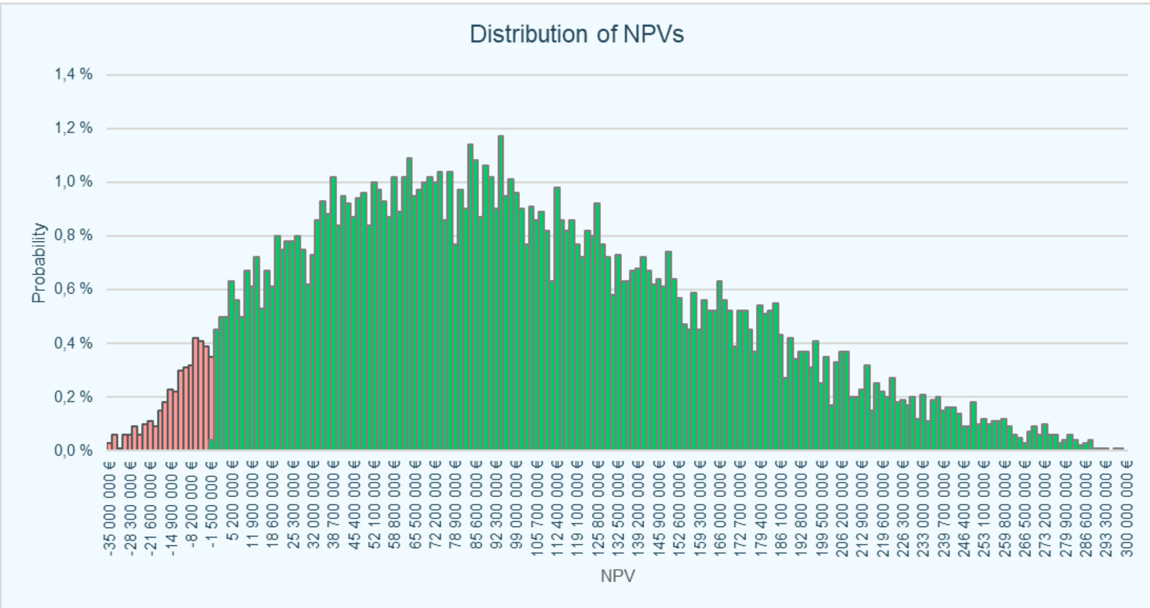


Figure 16. Strategy 2 (build in two phases with flexible construction parts) simulation results in histogram (200 bins).

The above Figure 16 shows the distribution of NPVs and their probabilities divided on 200 bins for more detailed examination. The green pillars represent a positive NPV value where the red pillars represent a negative NPV value. The Figure 17 below shows the same results divided only in 50 bins for more "high level" examination. From here, the probabilities in the Y-axis are easier to interpreted as a whole.

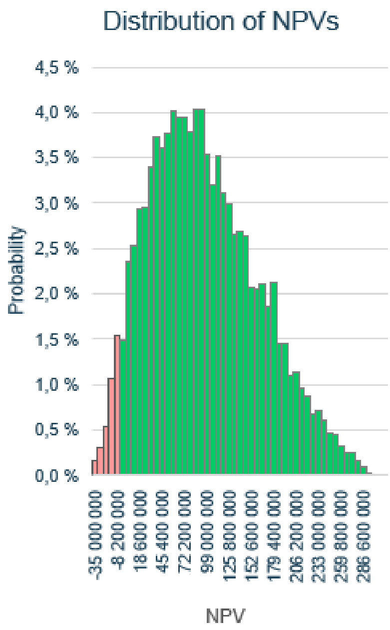


Figure 17. Strategy 2 (build in two phases with flexible construction parts) simulation results in histogram (50 bins).

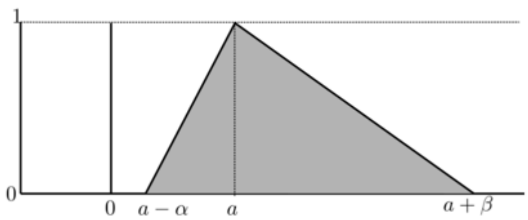
As can be seen, in 20 bins in strategy 1 the percentage shares change (become larger) on the Y-axis because the distribution in the X-axis is narrower. Same happens with 50 bins in strategy 2, although the difference is not that obvious. The results can be showed on the level that is suitable for one. The type of probability distribution is uniform meaning that all outcomes are equally likely to occurs between the ranges without emphasizing any particular range. It is noteworthy that the number of decimals in values between ranges are adjustable. It would be beneficial to adjust e.g., the tax rate into zero decimal level instead of the current two decimal level. The weighted average NPV is the same as expected NPV.

The real option values are 59.61M€ for strategy 1 (build in one phase) and 98.37M€ for strategy 2 (build in two phases with flexible construction parts). The absolute difference (38.76M€) is very high as well as relative difference (65%).

For strategy 1 (build in one phase), below there are the NPV scenarios as well as the triangular fuzzy distribution for the NPVs (the Y-axis represents the degree of membership, and the X-axis represents the NPV). The real option value is the fuzzy mean (possibilistic mean) of the positive side of the fuzzy NPVs multiplied by the area above the positive values divided by the total area of the fuzzy NPVs. As can be seen, the whole area of the fuzzy distribution of NPVs is above zero (visualized in grey area in the triangular). This also means that the possibilistic mean is the same as ROV because the whole area of the distribution is on the positive side, i.e., above zero.

Net present value (NPV) of strategy 1:

Maximum	**113 613 296**	a + β
Best estimation	**55 010 781**	a
Minimum	**23 997 560**	a - α



Value	Fuzzy number
113 613 296	a + β
55 010 781	a
23 997 560	a - α
58 602 515	β
31 013 221	α

ROV (A) = 59 608 996,87

Value	Fuzzy number
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	β
Distance between the best guess scenario NPV and minimum scenario NPV	α

$$ROV(A) = a + \frac{\beta - \alpha}{6}$$

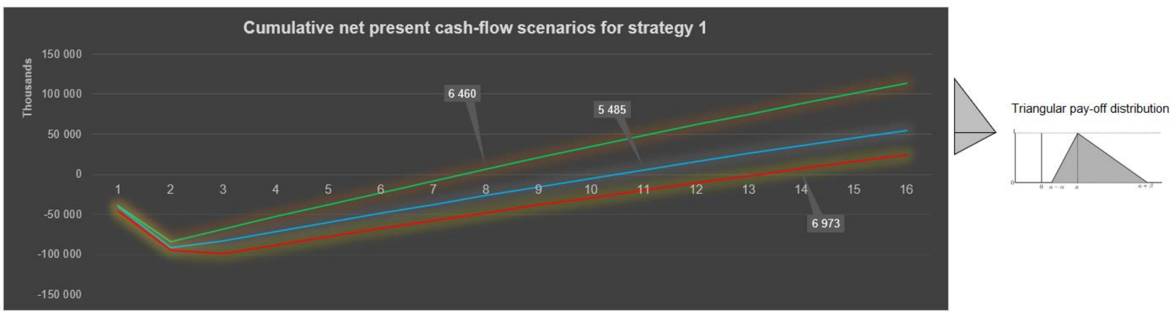
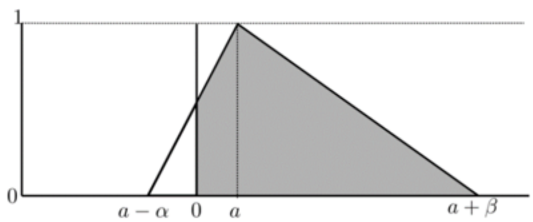


Figure 18. Strategy 1 (build in one phase) real option analysis (ROA).

For strategy 2 (build in two phases with flexible construction parts), it can be seen that only partial area of the fuzzy distribution of NPVs is above zero (visualized in grey area in the triangular – not in correct scale), in a way that zero is between the minimum possible NPV and the best estimation NPV. This also means that the possibilistic mean is not the same as ROV because only the partial area of the distribution is on the positive side, i.e., above zero. ROV equals only the positive side of the distribution as the negative side has no value.

Net present value (NPV) of strategy 2:

Maximum	**168 369 464**	a + β
Best estimation	**108 239 246**	a
Minimum	**-11 221 661**	a - α

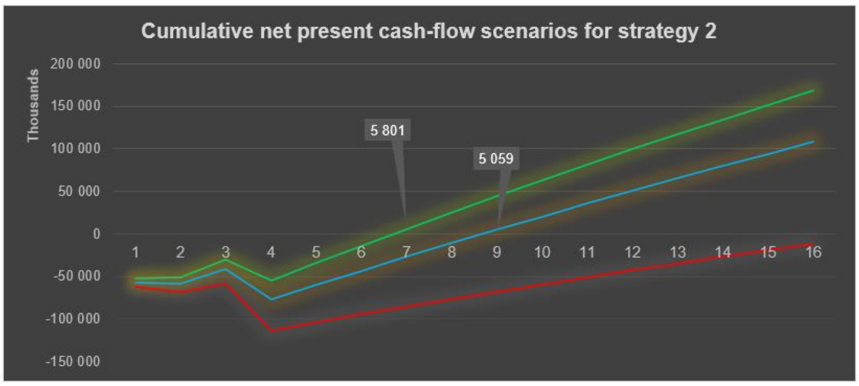


Value	Fuzzy number
168 369 464	a + β
108 239 246	a
-11 221 661	a - α
60 130 218	β
119 460 907	α

Value	Fuzzy number
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	β
Distance between the best guess scenario NPV and minimum scenario NPV	α

$$ROV(A) = -\frac{a^3}{6\alpha^2} + \frac{a^2}{2\alpha} + \frac{a}{2} + \frac{\beta}{6}$$

ROV (A) = 98 367 300,99



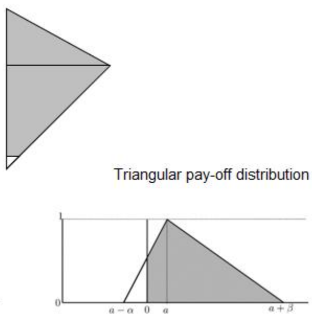


Figure 19. Strategy 2 (build in two phases with flexible construction parts) real option analysis (ROA).

The overall results provided cash flow analyses for three scenarios in two different strategies (strategy 1 and strategy 2), two real option calculations (one for each strategy), one sensitivity analysis for each of the scenarios of both strategies, and one simulation tool with two trials of 10,000 runs (based on some of the most sensitive variables found from sensitivity analyses). In total the analysis process provided six cash flow analyses, six sensitive analyses, two real option calculations, and one simulation tool.

5.1. Results analysis

The FPOM provided useful information during the process, putting the three scenarios' NPVs together, and, more importantly, was capable of providing a single monetary value for each strategy. This value represents the possibilistic mean NPV of each strategy (representing the whole NPV distribution of a strategy with a single number) that one can compare and discuss with others while making a decision on investment. The difference of these values (between strategies) can be considered as the value of flexibility, however, there is room for different interpretations: according to FPOM, ROV is the mean of the positive side of NPV distribution multiplied with the positive area of the distribution over the whole area of the distribution. This means that one can also calculate ROV for each strategy (value of possibilities), and then compare them instead of the possibilistic mean NPVs. Both of these numbers, possibilistic mean NPV and ROV, will tell useful information for the managers.

Monte Carlo simulation added value in terms of revealing the possibility that analysts may haven't estimated the initial maximum and minimum scenarios perfectly. By changing the range values, project analysts or experts may more easily estimate these most extreme scenarios. In addition, it provided more deep understanding about *the probabilities* of success in profitability that FPOM is not, by nature, doing. For managerial decision-making the risks and returns are always considered, or at least they both should be always considered, and this is essentially why these two methods were combined in this analysis. Risk can be adjusted also e.g., in discount rate but Monte Carlo simulation brings much more insight.

The below Table 12 summarizes the main findings and differences from this analysis process.

Table 12. Results table from the analysis.

Main results	Lessons learned	Numerical results
Real option value (ROV) is easy to calculate as a part of DCF analysis but there is room for different interpretations how to utilize it the best. ROA adds value to analysis process because it gives a single number value for different strategies for managers.	ROV tells the value of possibilities (positive outcomes) in an investment project while possibilistic mean NPV tells the value of the whole distribution of outcomes of an investment project. It remains very subjective to judge which one should be evaluated when making a decision. Either way, both ROV and possibilistic mean NPV tell valuable information because they put a single number for certain questions: what is the value of this strategy and what is the value of possibilities in this strategy?	Strategy 1 (build in one phase) has ROV of 59.61M€ which is the same as the whole distribution of outcomes because all NPV scenarios were larger than zero. Strategy 2 (build in two phases with flexible construction parts) has ROV of 98.37M€ while the whole distribution of outcomes was 98.35M€. The value of whole distribution is smaller because the area of total distribution (of NPVs) lies partially under zero.
Simulation revealed the possibility of analysts' / experts' failure in estimating the absolute worst and optimum scenarios. By adding simulation to analysis process, one may be able to prepare more accurate estimations about the most extreme scenarios which will improve the model.	By using simulation one is able to try several different estimations of the profitability analysis at once because the tool allows to take all the needed factors into account at once. If simulation reveals lower NPVs than what was estimated at the first place it likely tells that the initial estimation had some vulnerabilities. This way one can update the extreme scenarios which will make ROV more accurate (because ROV is re-calculated when the scenarios change), thus representing better the value of possibilities.	In DCF process, strategy 1 (build in one phase) was estimated having the extreme worst scenario resulting NPV of 24M€ and strategy 2 (build in two phases with flexible construction parts) -11.2M€, but simulation revealed that the extreme worst NPV would be 0.6M€ in strategy 1 and -34.6M€ in strategy 2. The reason for this is that the simulation tool was testing several different values for different factors (variables) at once that were static in DCF analysis (e.g., inflation rate).
Simulation gave insights about the probabilities of outcomes which is a simple way to model risk side of the project.	Presenting factors with their chosen ranges and the visual histogram of distributions one is able to receive more information about the risks involved. This may help to discuss more deeply about different risk factors and how they should be mitigated. Simulation can also reveal that some projects include very limited amount of risk which may result faster decision process.	Risk factor was 0% in strategy 1 (build in one phase) and 4% in strategy 2 (build in two phases with flexible construction parts). This means that, in strategy 2, out of total of 10,000 simulation runs, in 395 runs the NPV value was negative which is 4% from 10,000. In strategy 1, in 0 runs the NPV was negative.
Probable outcomes of both strategies are able to be presented with expected NPVs using simulation with uniform distribution.	While FPOM catches the possibilistic value of investment, simulation relies on probabilities. This helps understanding the risk side. Weighted average NPV provides more information than just simple average NPV which is very simplistic way of telling a single number value for probable outcome. Sometimes this can be enough to give confidence for decisions, however there is room for further improvements. Also, it is important to realize that sometimes it may be required to use other distribution types, for example for certain weighting purposes that is here missing.	Expected (i.e., weighted average) NPV for strategy 1 (build in one phase) was 91.9M€ and 98.8M€ for strategy 2 (build in two phases with flexible construction parts).
f **staregy 1:**	Building the office complex in one phase is justified. The expected NPV is 91.9M€ (based on simulation) on year 2037 with 0% probability to failure and the value of distribution of outcomes (based on ROA) is 59.6M€. This strategy does not include option to wait and option to expand the business later. ROV can be technically calculated but it adds no value to the strategy. Based only on DCF analysis, best estimation scenario the NPV is 55M€ on year 2037.	
f **staregy 2:**	Building the office complex in two phases and with flexible construction parts is justified. The expected NPV is 98.8M€ (based on simulation) on year 2037 with 4% probability to failure and the value of distribution of outcomes (based on ROA) is 98.35M€. This strategy includes option to wait and option to expand the business later. This means that during years 0 to 3 the project is re-evaluated according to the changing situation. In case of office rental market decline, the second phase can still be constructed but the business must be expanded into other areas. This is possible due to the flexible construction parts. This will then mean new cash flow estimations regarding new business area that will take place the latest at year 3, which are not yet shown in this calculation. Construction will cost 25% more including these real options and it adds risk of failure only 4%. Calculated ROV is 98.37M€ which is 38.77M€ higher than in strategy 1, making the value of these flexibilities as 38.77M€. Based only on DCF analysis, best estimation scenario the NPV is 108.2M€ on year 2037. This analysis lacks of evaluating the possibility to not to construct the second phase. Analysing this would require establishing "strategy 3" with accurate cash flow analysis (same that was performed for strategies 1 and 2).	

5.1.1. Discussion

In this case, the flexibility was the option to phase the construction and option to plan the investment in a way it enables to change the course, which means extending the business into new area if the pessimistic scenario would realize. The approach of the method proved to be straightforward and fast, which are typically highly valued features in real life business environment.

Some literature supports these findings, however, there seems not to be much of research papers yet about practically applying FPOM into real estate investment cases. According to Vimpari et al. (2014) while the cost of flexibility is rather straightforward to approximate, measuring monetary value of the flexibility is not. They conducted a study in 2014 considering a retrofit investment case where they aimed to explore how real options analysis with FPOM can be used for valuing flexibility, present the process of valuation, and evaluate the empirical usability of real options valuation results compared with traditional discounted cash flow valuation results. This is almost perfectly the same as is the intention of this study, excluding the simulation part. According to Vimpari et al. (2014) the main advantage was the practical applicability of FPOM, i.e., only the three scenarios (minimum, best estimation, and maximum) are needed for the valuation. The scenarios were determined by a detailed research process which can be paralleled to having a project expert defining the scenarios. The main finding of Vimpari et al. (2014) was that the fuzzy pay-off method can be used for straightforwardly assessing the monetary value of flexibility without the need of assignment of probabilities into different uncertainty scenarios. In the empirical case they found that flexibility investments were profitable only when parts of the building were designed flexible instead of the whole building.

Based on the results of this study, the beforementioned main advantage and findings must be repeated here as well. FPOM, as a method, could be well adapted by practitioners based on the findings of this study. Crăciun & Csorba (2017) support this based on their study of applying FPOM into valuing patent, stating that it is possible to use FPOM as an extension to the common DCF method, as well as Collan and Savolainen (2020) who stated that the method is simple, useable, and suitable for fast analysis of the effects of phasing on construction investments.

The results from the empirical case of this study were that strategy 2 (build in two phases with flexible construction parts) had more value that comes from the flexibility. When planning this case study, it was clear that for a risk averse investor that lives the daily life in business environment there is something else that needed to be added in the big picture, and this the risk side. This is why the Monte Carlo simulation was brought into the model. Adding visibility there can ease the understanding of the situation as a whole, which eventually can ease the decision-making process. This is not to say, that this can help all managers as every manager is an individual and such statement would require a lot of further research. However, some individuals may find this suitable for them. The empirical results of the Monte Carlo simulation, the risk side, supported the story of cash flow analyses but brought it visible to the management while corrected the absolute extreme circumstances into the model. As a tool, the simulation part addition proved to be useful because this way the cash flow analysis can remain highly simpler without the need to adjust every possible variable in every possible scenario in it (the simulation tool does that more conveniently).

The results of the simulation in this case study indicated that strategy 2 (build in two phases with flexible construction parts) involves more risk but the amount of risk was extremely modest (4%). It is easy to adjust the parameters of simulation by changing the values of factor ranges to see alternative outcomes. Such alternative results could be then screenshotted and demonstrated for managers for further discussion. The downside of the simulation part is that creating more sophisticated models is hard or can be quite impossible using basic spreadsheet software. The model presented in this case study is highly simple and is based purely on uniform distribution. Therefore, for example, for trying out different types of distributions would likely require more efficient software tools. This would also bring efficiency to the time consuming of the process which is too long in this model (minutes instead of seconds). This is a clear limitation of the model in this study.

The overall results demonstrated that while strategy 2 (build in two phases with flexible construction parts) has only moderately more risk, it has a lot more earning potential based on cash flow analyses and it is has 38,758,304.12 € (65%) more value than strategy 1 (build with one phase), because it includes the flexibility of phasing the construction and build it in a way it can enable expanding the business into new area (instead of offices, the space can be transformed suitable for almost any type of space) if circumstances later indicate that.

It is important to notice that what this case was also about was the real option thinking. Only if one has that adapted into the organization, such planning is possible. Real option thinking may also differ on the point of view of each individual. One perspective is to approach the investment valuation with real options as: total NPV = NPV (without options) + value of options. This might be suitable when using other real option valuating methods. It is very pleasant to calculate the value of the real option and add it to the project NPV because it keeps things simple. However, in this analysis process it is recognized that the value of the real option comes specifically from the monetary possibilities it derives from, i.e., the project’s cash flows, and that *each strategy itself can be considered as a real option*. This is actually not what can be interpreted from Collan's previous work even that it is based on cash flows of each strategy (see for example, Collan, 2011b, 13–15). Collan specifically underlines the process being i) modelling the future value distribution, ii) calculating the expected value of the future value distribution while mapping negative values of the distribution zero, and iii) modelling the calculation of the present value of the expected value (Collan, 2011b, 11).

Here, two strategies were evaluated as an (real) option to proceed and thus, each strategy received an absolute monetary value from real option analysis as well as the ROVs, strictly following the mechanics of FPOM. Then, the two real option values (the two strategies) were compared to each other to see which one has more value, and more possibilities (potential). Collan and Savolainen (2020) seem to have had the same approach with different wording, stating that by calculating the difference between the expected mean NPV of the alternative strategies, a representative value for the real option (to phase) can be calculated. However, they specifically excluded ROVs from their study which is the main difference compared to this thesis and they do not consider each strategy itself being a real option (nor does any literature). Theoretically, this correct as a strategy is not seen as real option itself but instead, usually, "something extra" that has value within the strategy.

Therefore, there remains a slight interpretation difference in the approach in this study (how each individual sees the world) and a slight difference in interpreting the results. In practice, this means that the real option value (ROV), calculated as the mean of the positive NPV area (possibilistic mean of the positive side of the distribution multiplied with the positive area of the distribution over the whole area of the distribution) is the number that is compared between strategies in this study, as well as the possibilistic mean NPVs, where Collan and Savolainen (2020) compared only the possibilistic mean NPVs without ROVs. They stated that by calculating the difference between the expected mean NPV (which is the same as possibilistic mean NPV) of the alternative strategies (with and without phasing) a representative value for the real option to phase the investment can be found.

This thesis claims that real options are not just a small parts of additional possibilities that should be added to projects as some absolute monetary values, although in several other literature it might be seen as that (see e.g., Putten & MacMillan, 2004). This is because when planning of an investment project one could recognize each route, i.e., strategy (each possibility to proceed in the project) as a (real) option itself and evaluate each of them via cash flow and real option analysis. There is no mandatory need to break the strategy into pieces and try to value each part separately. Instead, it might be easier to treat each possible plan (strategy) as a whole. This idea can be interpreted also from Collan and Savolainen's (2020) paper where, instead of trying just to add the value of phasing into single strategy, ROV for phasing was obtained by comparing two totally different strategies (that are indeed options for project managers to execute the project). In order to do that, one must calculate the value of each strategy first as a whole, after which the value of real options can be obtained. This was also done in this study, by calculating possibilistic mean NPVs and ROVs for both strategies as a whole. The strategy 2 (build in two phases with flexible construction parts) and its cash flow analysis included the real options of postponing the second phase and the real option to expand the business at later stage. Therefore, real options can be interpreted also as different strategies instead of first having NPV of a single strategy and then trying to calculate the ROV of some flexibility that is to be added to the single NPV.

One can compare the monetary story that numbers tell in comparison charts of each strategy, along with the visualizations of the cash flows and the simulated probabilities of each outcome, if one sees value in the latter process. One can calculate and compare the monetary value of each route (possibilistic mean NPV), which is the value of each strategy. To see which route (strategy) has the most potential, one can then calculate the value of potential (ROV) for each strategy.

In addition to possibilistic ROA, from probabilistic simulation process one is able to model the risk side of each route (strategy) which is a separate part of the investment analysis process. And from the traditional capital budgeting analysis process one is still able to see the essential behaviour of the cash flows and the effects of the most sensitive factors.

There are countless research papers that have found very good other methods in valuation real options. For example, Shafiee, Topal and Nehring (2009) compared investment in mining projects with other industrial projects and introduced a model that adds the total cost as a function in the model (the original model was developed by Brennan and Schwartz in 1985 which was now re-versioned). In the model, binomial option price (BOP), the ROV was calculated to be $1298 million, being significantly greater than calculated with DCF model (-$708 million). The main reason of this difference was that the new method allowed mine closure if the zinc price went down and the option to re-open when the zinc price went up. While this is highly useful information in any kind of investment analysis and the results are fascinating, the one problem remains: the complexity of the model's application. This issue has been considered through during this whole study with several examples from the existing literature as well as some of the examples from previous theses as well.

Considering managerial flexibility, adding these additional methods, ROA with FPOM and Monte Carlo simulation, to the traditional DCF analysis it may offer more in-depth insights that can help managers in making decisions. The main utility of the presented model is its simpleness which makes it easy to use, without the need for additional software investments. In addition, the theory behind the model is presented and discussed from a practical point of view so that the idea behind theory of FPOM remains clear. For these reasons this study can be considered as a relevant part of the continuum of research aiming to test, implement and utilize the previous findings, serving the practical contribution of research.

6. CONCLUSIONS AND DISCUSSION

This thesis studied how easily the real option analysis can be taken into commonly used profitability analysis method, how the risk side of the analysis can be modelled with simulation, and what are their possible benefits. The results show that some real option methods are straightforward to apply in cash flow analysis, and simulation increased visibility to the risks of the investment. Fuzzy pay-off method gave a single value for each investment strategy and a single value for the possibilities within each investment strategy. Simulation part revealed that the DCF analysis did not manage to catch the most extreme evaluated scenarios due to its static nature which can be refined after simulation.

6.1. Answering the research questions

The first research question of this thesis was formalized as follows:

> *1) According to the literature, what are the state-of-the-art real option methods that are both easy to use and coherent in terms of managerial flexibility?*

As an answer to the question, this thesis found that such the state-of-the-art real option methods are the Datar-Mathews method and the fuzzy pay-off method (FPOM).

The second research question dealt with the application of the methods:

> *2) How to apply the state-of-the-art real options methods with Monte Carlo simulation into an illustrative real estate investment case and what would be the main benefits compared to traditional discounted cash flow method?*

For decision-makers, according to this thesis, utilization of real options with FPOM and simulation allow simple and straightforward monetary value for different strategies along with deeper understanding of the risk factors. With the illustrated method one is able to answer the following questions: "Taking into account all the most extreme risks and possibilities, what is the value of this strategy compared to the other and how likely it can succeed?". This question is very hard to be answered without the use of real option analysis with FPOM and application of Monte Carlo simulation in any of its form. This can be suitable for decision-makers who appreciate fast and simple fact-based approach in profitability analysis. The results also showed that both of these methods (FPOM and MCS) can be easily applied in spreadsheet software as additional steps within cash flow calculation.

Theoretical background and framework of this study was conducted by summarizing the commonly used investment analysis methods and whether real options are currently used in real estate investments, including the main reasons why they are not exploited, following the examination of existing state-of-the-art real option valuation methods. The results revealed that the most commonly used methods are cash flow-based models, and the main reason for not exploiting real options in (real estate) investment analyses was the experience of real options being too complex. Several research papers demonstrated highly sophisticated real option valuation methods that are not easily adaptable without deep experience and understanding of the research field, but two methods (DM and FPOM) were found promising, of which the latter one was selected to be applied. Based on this literature review, the chosen methods (cash flow analysis and FPOM) were briefly introduced and then applied, along with simulation part that was added to the model.

The use of these chosen methods was illustrated with a construction investment case from existing literature (Collan & Savolainen, 2020) that was altered. Strategy 1 was to build 10,000 m² office complex in one phase and strategy 2 was to build two 5,000 m² office complexes with flexible structure to allow adjustment possibilities for tenants, that increased the construction costs but offered time for project management to see the development of office premises rental and the possibility to extend business into new area, if needed. The real options of i) waiting until uncertainty disappears, and ii) expanding business at a later stage were examined, and both real options were included in strategy 2 (building in two phases with flexible construction parts) that received one ROV in the study. The ROV for strategy 1 (build in one phase) was calculated as well, making the ROVs (values of possibilities) to be easily compared. Possibilistic mean NPVs were calculated as well to compare the total value of each strategy.

FPOM allowed easy calculation for real option value because it is based on the commonly used cash flow analysis with the maximum and minimum extreme scenario evaluations, making it easy to understand. Neither of the examined methods, ROA with FPOM and simulation, did not require any additional software tool and they can be added into traditional profitability analysis process. FPOM only needs the cash flow scenarios and the simple equations, and it offers two single numbers that can be compared between strategies (value of each strategy and value of their possibilities).

Simulation part of the analysis was not as easy to build, and it does not offer possibilities to adjust different probability distribution types. However, it made the risk side of the investment more visible with the use of uniform probability distribution type. This allows the project management to dive deeper to the most important factors in the investment, which also revealed that there is a possibility that the most extreme cases were not correctly estimated in the first place, due to the lack of deeper visibility before simulation. This allows adjustments to the most extreme scenarios, improving the overall quality of the analysis.

6.1. Validity, reliability, and limitations of the research

The focus of this study has been to keep the empirical model simple while trying to avoid tripping too much to sophisticated tuning. Another important undertaking with the case study has been succeeding to illustrate the behavioural factors of the model that required some limitations that would not have been possible in real-life applications (for example, excluding terminal value from the cash flow forecast to obtain negative NPV scenario).

Therefore, the model does not reflect reality perfectly – however, there exists no such model in the world that would illustrate real life perfectly.

The case has been taken from previous peer reviewed literature and adjusted on needed parts for it to suit well in the initial setup of the model in this study. This means that the original case of Collan and Savolainen (2020) has been published in an academic journal and it has, therefore, been reviewed by independent researcher referees to evaluate its contribution, i.e., the importance, novelty, and accuracy of the contents. All the values in this study are pre-tested to match perfectly with the original case considering FPOM part, including calculation equations, before they were adjusted and further applied into this model. The model applied here follows strictly and systematically the fuzzy pay-off method along with the theory of Monte Carlo simulation, and the model has been cross-checked several times during the empirical study. Therefore, the results of this study can be considered as reliable and valid, although there always remains the possibility of missing some small detail. The results would have been different if different parameters had been used.

This study intentionally did not examine any other types of real options but option to postpone and the option to expand, as was described in Section 1.4. One relevant limitation in this study is that, compared to the original case, preparing a “strategy 2 two” was left missing which means a third strategy were the second 5,000 m² office complex would have not been built. The reason for this is that it would have been an option to abandon (see different option types in Section 2.5.1) and thus, out of scope of this study (see Section 1.4).

Lastly, while the model is simple and easy, some limitations can be found there, such as the already mentioned distribution type limitation. It is clear that there is room for further improvements of this model, but this will remain for other researchers to examine, as science is never ready.

6.2. Future research

In this research Monte Carlo simulation was applied without considering more deeply the suitability of different types of distributions in the chosen context. Uniform distribution, that was applied here, may be justified but there might be other more suitable distribution types depending on the perspectives of individual experts. Therefore, in the further research this deficiency should be taken into account so that the model is capable to capture relevant distribution types that is evaluated and justified by, for example, market experts and thus reflecting the reality more accurate.

For further research it is suggested to apply the presented combination of FPOM and Monte Carlo simulation in a more efficient computational programming environment and try out different alternatives in context of different types of distributions to see what benefits it could offer into profitability analysis process. Also, the application of Datar-Mathews method instead would be interesting alternative as this study found it as one of the state-of-the-art methods.

If, at some point, further quantitative research is conducted regarding this model, or its variations, it would be useful to examine the usability of it by real world managers with qualitative approach in the later phase. Eventually, it is them who are to judge the concrete, practical value of it.

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APPENDICES

Appendix 1. Numerical results from the analysis process.

	Strategy 1 (build in one phase)	Strategy 2 (build in two phases with flexible construction parts)	*Difference*	Method from which the value is obtained
Real option value	59 608 997	98 367 301	*38 758 304*	ROA
Possibilistic mean NPV	59 608 997	98 350 798	*38 741 801*	ROA
Optimistic NPV	113 613 296	168 369 464	*54 756 167*	DCF
Realistic NPV	55 010 781	108 239 246	*53 228 465*	DCF
Pessimistic NPV	23 997 560	-11 221 661	*35 219 221*	DCF
Expected NPV	91 892 582	98 795 606	*6 903 024*	Simulation
"Risk factor"	0 %	4 %	*4 %*	Simulation
"Success factor"	100 %	96 %	*4 %*	Simulation
Standard deviation	41 740 591	65 451 452	*23 710 861*	Simulation
Min NPV	623 256	-34 566 359	*35 189 615*	Simulation
Max NPV	216 880 008	299 987 315	*83 107 306*	Simulation

Appendix 2. Application of FPOM in strategy 1 (build in one phase).

Adjusted building strategy 1: Build in one phase

Cost cashflows

Time		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maximum		-38 500 000	-49 500 000														
Best estimation		-40 000 000	-55 000 000	-5 000 000													
Minimum		-45 000 000	-52 500 000	-17 500 000													

PV of cost cashflows 5 % **Discount rate**

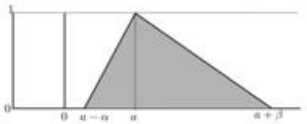
Time		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maximum	-85 729 358	-38 500 000	-47 229 358	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Best estimatio	-97 028 870	-40 000 000	-52 477 064	-4 551 805	0	0	0	0	0	0	0	0	0	0	0	0	0
Minimum	-111 023 062	-45 000 000	-50 091 743	-15 931 319	0	0	0	0	0	0	0	0	0	0	0	0	0

PV of the total positive wealth 5 % **Discount rate**

Time		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maximum	199 342 654	0	1 336 691	15 786 051	15 562 507	15 289 636	14 998 216	14 736 664	14 480 003	14 228 126	13 980 927	13 738 304	13 500 158	13 266 391	13 036 910	12 811 625	12 590 445
Best estimatio	152 039 651	0	578 264	12 924 407	11 853 058	11 641 780	11 411 000	11 209 146	11 011 254	10 817 227	10 626 971	10 440 395	10 257 412	10 077 936	9 901 884	9 729 178	9 559 739
Minimum	135 020 622	0	286 877	12 260 559	10 500 093	10 309 166	10 098 525	9 916 592	9 738 402	9 563 856	9 392 858	9 225 317	9 061 143	8 900 251	8 742 557	8 587 981	8 436 445

Net present value (NPV) of strategy 1:

Maximum	**113 613 296**	a+β
Best estimation	**55 010 781**	a
Minimum	**23 997 560**	a-α



Net present cash-flow scenarios for the investment

Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Max	-38 500 000	-45 892 666	15 786 051	15 562 507	15 289 636	14 998 216	14 736 664	14 480 003	14 228 126	13 980 927	13 738 304	13 500 158	13 266 391	13 036 910	12 811 625	12 590 445
Best estimation	-40 000 000	-51 898 801	8 372 602	11 853 058	11 641 780	11 411 000	11 209 146	11 011 254	10 817 227	10 626 971	10 440 395	10 257 412	10 077 936	9 901 884	9 729 178	9 559 739
Min	-45 000 000	-49 804 866	-3 670 760	10 500 093	10 309 166	10 098 525	9 916 592	9 738 402	9 563 856	9 392 858	9 225 317	9 061 143	8 900 251	8 742 557	8 587 981	8 436 445

Cumulative net present cash-flow scenarios for the investment

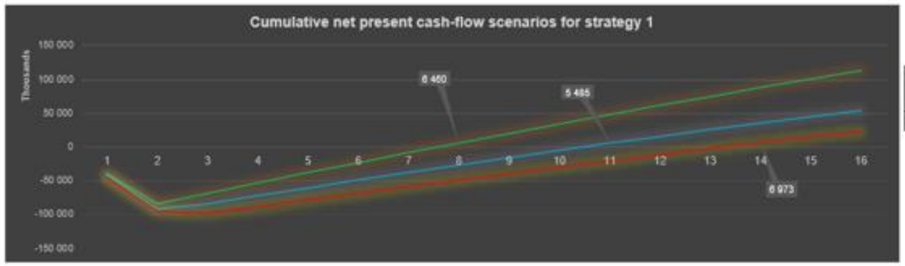
Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Max	-38 500 000	-84 392 666	-68 606 615	-53 044 109	-37 754 473	-22 756 257	-8 019 593	6 460 410	20 688 536	34 669 464	48 407 768	61 907 926	75 174 317	88 211 227	101 022 852	113 613 296
Best estimation	-40 000 000	-91 898 801	-83 526 199	-71 673 141	-60 031 361	-48 620 361	-37 411 215	-26 399 961	-15 582 734	-4 955 763	5 484 632	15 742 044	25 819 979	35 721 864	45 451 042	55 010 781
Min	-45 000 000	-94 804 866	-98 475 626	-87 975 533	-77 666 366	-67 567 842	-57 651 250	-47 912 848	-38 348 993	-28 956 134	-19 730 817	-10 669 674	-1 769 423	6 973 134	15 561 115	23 997 560

Value	Fuzzy number
113 613 296	a + β
55 010 781	a
23 997 560	a - α
58 602 515	β
31 013 221	α

ROV (A) = 59 608 996,87

Value	Fuzzy number
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	β
Distance between the best guess scenario NPV and minimum scenario NPV	α

$$ROV(A) = a + \frac{\beta - \alpha}{6}$$



Triangular pay-off distribution

Appendix 3. Application of FPOM in strategy 2 (build in two phases with flexible construction parts).

Adjusted uilding strategy 2: Build in two phases

Cost cashflows

Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maximum	-52 800 000	0	0	-57 200 000												
Best estimation	-57 000 000	-3 000 000	0	-65 000 000												
Minimum	-62 000 000	-7 000 000	0	-74 750 000												

PV of cost cashflows 4,81 % **Discount rate**

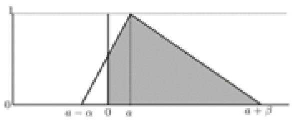
Time		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maximum	-102 484 000	-52 800 000	0	0	-49 684 000												
Best esti	-116 321 476	-57 000 000	-2 862 385	0	-56 459 091	0	0	0	0	0	0	0	0	0	0	0	0
Minimum	-133 606 854	-62 000 000	-6 678 899	0	-64 927 955												

PV of the total positive wealth 4,81 % **Discount rate**

Time		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maximum	270 853 464	0	2 282 657	20 720 182	25 058 455	20 448 482	20 063 909	19 711 001	19 364 744	19 024 990	18 691 596	18 364 423	18 043 337	17 728 205	17 418 901	17 115 300	16 817 281
Best esti	224 560 722	0	1 639 559	17 123 326	20 575 517	17 023 438	16 695 093	16 397 573	16 105 874	15 819 855	15 539 383	15 264 328	14 994 563	14 729 967	14 470 420	14 215 808	13 966 018
Minimum	122 385 193	0	66 789	9 729 939	10 691 788	9 368 394	9 217 391	9 045 449	8 877 317	8 712 884	8 552 042	8 394 689	8 240 725	8 090 055	7 942 588	7 798 234	7 656 908

Net present value (NPV) of strategy 2:

Maximum	168 369 464	a+β
Best estimation	108 239 246	a
Minimum	-11 221 661	a-α



Net present cash-flow scenarios for the investment

Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Max	-52 800 000	2 282 657	20 720 182	-24 625 545	20 448 482	20 063 909	19 711 001	19 364 744	19 024 990	18 691 596	18 364 423	18 043 337	17 728 205	17 418 901	17 115 300	16 817 281
Best estimation	-57 000 000	-1 222 827	17 123 326	-35 883 574	17 023 438	16 695 093	16 397 573	16 105 874	15 819 855	15 539 383	15 264 328	14 994 563	14 729 967	14 470 420	14 215 808	13 966 018
Min	-62 000 000	-6 612 110	9 729 939	-54 236 166	9 368 394	9 217 391	9 045 449	8 877 317	8 712 884	8 552 042	8 394 689	8 240 725	8 090 055	7 942 588	7 798 234	7 656 908

Cumulative net present cash-flow scenarios for the investment

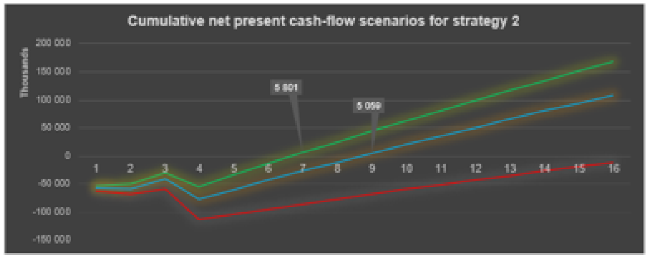
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Max	-52 800 000	-50 517 343	-29 797 161	-54 422 705	-33 974 224	-13 910 314	5 800 687	25 165 431	44 190 421	62 882 017	81 246 440	99 289 777	117 017 982	134 436 883	151 552 183	168 369 464
Best estimation	-57 000 000	-58 222 827	-41 099 500	-76 983 074	-59 959 636	-43 264 543	-26 866 970	-10 761 096	5 058 759	20 598 142	35 862 470	50 857 033	65 587 000	80 057 420	94 273 228	108 239 246
Min	-62 000 000	-68 612 110	-58 882 171	-113 118 337	-103 749 943	-94 532 552	-85 487 103	-76 609 785	-67 896 901	-59 344 859	-50 950 170	-42 709 445	-34 619 390	-26 676 802	-18 878 568	-11 221 661

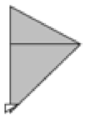
Value	Fuzzy number
168 369 464	a + β
108 239 246	a
-11 221 661	a - α
60 130 218	β
119 460 907	α

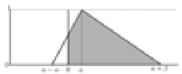
Value	Fuzzy number
Maximum scenario NPV	$a+\beta$
Best guess scenario NPV	a
Minimum scenario NPV	$a-\alpha$
Distance between best guess scenario NPV and maximum scenario NPV	β
Distance between the best guess scenario NPV and minimum scenario NPV	α

$$ROV(A) = -\frac{a^3}{6\alpha^2} + \frac{a^2}{2\alpha} + \frac{a}{2} + \frac{\beta}{6}$$

ROV (A) = 98 367 300,99







Triangular pay-off distribution

Appendix 4. Simulation tool and results with 10,000 runs for strategy 1 (build in one phase).

Outcome	
Expected NPV	**€ 91 892 581,86**

Uncertain variables			
Variable	Min	Max	Random value
Investment	€ 88 000 000	€ 115 000 000	€ 92 571 246
Inflation	2,00 %	10,00 %	4,42 %
Rental income per square meter	€ 1 553,78	€ 2 287,30	€ 1 880,88
Maintenance costs per square meter	€ 200	€ 250	€ 243,08
Tax rate	20,00 %	23,00 %	22,85 %
	Enter values	Enter values	

Monte Carlo simulation	
Runs	10 000
Simulation progress (%)	100

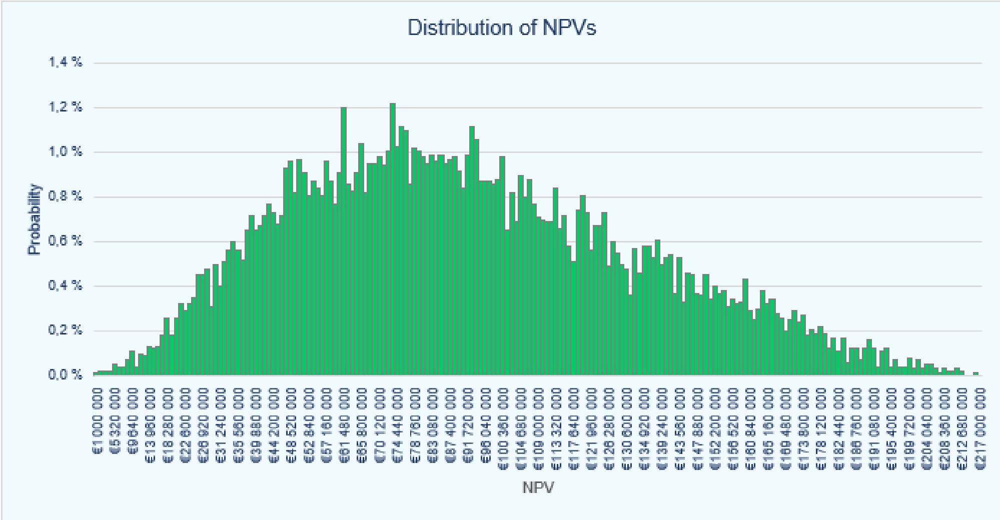
Run simulation

To STOP press Esc or Ctrl + Break

Enter value here and run simulation **(max 10 000)**

Set bins: 200 **(max 200)**

Results			
Min	€ 623 256,46	Probability of negative NPV	0 %
Max	€ 216 880 008,20	Probability of positive NPV	100 %
Weighted average	€ 91 892 581,86		
Standard deviation	€ 41 740 591,23		



Appendix 5. Simulation tool and results with 10,000 runs for strategy 2 (build in two phases with flexible construction parts).

Outcome	
Expected NPV	**€ 98 795 606,25**

Uncertain variables			
Variable	Min	Max	Random value
Investment	**€ 110 000 000**	**€ 143 750 000**	€ 133 637 317
Inflation	**2,00 %**	**10,00 %**	5,97 %
Rental income per square meter	**€ 1 404,68**	**€ 3 000,00**	€ 2 195,18
Maintenance costs per square meter	**€ 200**	**€ 250**	€ 220,40
Tax rate	**20,00 %**	**23,00 %**	21,30 %
	Enter values	Enter values	

Monte Carlo simulation	
Runs	**10 000**
Simulation progress (%)	100

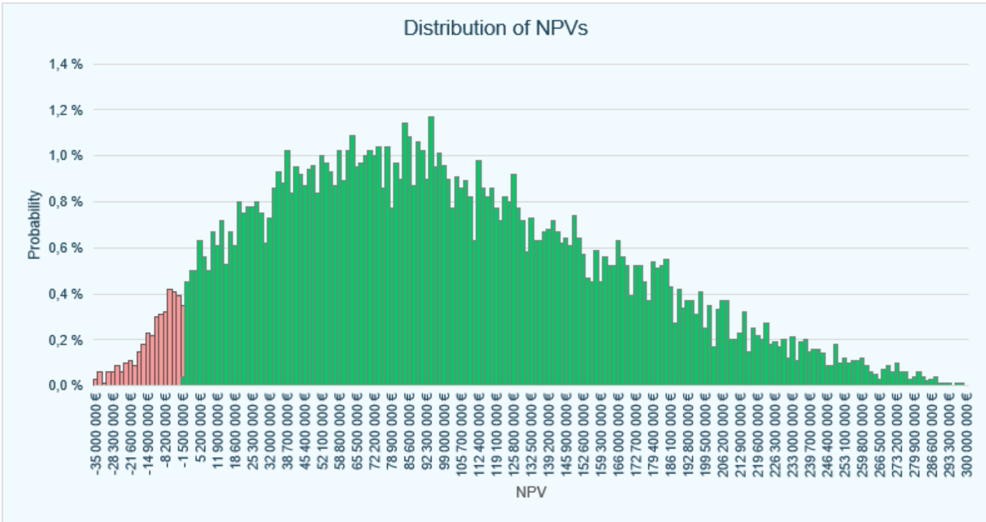
Run simulation

To STOP press Esc or Ctrl + Break

Enter value here and run simulation **(max 10 000)**

Set bins: **200** **(max 200)**

Results			
Min	-€ 34 566 358,59	Probability of negative NPV	4 %
Max	€ 299 987 314,59	Probability of positive NPV	96 %
Weighted average	€ 98 795 606,25		
Standard deviation	€ 65 451 452,20		



Appendix 6. Sensitivity analysis for maximum scenario in strategy 1 (build in one phase).

		NPV										
Factors		-50 %	-40 %	-30 %	-20 %	-10 %	0 %	10 %	20 %	30 %	40 %	50 %
Investment	1	€ 156 477 975,37	€ 147 905 039,59	€ 139 332 103,81	€ 130 759 168,03	€ 122 186 232,25	€ 113 613 296,47	€ 105 040 360,69	€ 96 467 424,91	€ 87 894 489,13	€ 79 321 553,35	€ 70 748 617,57
Discount rate	1	€ 155 164 393,26	€ 145 933 572,81	€ 137 191 994,42	€ 128 909 710,29	€ 121 058 815,57	€ 113 613 296,47	€ 106 548 890,65	€ 99 842 958,55	€ 93 474 364,97	€ 87 423 369,89	€ 81 671 527,88
Inflation	1	€ 85 815 394,75	€ 90 978 915,01	€ 96 333 147,75	€ 101 885 275,27	€ 107 642 748,47	€ 113 613 296,47	€ 119 804 936,56	€ 126 225 984,48	€ 132 885 065,01	€ 139 791 122,97	€ 146 953 434,56
Rental income per square meter	1	€ 7 581 552,77	€ 28 787 901,51	€ 49 994 250,25	€ 71 200 598,99	€ 92 406 947,73	€ 113 613 296,47	€ 134 819 645,21	€ 156 025 993,95	€ 177 232 342,69	€ 198 438 691,43	€ 219 645 040,17
Maintenance costs per square met	1	€ 123 336 952,46	€ 121 392 221,26	€ 119 447 490,06	€ 117 502 758,86	€ 115 558 027,67	€ 113 613 296,47	€ 111 668 565,27	€ 109 723 834,08	€ 107 779 102,88	€ 105 834 371,68	€ 103 889 640,48

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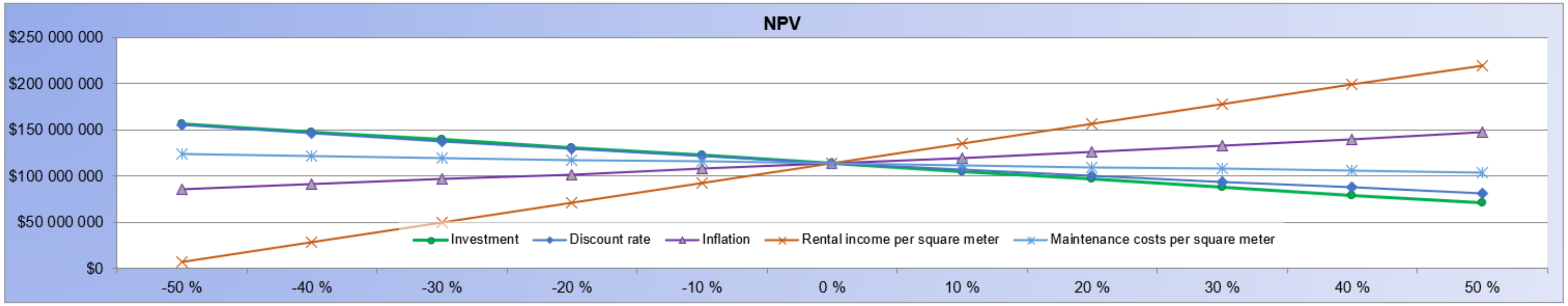

Appendix 7. Sensitivity analysis for best estimation scenario in strategy 1 (build in one phase).

		NPV										
Factors		-50 %	-40 %	-30 %	-20 %	-10 %	0 %	10 %	20 %	30 %	40 %	50 %
Investment	1	€ 102 705 890,99	€ 93 166 869,02	€ 83 627 847,05	€ 74 088 825,09	€ 64 549 803,12	€ 55 010 781,15	€ 45 471 759,18	€ 35 932 737,21	€ 26 393 715,25	€ 16 854 693,28	€ 7 315 671,31
Discount rate	1	€ 86 015 735,78	€ 79 117 759,63	€ 72 590 242,53	€ 66 410 453,90	€ 60 557 214,48	€ 55 010 781,15	€ 49 752 740,76	€ 44 765 912,50	€ 40 034 257,90	€ 35 542 797,94	€ 31 277 536,65
Inflation	1	€ 34 349 987,27	€ 38 181 446,10	€ 42 157 696,29	€ 46 284 193,73	€ 50 566 598,28	€ 55 010 781,15	€ 59 622 832,41	€ 64 409 068,82	€ 69 376 041,84	€ 74 530 546,06	€ 79 879 627,70
Rental income per square meter	1	-€ 26 865 544,97	-€ 10 252 356,34	€ 6 131 123,55	€ 22 424 342,75	€ 38 717 561,95	€ 55 010 781,15	€ 71 304 000,35	€ 87 597 219,55	€ 103 890 438,75	€ 120 183 657,94	€ 136 476 877,14
Maintenance costs per square met	1	€ 64 734 437,14	€ 62 789 705,94	€ 60 844 974,74	€ 58 900 243,54	€ 56 955 512,35	€ 55 010 781,15	€ 53 066 049,95	€ 51 121 318,76	€ 49 176 587,56	€ 47 231 856,36	€ 45 287 125,16

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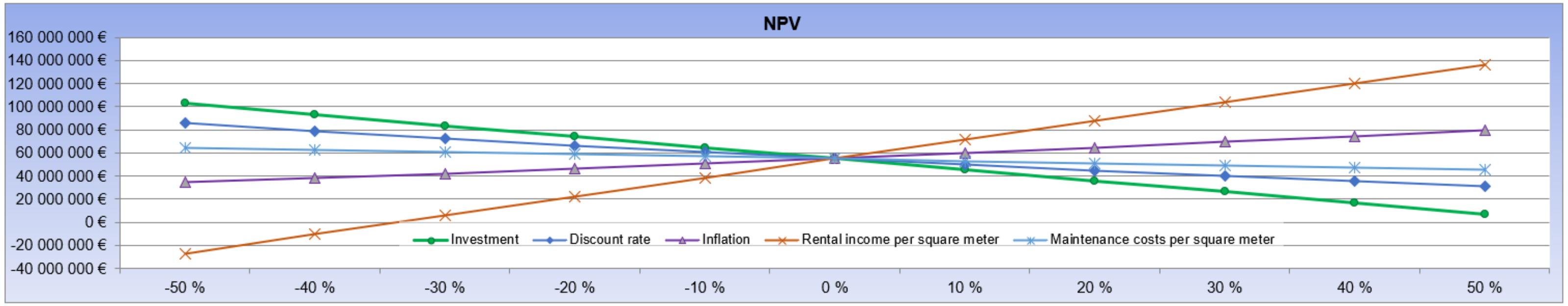

Appendix 8. Sensitivity analysis for minimum scenario in strategy 1 (build in one phase).

		NPV										
Factors		-50 %	-40 %	-30 %	-20 %	-10 %	0 %	10 %	20 %	30 %	40 %	50 %
Investment	1	€ 79 063 415,20	€ 68 363 488,59	€ 57 304 478,77	€ 46 202 172,56	€ 35 099 866,36	€ 23 997 560,15	€ 12 895 253,94	€ 1 792 947,74	-€ 9 309 358,47	-€ 20 411 664,67	-€ 31 513 970,88
Discount rate	1	€ 50 774 184,21	€ 44 806 513,91	€ 39 164 385,76	€ 33 827 755,92	€ 28 777 949,78	€ 23 997 560,15	€ 19 470 353,64	€ 15 181 184,43	€ 11 115 914,81	€ 7 261 342,06	€ 3 605 130,92
Inflation	1	€ 6 238 425,95	€ 9 525 299,64	€ 12 939 741,25	€ 16 486 568,73	€ 20 170 780,15	€ 23 997 560,15	€ 27 972 286,62	€ 32 100 537,59	€ 36 388 098,33	€ 40 840 968,73	€ 45 465 370,90
Rental income per square meter	1	-€ 49 444 975,08	-€ 34 756 468,04	-€ 20 067 960,99	-€ 5 379 453,94	€ 9 309 053,10	€ 23 997 560,15	€ 38 686 067,20	€ 53 374 574,24	€ 68 063 081,29	€ 82 751 588,34	€ 97 440 095,38
Maintenance costs per square met	1	€ 33 906 929,80	€ 31 925 055,87	€ 29 943 181,94	€ 27 961 308,01	€ 25 979 434,08	€ 23 997 560,15	€ 22 015 686,22	€ 20 033 812,29	€ 18 051 938,36	€ 16 070 064,43	€ 14 088 190,50

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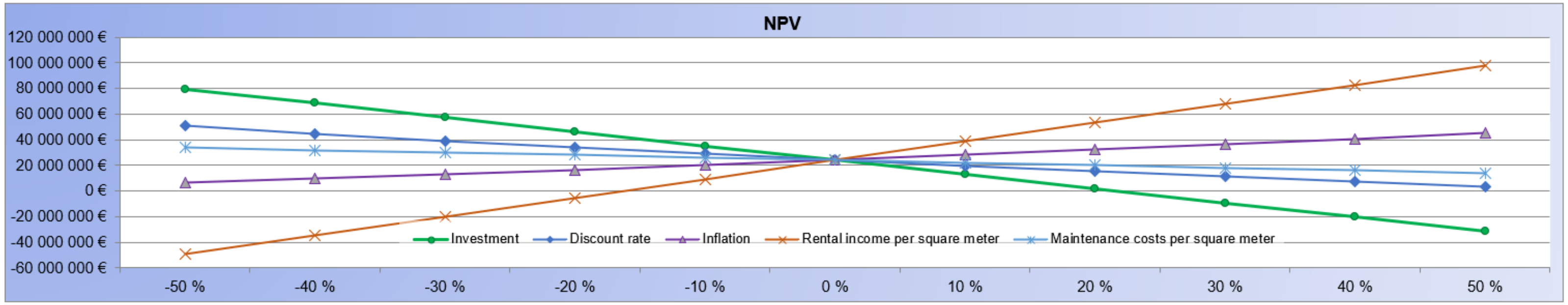

Appendix 9. Sensitivity analysis for maximum scenario in strategy 2 (build in two phases with flexible construction parts).

		NPV										
Factors		-50 %	-40 %	-30 %	-20 %	-10 %	0 %	10 %	20 %	30 %	40 %	50 %
Investment	1	€ 219 217 683,45	€ 209 048 039,49	€ 198 878 395,53	€ 188 708 751,57	€ 178 539 107,61	€ 168 369 463,65	€ 158 199 819,69	€ 148 023 611,33	€ 137 813 664,98	€ 127 603 718,64	€ 117 393 772,29
Discount rate	1	€ 222 106 226,26	€ 210 147 696,73	€ 198 833 181,64	€ 188 122 914,08	€ 177 979 849,62	€ 168 369 463,65	€ 159 259 565,00	€ 150 620 124,29	€ 142 423 115,92	€ 134 642 372,40	€ 127 253 450,07
Inflation	1	€ 132 576 018,96	€ 139 213 404,39	€ 146 101 679,09	€ 153 250 424,83	€ 160 669 582,23	€ 168 369 463,65	€ 176 360 766,48	€ 184 654 586,84	€ 193 262 433,80	€ 202 196 244,02	€ 211 468 396,90
Rental income per square meter	1	€ 26 689 558,25	€ 55 040 347,40	€ 83 391 136,56	€ 111 741 925,71	€ 140 092 714,87	€ 168 369 463,65	€ 196 634 381,25	€ 224 899 298,84	€ 253 164 216,44	€ 281 429 134,03	€ 309 694 051,63
Maintenance costs per square met	1	€ 178 083 032,53	€ 176 140 318,76	€ 174 197 604,98	€ 172 254 891,20	€ 170 312 177,43	€ 168 369 463,65	€ 166 426 749,88	€ 164 481 746,19	€ 162 500 867,28	€ 160 519 988,37	€ 158 539 109,45

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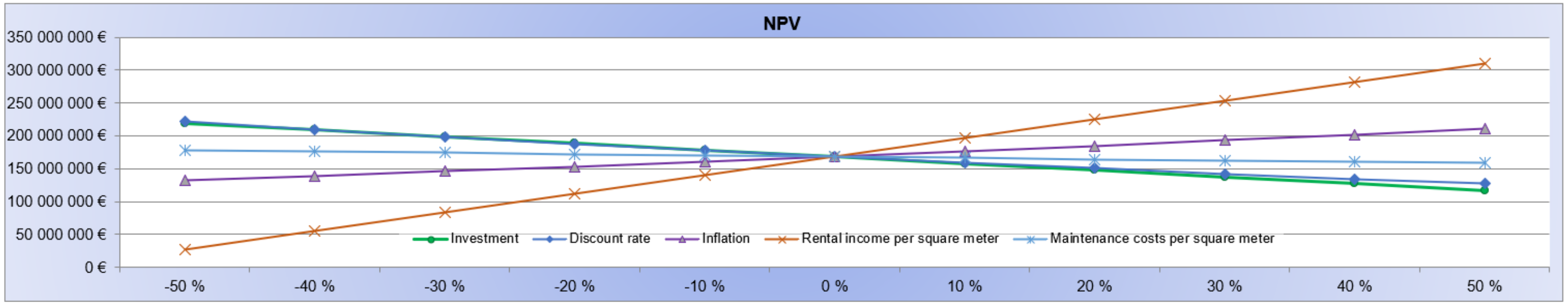

Appendix 10. Sensitivity analysis for best estimation scenario in strategy 2 (build in two phases with flexible construction parts).

		NPV										
Factors		-50 %	-40 %	-30 %	-20 %	-10 %	0 %	10 %	20 %	30 %	40 %	50 %
Investment	1	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90	€ 108 239 245,90
Discount rate	1	€ 151 711 763,90	€ 142 019 458,79	€ 132 857 882,07	€ 124 194 093,40	€ 115 997 411,50	€ 108 239 245,90	€ 100 892 942,20	€ 93 933 639,55	€ 87 338 139,42	€ 81 084 784,70	€ 75 153 348,20
Inflation	1	€ 79 425 314,50	€ 84 757 624,03	€ 90 297 066,24	€ 96 051 596,68	€ 102 029 469,06	€ 108 239 245,90	€ 114 689 809,56	€ 121 390 373,65	€ 128 350 494,82	€ 135 580 084,94	€ 143 089 423,67
Rental income per square meter	1	-€ 9 838 121,50	€ 13 777 351,98	€ 37 392 825,46	€ 61 008 298,94	€ 84 623 772,42	€ 108 239 245,90	€ 131 854 719,38	€ 155 470 192,86	€ 179 085 666,34	€ 202 701 139,82	€ 226 316 613,30
Maintenance costs per square met	1	€ 118 143 640,47	€ 116 162 761,55	€ 114 181 882,64	€ 112 201 003,73	€ 110 220 124,81	€ 108 239 245,90	€ 106 258 366,99	€ 104 277 488,07	€ 102 296 609,16	€ 100 315 730,25	€ 98 334 851,33

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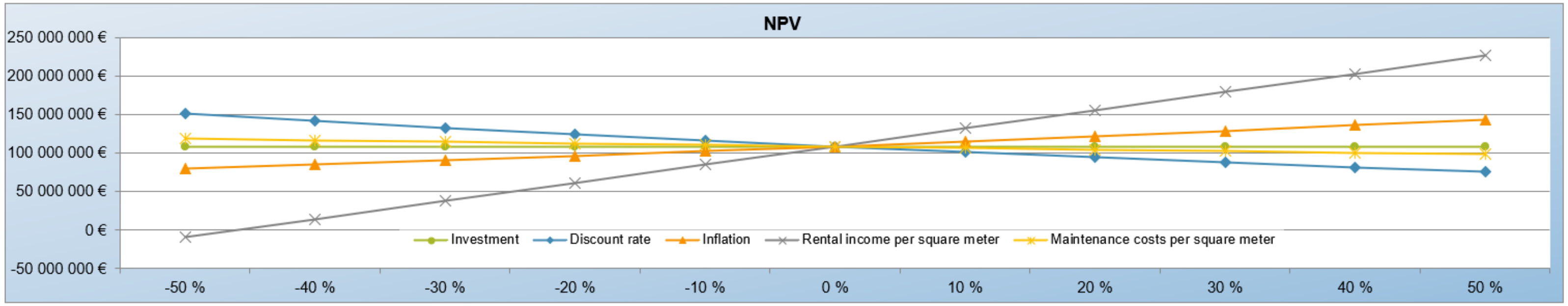

Appendix 11. Sensitivity analysis for minimum scenario in strategy 2 (build in two phases with flexible construction parts).

		NPV										
Factors		-50 %	-40 %	-30 %	-20 %	-10 %	0 %	10 %	20 %	30 %	40 %	50 %
Investment	1	€ 55 330 506,52	€ 42 020 073,09	€ 28 709 639,66	€ 15 399 206,24	€ 2 088 772,81	-€ 11 221 660,62	-€ 24 532 094,05	-€ 37 842 527,48	-€ 51 152 960,90	-€ 64 463 394,33	-€ 77 773 827,76
Discount rate	1	€ 10 138 645,92	€ 5 335 586,81	€ 815 348,04	-€ 3 440 001,88	-€ 7 447 155,84	-€ 11 221 660,62	-€ 14 778 001,94	-€ 18 129 682,79	-€ 21 289 295,56	-€ 24 268 588,47	-€ 27 078 526,83
Inflation	1	-€ 25 056 361,98	-€ 22 520 743,95	-€ 19 873 919,87	-€ 17 111 517,37	-€ 14 228 999,85	-€ 11 221 660,62	-€ 8 084 616,79	-€ 4 812 803,02	-€ 1 400 965,00	€ 2 156 347,21	€ 5 864 786,18
Rental income per square meter	1	-€ 77 710 626,15	-€ 64 320 155,47	-€ 51 045 531,76	-€ 37 770 908,05	-€ 24 496 284,33	-€ 11 221 660,62	€ 2 052 963,09	€ 15 327 586,81	€ 28 602 210,52	€ 41 876 834,23	€ 55 151 457,94
Maintenance costs per square met	1	-€ 1 317 266,05	-€ 3 298 144,97	-€ 5 279 023,88	-€ 7 259 902,79	-€ 9 240 781,71	-€ 11 221 660,62	-€ 13 202 539,53	-€ 15 183 418,45	-€ 17 164 297,36	-€ 19 145 176,27	-€ 21 126 055,19

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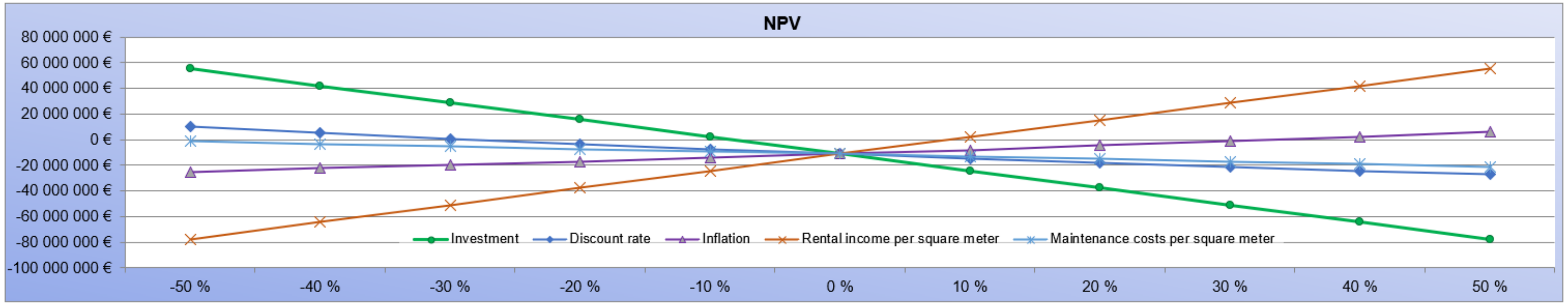


Appendix 12. Capital budgeting analysis and cash flows in maximum scenario of strategy 1 (build in one phase).

Inputs

Total cost of investment	€	88 000 000,00
Number of years of investment cost allocation		2
Real interest rate (discount rate)**)		5 %
Nominal interest rate*)		9 %
Inflation		4 %
Square meter		10 000
Rental income per square meter	€	2 287,30
Yearly increase in maintenance costs		2 %
Maintenance costs per square meter	€	200,00
Depreciation per year from total investment	€	3 520 000,00
Working capital investments	€	30 000,00
Tax rate		20 %
Operating duration (how long operations are active)		15
Production start after		1

**) Excluding inflation (real terms)
*) Including inflation nominal terms

Outputs

P&L

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(38 500 000)	(49 500 000)	-	-	-	-	-	-
Rental income	-	3 430 955	22 873 036	23 559 227	24 266 003	24 993 984	25 743 803	26 516 117
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Other expenses (please insert as negative value)								
EBITDA	**(38 500 000)**	**(48 069 045)**	**20 833 036**	**21 478 427**	**22 143 587**	**22 829 119**	**23 535 641**	**24 263 792**
Depreciation	-	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**(38 500 000)**	**(51 589 045)**	**17 313 036**	**17 958 427**	**18 623 587**	**19 309 119**	**20 015 641**	**20 743 792**
Taxes	-	-	(3 462 607)	(3 591685)	(3 724 717)	(3 861824)	(4 003 128)	(4 148 758)
Net Income	**(38 500 000)**	**(51 589 045)**	**13 850 428**	**14 366 741**	**14 898 870**	**15 447 295**	**16 012 513**	**16 595 034**
Annual sales growth rate			**566,67 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	27 311 601	28 130 949	28 974 877	29 844 123	30 739 447	31 661 631	32 611 479	33 589 824
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Other expenses (please insert as negative value)								
EBITDA	**25 014 229**	**25 787 630**	**26 584 692**	**27 406 135**	**28 252 699**	**29 125 147**	**30 024 266**	**30 950 866**
Depreciation	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)	(3 520 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**21 494 229**	**22 267 630**	**23 064 692**	**23 886 135**	**24 732 699**	**25 605 147**	**26 504 266**	**27 430 866**
Taxes	(4 298 846)	(4 453 526)	(4 612 938)	(4 777 227)	(4 946 540)	(5 121 029)	(5 300 853)	(5 486 173)
Net Income	**17 195 383**	**17 814 104**	**18 451 754**	**19 108 908**	**19 786 159**	**20 484 118**	**21 203 413**	**21 944 693**
Annual sales growth rate	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

Cash Flows

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(38 500 000)	(49 500 000)	-	-	-	-	-	-
Rental income	-	3 430 955	22 873 036	23 559 227	24 266 003	24 993 984	25 743 803	26 516 117
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Working capital investments	-	(30 000)	(30 000)	-	-	-	-	-
Taxes	-	-	(3 462 607)	(3 591685)	(3 724 717)	(3 861824)	(4 003 128)	(4 148 758)
Released working capital	-	-	-	30 000	30 000	-	-	-
Free cash flow	**(38 500 000)**	**(48 099 045)**	**17 340 428**	**17 916 741**	**18 448 870**	**18 967 295**	**19 532 513**	**20 115 034**
Cumulative free cash flow	**(38 500 000)**	**(86 599 045)**	**(69 258 616)**	**(51 341 875)**	**(32 893 005)**	**(13 925 710)**	**5 606 804**	**25 721 837**
Discounted free cash flow (real terms)	**(38 500 000)**	**(45 892 666)**	**15 786 051**	**15 562 507**	**15 289 636**	**14 998 216**	**14 736 664**	**14 480 003**
Cumulative discounted free cash flow (real terms)	**(38 500 000)**	**(84 392 666)**	**(68 606 615)**	**(53 044 109)**	**(37 754 473)**	**(22 756 257)**	**(8 019 593)**	**6 460 410**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	27 311 601	28 130 949	28 974 877	29 844 123	30 739 447	31 661 631	32 611 479	33 589 824
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Working capital investments	-	-	-	-	-	-	-	-
Taxes	(4 298 846)	(4 453 526)	(4 612 938)	(4 777 227)	(4 946 540)	(5 121 029)	(5 300 853)	(5 486 173)
Released working capital	-	-	-	-	-	-	-	-
Free cash flow	**20 715 383**	**21 334 104**	**21 971 754**	**22 628 908**	**23 306 159**	**24 004 118**	**24 723 413**	**25 464 693**
Cumulative free cash flow	**46 437 221**	**67 771 325**	**89 743 078**	**112 371 986**	**135 678 145**	**159 682 262**	**184 405 675**	**209 870 368**
Discounted free cash flow (real terms)	**14 228 126**	**13 980 927**	**13 738 304**	**13 500 158**	**13 266 391**	**13 036 910**	**12 811 625**	**12 590 445**
Cumulative discounted free cash flow (real terms)	**20 688 536**	**34 669 464**	**48 407 768**	**61 907 926**	**75 174 317**	**88 211 227**	**101 022 852**	**113 613 296**

Profitability indicators:	NPV	IRR	PI	DPP
	€ 113 613 296,47	19 %	2,29	6,55

Summary of key factors:	Investment	Discount rate	Inflation	Square meter	Maintenance costs per square meter
	€ 88 000 000,00	5 %	4 %	10000	€ 200,00

Appendix 13. Capital budgeting analysis and cash flows in best estimation scenario of strategy 1 (build in one phase).

Inputs

Total cost of investment	€	100 000 000,00
Number of years of investment cost allocation		3
Real interest rate (discount rate)**)		5 %
Nominal interest rate*)		9 %
Inflation		4 %
Square meter		10 000
Rental income per square meter	€	1 757,38
Yearly increase in maintenance costs		2 %
Maintenance costs per square meter	€	200,00
Depreciation per year from total investment	€	4 000 000,00
Working capital investments	€	30 000,00
Tax rate		20 %
Operating duration (how long operations are active)		15
Production start after		1

**) Excluding inflation (real terms)
*) Including inflation nominal terms

Outputs

P&L

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(40 000 000)	(55 000 000)	(5 000 000)	-	-	-	-	-
Rental income	-	2 636 065	17 573 765	18 100 978	18 644 007	19 203 327	19 779 427	20 372 810
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Other expenses								
EBITDA	**(40 000 000)**	**(54 363 935)**	**10 533 765**	**16 020 178**	**16 521 591**	**17 038 463**	**17 571 265**	**18 120 485**
Depreciation	-	(3 800 000)	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)
Impairment								
Operating profit (EBIT)	**(40 000 000)**	**(58 163 935)**	**6 533 765**	**12 020 178**	**12 521 591**	**13 038 463**	**13 571 265**	**14 120 485**
Taxes	-	-	(1 306 753)	(2 404 036)	(2 504 318)	(2 607 693)	(2 714 253)	(2 824 097)
Net Income	**(40 000 000)**	**(58 163 935)**	**5 227 012**	**9 616 142**	**10 017 273**	**10 430 770**	**10 857 012**	**11 296 388**
Annual sales growth rate			**566,67 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	20 983 994	21 613 514	22 261 919	22 929 777	23 617 670	24 326 200	25 055 986	25 807 666
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Other expenses								
EBITDA	**18 686 623**	**19 270 195**	**19 871 734**	**20 491 788**	**21 130 922**	**21 789 717**	**22 468 773**	**23 168 708**
Depreciation	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)	(4 000 000)
Impairment								
Operating profit (EBIT)	**14 686 623**	**15 270 195**	**15 871 734**	**16 491 788**	**17 130 922**	**17 789 717**	**18 468 773**	**19 168 708**
Taxes	(2 937 325)	(3 054 039)	(3 174 347)	(3 298 358)	(3 426 184)	(3 557 943)	(3 693 755)	(3 833 742)
Net Income	**11 749 298**	**12 216 156**	**12 697 387**	**13 193 430**	**13 704 737**	**14 231 773**	**14 775 018**	**15 334 967**
Annual sales growth rate	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

Cash Flows

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(40 000 000)	(55 000 000)	(5 000 000)	-	-	-	-	-
Rental income	-	2 636 065	17 573 765	18 100 978	18 644 007	19 203 327	19 779 427	20 372 810
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Working capital investments	-	(30 000)	(30 000)	-	-	-	-	-
Taxes	-	-	(1 306 753)	(2 404 036)	(2 504 318)	(2 607 693)	(2 714 253)	(2 824 097)
Released working capital	-	-	-	30 000	30 000	-	-	-
Free cash flow	**(40 000 000)**	**(54 393 935)**	**9 197 012**	**13 646 142**	**14 047 273**	**14 430 770**	**14 857 012**	**15 296 388**
Cumulative free cash flow	**(40 000 000)**	**(94 393 935)**	**(85 196 924)**	**(71 550 781)**	**(57 503 509)**	**(43 072 738)**	**(28 215 726)**	**(12 919 338)**
Discounted free cash flow (real terms)	**(40 000 000)**	**(51 898 801)**	**8 372 602**	**11 853 058**	**11 641 780**	**11 411 000**	**11 209 146**	**11 011 254**
Cumulative discounted free cash flow (real terms)	**(40 000 000)**	**(91 898 801)**	**(83 526 199)**	**(71 673 141)**	**(60 031 361)**	**(48 620 361)**	**(37 411 215)**	**(26 399 961)**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	20 983 994	21 613 514	22 261 919	22 929 777	23 617 670	24 326 200	25 055 986	25 807 666
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Working capital investments	-	-	-	-	-	-	-	-
Taxes	(2 937 325)	(3 054 039)	(3 174 347)	(3 298 358)	(3 426 184)	(3 557 943)	(3 693 755)	(3 833 742)
Released working capital	-	-	-	-	-	-	-	-
Free cash flow	**15 749 298**	**16 216 156**	**16 697 387**	**17 193 430**	**17 704 737**	**18 231 773**	**18 775 018**	**19 334 967**
Cumulative free cash flow	**2 829 960**	**19 046 116**	**35 743 503**	**52 936 934**	**70 641 671**	**88 873 444**	**107 648 463**	**126 983 429**
Discounted free cash flow (real terms)	**10 817 227**	**10 626 971**	**10 440 395**	**10 257 412**	**10 077 936**	**9 901 884**	**9 729 178**	**9 559 739**
Cumulative discounted free cash flow (real terms)	**(15 582 734)**	**(4 955 763)**	**5 484 632**	**15 742 044**	**25 819 979**	**35 721 864**	**45 451 042**	**55 010 781**

Profitability indicators:	NPV	IRR	PI	DPP
	€ 55 010 781,15	12 %	1,55	9,47

Summary of key factors:	Investment	Discount rate	Inflation	Square meter	Maintenance costs per square meter
	€ 100 000 000,00	5 %	4 %	10000	€ 200,00

Appendix 14. Capital budgeting analysis and cash flows in minimum scenario of strategy 1 (build in one phase).

Inputs

Total cost of investment	€	115 000 000,00
Number of years of investment cost allocation		3
Real interest rate (discount rate)**)		5 %
Nominal interest rate*)		9 %
Inflation		4 %
Square meter		10 000
Rental income per square meter	€	1 553,78
Yearly increase in maintenance costs		2 %
Maintenance costs per square meter	€	200,00
Depreciation per year from total investment	€	4 600 000,00
Working capital investments	€	30 000,00
Tax rate		20 %
Operating duration (how long operations are active)		15
Production start after		1

**) Excluding inflation (real terms)
*) Including inflation nominal terms

Outputs

P&L

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(45 000 000)	(52 500 000)	(17 500 000)	-	-	-	-	-
Rental income	-	2 330 670	15 537 798	16 003 932	16 484 050	16 978 571	17 487 928	18 012 566
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Other expenses (please insert as negative value)								
EBITDA	**(45 000 000)**	**(52 169 330)**	**(4 002 202)**	**13 923 132**	**14 361 634**	**14 813 707**	**15 279 767**	**15 760 241**
Depreciation	-	(3 900 000)	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**(45 000 000)**	**(56 069 330)**	**(8 602 202)**	**9 323 132**	**9 761 634**	**10 213 707**	**10 679 767**	**11 160 241**
Taxes	-	-	-	(1 864 626)	(1 952 327)	(2 042 741)	(2 135 953)	(2 232 048)
Net Income	**(45 000 000)**	**(56 069 330)**	**(8 602 202)**	**7 458 505**	**7 809 307**	**8 170 966**	**8 543 813**	**8 928 193**
Annual sales growth rate			**566,67 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	18 552 943	19 109 531	19 682 817	20 273 302	20 881 501	21 507 946	22 153 184	22 817 780
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Other expenses (please insert as negative value)								
EBITDA	**16 255 572**	**16 766 213**	**17 292 632**	**17 835 313**	**18 394 752**	**18 971 462**	**19 565 971**	**20 178 822**
Depreciation	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)	(4 600 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**11 655 572**	**12 166 213**	**12 692 632**	**13 235 313**	**13 794 752**	**14 371 462**	**14 965 971**	**15 578 822**
Taxes	(2 331 114)	(2 433 243)	(2 538 526)	(2 647 063)	(2 758 950)	(2 874 292)	(2 993 194)	(3 115 764)
Net Income	**9 324 457**	**9 732 970**	**10 154 106**	**10 588 250**	**11 035 802**	**11 497 170**	**11 972 777**	**12 463 058**
Annual sales growth rate	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

Cash Flows

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(45 000 000)	(52 500 000)	(17 500 000)	-	-	-	-	-
Rental income	-	2 330 670	15 537 798	16 003 932	16 484 050	16 978 571	17 487 928	18 012 566
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Working capital investments	-	(30 000)	(30 000)	-	-	-	-	-
Taxes	-	-	-	(1 864 626)	(1 952 327)	(2 042 741)	(2 135 953)	(2 232 048)
Released working capital	-	-	-	30 000	30 000	-	-	-
Free cash flow	**(45 000 000)**	**(52 199 330)**	**(4 032 202)**	**12 088 505**	**12 439 307**	**12 770 966**	**13 143 813**	**13 528 193**
Cumulative free cash flow	**(45 000 000)**	**(97 199 330)**	**(101 231 533)**	**(89 143 027)**	**(76 703 720)**	**(63 932 755)**	**(50 788 941)**	**(37 260 748)**
Discounted free cash flow (real terms)	**(45 000 000)**	**(49 804 866)**	**(3 670 760)**	**10 500 093**	**10 309 166**	**10 098 525**	**9 916 592**	**9 738 402**
Cumulative discounted free cash flow (real terms)	**(45 000 000)**	**(94 804 866)**	**(98 475 626)**	**(87 975 533)**	**(77 666 366)**	**(67 567 842)**	**(57 651 250)**	**(47 912 848)**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	18 552 943	19 109 531	19 682 817	20 273 302	20 881 501	21 507 946	22 153 184	22 817 780
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Working capital investments	-	-	-	-	-	-	-	-
Taxes	(2 331 114)	(2 433 243)	(2 538 526)	(2 647 063)	(2 758 950)	(2 874 292)	(2 993 194)	(3 115 764)
Released working capital	-	-	-	-	-	-	-	-
Free cash flow	**13 924 457**	**14 332 970**	**14 754 106**	**15 188 250**	**15 635 802**	**16 097 170**	**16 572 777**	**17 063 058**
Cumulative free cash flow	**(23 336 291)**	**(9 003 321)**	**5 750 785**	**20 939 036**	**36 574 838**	**52 672 008**	**69 244 785**	**86 307 842**
Discounted free cash flow (real terms)	**9 563 856**	**9 392 858**	**9 225 317**	**9 061 143**	**8 900 251**	**8 742 557**	**8 587 981**	**8 436 445**
Cumulative discounted free cash flow (real terms)	**(38 348 993)**	**(28 956 134)**	**(19 730 817)**	**(10 669 674)**	**(1 769 423)**	**6 973 134**	**15 561 115**	**23 997 560**

Profitability indicators:	NPV	IRR	PI	DPP
	€ 23 997 560,15	8 %	1,21	12,20

Summary of key factors:	Investment	Discount rate	Inflation	Square meter	Maintenance costs per square meter
	€ 115 000 000,00	5 %	4 %	10000	€ 200,00

Appendix 15. Capital budgeting analysis and cash flows in maximum scenario of strategy 2 (build in two phases with flexible construction parts).

Inputs

Total cost of investment	€	110 000 000,00
Number of years of investment cost allocation		2
Real interest rate (discount rate)**)		5 %
Nominal interest rate*)		9 %
Inflation		4 %
Square meter		10 000
Rental income per square meter	€	3 000,00
Yearly increase in maintenance costs		2 %
Maintenance costs per square meter	€	200,00
Depreciation per year from total investment	€	4 400 000,00
Working capital investments	€	30 000,00
Tax rate		20 %
Operating duration (how long operations are active)		15
Production start after		1

**) Excluding inflation (real terms)
*) Including inflation nominal terms

Outputs

P&L

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	(52 800 000)		-	(57 200 000)	-	-	-	-	-	-	-	-	-	-	-	-
Rental income	-	4 500 000	30 000 000	30 900 000	31 827 000	32 781 810	33 765 264	34 778 222	35 821 569	36 896 216	38 003 102	39 143 196	40 317 491	41 527 016	42 772 827	44 056 011
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Other expenses (please insert as negative value)																
EBITDA	**(52 800 000)**	**2 500 000**	**27 960 000**	**(28 380 800)**	**29 704 584**	**30 616 946**	**31 557 103**	**32 525 897**	**33 524 198**	**34 552 897**	**35 612 917**	**36 705 207**	**37 830 743**	**38 990 533**	**40 185 613**	**41 417 054**
Depreciation	-	(2 112 000)	(2 112 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)	(4 400 000)
Impairment (please insert as negative value)																
Operating profit (EBIT)	**(52 800 000)**	**388 000**	**25 848 000**	**(32 780 800)**	**25 304 584**	**26 216 946**	**27 157 103**	**28 125 897**	**29 124 198**	**30 152 897**	**31 212 917**	**32 305 207**	**33 430 743**	**34 590 533**	**35 785 613**	**37 017 054**
Taxes	-	(77 600)	(5 169 600)	-	(5 060 917)	(5 243 389)	(5 431 421)	(5 625 179)	(5 824 840)	(6 030 579)	(6 242 583)	(6 461 041)	(6 686 149)	(6 918 107)	(7 157 123)	(7 403 411)
Net Income	**(52 800 000)**	**310 400**	**20 678 400**	**(32 780 800)**	**20 243 667**	**20 973 557**	**21 725 682**	**22 500 718**	**23 299 358**	**24 122 318**	**24 970 334**	**25 844 165**	**26 744 594**	**27 672 426**	**28 628 491**	**29 613 643**
Annual sales growth rate			**566,67 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

Cash Flows

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	(52 800 000)	-	-	(57 200 000)	-	-	-	-	-	-	-	-	-	-	-	-
Rental income	-	4 500 000	30 000 000	30 900 000	31 827 000	32 781 810	33 765 264	34 778 222	35 821 569	36 896 216	38 003 102	39 143 196	40 317 491	41 527 016	42 772 827	44 056 011
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Working capital investments	-	(30 000)	(30 000)	-	-	-	-	-	-	-	-	-	-	-	-	-
Taxes	-	(77 600)	(5 169 600)	-	(5 060 917)	(5 243 389)	(5 431 421)	(5 625 179)	(5 824 840)	(6 030 579)	(6 242 583)	(6 461 041)	(6 686 149)	(6 918 107)	(7 157 123)	(7 403 411)
Released working capital	-	-	-	30 000	30 000	-	-	-	-	-	-	-	-	-	-	-
Free cash flow	**(52 800 000)**	**2 392 400**	**22 760 400**	**(28 350 800)**	**24 673 667**	**25 373 557**	**26 125 682**	**26 900 718**	**27 699 358**	**28 522 318**	**29 370 334**	**30 244 165**	**31 144 594**	**32 072 426**	**33 028 491**	**34 013 643**
Cumulative free cash flow	**(52 800 000)**	**(50 407 600)**	**(27 647 200)**	**(55 998 000)**	**(31 324 333)**	**(5 950 776)**	**20 174 906**	**47 075 624**	**74 774 982**	**103 297 300**	**132 667 633**	**162 911 799**	**194 056 393**	**226 128 819**	**259 157 310**	**293 170 953**
Discounted free cash flow (real terms)	**(52 800 000)**	**2 282 657**	**20 720 182**	**(24 625 545)**	**20 448 482**	**20 063 909**	**19 711 001**	**19 364 744**	**19 024 990**	**18 691 596**	**18 364 423**	**18 043 337**	**17 728 205**	**17 418 901**	**17 115 300**	**16 817 281**
Cumulative discounted free cash flow (real terms)	**(52 800 000)**	**(50 517 343)**	**(29 797 161)**	**(54 422 705)**	**(33 974 224)**	**(13 910 314)**	**5 800 687**	**25 165 431**	**44 190 421**	**62 882 017**	**81 246 440**	**99 289 777**	**117 017 982**	**134 436 883**	**151 552 183**	**168 369 464**

Profitability indicators:	NPV	IRR	PI	DPP
	€ 168 369 463,65	25 %	2,53	5,71

Summary of key factors:	Investment	Discount rate	Inflation	Square meter	Maintenance costs per square meter
	€ 110 000 000,00	5 %	4 %	10000	€ 200,00

Appendix 16. Capital budgeting analysis and cash flows in best estimation scenario of strategy 2 (build in two phases with flexible construction parts).

Inputs

Total cost of investment	€	125 000 000,00
Number of years of investment cost allocation		2
Real interest rate (discount rate)**)		5 %
Nominal interest rate*)		9 %
Inflation		4 %
Square meter		10 000
Rental income per square meter	€	2 498,92
Yearly increase in maintenance costs		2 %
Maintenance costs per square meter	€	200,00
Depreciation per year from total investment	€	5 000 000,00
Working capital investments	€	30 000,00
Tax rate		20 %
Operating duration (how long operations are active)		15
Production start after		1

**) Excluding inflation (real terms)
*) Including inflation nominal terms

Outputs

P&L

	0	1	2	3	4	5	6	7
in EUR	2022	2023	2024	2025	2026	2027	2028	2029
Investment	(57 000 000)	(3 000 000)	-	(65 000 000)	-	-	-	-
Rental income	-	3 748 384	24 989 223	25 738 900	26 511 067	27 306 399	28 125 591	28 969 359
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Other expenses (please insert as negative value)								
EBITDA	**(57 000 000)**	**(1 251 616)**	**22 949 223**	**(41 341 900)**	**24 388 651**	**25 141 535**	**25 917 430**	**26 717 034**
Depreciation	-	(2 400 000)	(2 400 000)	(5 000 000)	(5 000 000)	(5 000 000)	(5 000 000)	(5 000 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**(57 000 000)**	**(3 651 616)**	**20 549 223**	**(46 341 900)**	**19 388 651**	**20 141 535**	**20 917 430**	**21 717 034**
Taxes	-	-	(4 109 845)	-	(3 877 730)	(4 028 307)	(4 183 486)	(4 343 407)
Net Income	**(57 000 000)**	**(3 651 616)**	**16 439 379**	**(46 341 900)**	**15 510 921**	**16 113 228**	**16 733 944**	**17 373 627**
Annual sales growth rate			**566,67 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

	8	9	10	11	12	13	14	15
in EUR	2030	2031	2032	2033	2034	2035	2036	2037
Investment	-	-	-	-	-	-	-	-
Rental income	29 838 440	30 733 593	31 655 601	32 605 269	33 583 427	34 590 929	35 628 657	36 697 517
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Other expenses (please insert as negative value)								
EBITDA	**27 541 068**	**28 390 274**	**29 265 415**	**30 167 280**	**31 096 678**	**32 054 446**	**33 041 444**	**34 058 560**
Depreciation	(5 000 000)	(5 000 000)	(5 000 000)	(5 000 000)	(5 000 000)	(5 000 000)	(5 000 000)	(5 000 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**22 541 068**	**23 390 274**	**24 265 415**	**25 167 280**	**26 096 678**	**27 054 446**	**28 041 444**	**29 058 560**
Taxes	(4 508 214)	(4 678 055)	(4 853 083)	(5 033 456)	(5 219 336)	(5 410 889)	(5 608 289)	(5 811 712)
Net Income	**18 032 855**	**18 712 219**	**19 412 332**	**20 133 824**	**20 877 342**	**21 643 557**	**22 433 155**	**23 246 848**
Annual sales growth rate	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

Cash Flows

	0	1	2	3	4	5	6	7
in EUR	2022	2023	2024	2025	2026	2027	2028	2029
Investment	(57 000 000)	(3 000 000)	-	(65 000 000)	-	-	-	-
Rental income	-	3 748 384	24 989 223	25 738 900	26 511 067	27 306 399	28 125 591	28 969 359
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Working capital investments	-	(30 000)	(30 000)	-	-	-	-	-
Taxes	-	-	(4 109 845)	-	(3 877 730)	(4 028 307)	(4 183 486)	(4 343 407)
Released working capital	-	-	-	30 000	30 000	-	-	-
Free cash flow	**(57 000 000)**	**(1 281 616)**	**18 809 379**	**(41 311 900)**	**20 540 921**	**21 113 228**	**21 733 944**	**22 373 627**
Cumulative free cash flow	**(57 000 000)**	**(58 281 616)**	**(39 472 238)**	**(80 784 138)**	**(60 243 217)**	**(39 129 989)**	**(17 396 045)**	**4 977 582**
Discounted free cash flow (real terms)	**(57 000 000)**	**(1 222 827)**	**17 123 326**	**(35 883 574)**	**17 023 438**	**16 695 093**	**16 397 573**	**16 105 874**
Cumulative discounted free cash flow (real terms)	**(57 000 000)**	**(58 222 827)**	**(41 099 500)**	**(76 983 074)**	**(59 959 636)**	**(43 264 543)**	**(26 866 970)**	**(10 761 096)**

	8	9	10	11	12	13	14	15
in EUR	2030	2031	2032	2033	2034	2035	2036	2037
Investment	-	-	-	-	-	-	-	-
Rental income	29 838 440	30 733 593	31 655 601	32 605 269	33 583 427	34 590 929	35 628 657	36 697 517
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Working capital investments	-	-	-	-	-	-	-	-
Taxes	(4 508 214)	(4 678 055)	(4 853 083)	(5 033 456)	(5 219 336)	(5 410 889)	(5 608 289)	(5 811 712)
Released working capital	-	-	-	-	-	-	-	-
Free cash flow	**23 032 855**	**23 712 219**	**24 412 332**	**25 133 824**	**25 877 342**	**26 643 557**	**27 433 155**	**28 246 848**
Cumulative free cash flow	**28 010 437**	**51 722 656**	**76 134 988**	**101 268 812**	**127 146 154**	**153 789 711**	**181 222 866**	**209 469 714**
Discounted free cash flow (real terms)	**15 819 855**	**15 539 383**	**15 264 328**	**14 994 563**	**14 729 967**	**14 470 420**	**14 215 808**	**13 966 018**
Cumulative discounted free cash flow (real terms)	**5 058 759**	**20 598 142**	**35 862 470**	**50 857 033**	**65 587 000**	**80 057 420**	**94 273 228**	**108 239 246**

Profitability indicators:	NPV	IRR	PI	DPP
	€ 108 239 245,90	17 %	1,87	7,68

Summary of key factors:	Investment	Discount rate	Inflation	Square meter	Maintenance costs per square meter
	€ 125 000 000,00	5 %	4 %	10000	€ 200,00

Appendix 17. Capital budgeting analysis and cash flows in minimum scenario of strategy 2 (build in two phases with flexible construction parts).

Inputs

Total cost of investment	€	143 750 000,00
Number of years of investment cost allocation		2
Real interest rate (discount rate)**)		5 %
Nominal interest rate*)		9 %
Inflation		4 %
Square meter		10 000
Rental income per square meter	€	1 404,68
Yearly increase in maintenance costs		2 %
Maintenance costs per square meter	€	200,00
Depreciation per year from total investment	€	5 750 000,00
Working capital investments	€	30 000,00
Tax rate		20 %
Operating duration (how long operations are active)		15
Production start after		1

**) Excluding inflation (real terms)
*) Including inflation nominal terms

Outputs

P&L

in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(62 000 000)	(7 000 000)	-	(74 750 000)	-	-	-	-
Rental income	-	2 107 024	14 046 830	14 468 235	14 902 282	15 349 350	15 809 831	16 284 126
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Other expenses (please insert as negative value)								
EBITDA	**(62 000 000)**	**(6 892 976)**	**12 006 830**	**(62 362 565)**	**12 779 866**	**13 184 486**	**13 601 669**	**14 031 801**
Depreciation	-	(2 760 000)	(2 760 000)	(5 750 000)	(5 750 000)	(5 750 000)	(5 750 000)	(5 750 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**(62 000 000)**	**(9 652 976)**	**9 246 830**	**(68 112 565)**	**7 029 866**	**7 434 486**	**7 851 669**	**8 281 801**
Taxes	-	-	(1849 366)	-	(1405 973)	(1486 897)	(1570 334)	(1656 360)
Net Income	**(62 000 000)**	**(9 652 976)**	**7 397 464**	**(68 112 565)**	**5 623 893**	**5 947 589**	**6 281 335**	**6 625 441**
Annual sales growth rate			**566,67 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	16 772 649	17 275 829	17 794 104	18 327 927	18 877 765	19 444 098	20 027 421	20 628 243
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Other expenses (please insert as negative value)								
EBITDA	**14 475 278**	**14 932 510**	**15 403 919**	**15 889 938**	**16 391 016**	**16 907 614**	**17 440 207**	**17 989 286**
Depreciation	(5 750 000)	(5 750 000)	(5 750 000)	(5 750 000)	(5 750 000)	(5 750 000)	(5 750 000)	(5 750 000)
Impairment (please insert as negative value)								
Operating profit (EBIT)	**8 725 278**	**9 182 510**	**9 653 919**	**10 139 938**	**10 641 016**	**11 157 614**	**11 690 207**	**12 239 286**
Taxes	(1745 056)	(1836 502)	(1930 784)	(2 027 988)	(2 128 203)	(2 231523)	(2 338 041)	(2 447 857)
Net Income	**6 980 222**	**7 346 008**	**7 723 135**	**8 111 950**	**8 512 813**	**8 926 091**	**9 352 166**	**9 791 429**
Annual sales growth rate	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**	**3,00 %**

Cash Flows

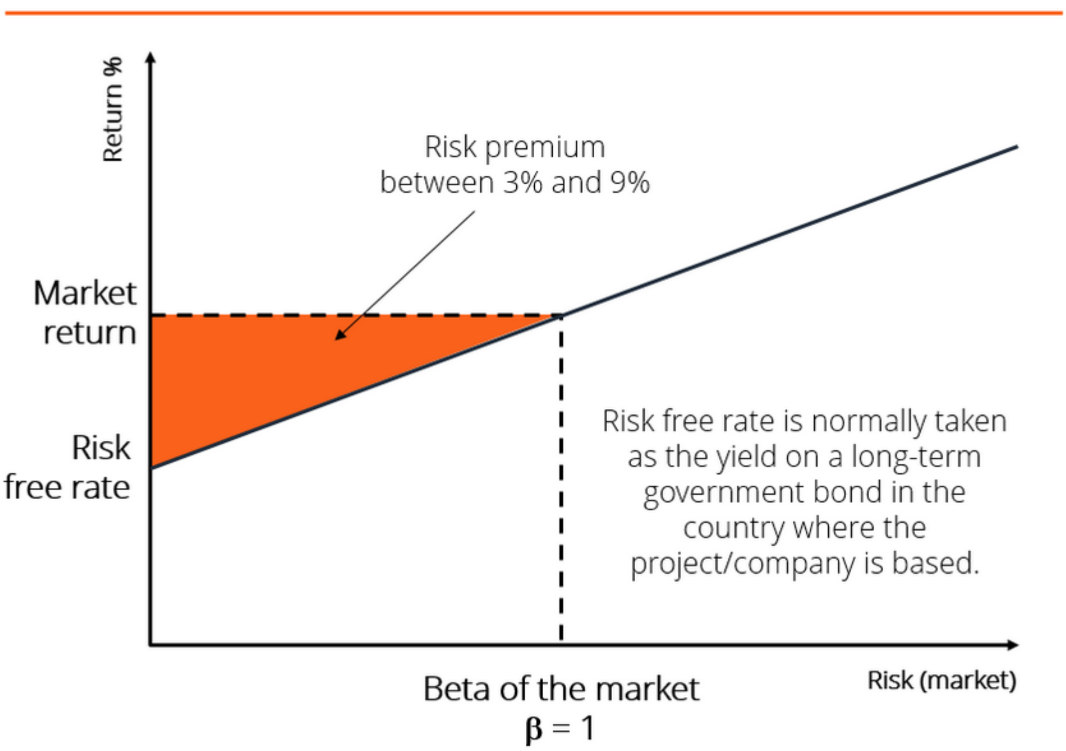
in EUR	0 2022	1 2023	2 2024	3 2025	4 2026	5 2027	6 2028	7 2029
Investment	(62 000 000)	(7 000 000)	-	(74 750 000)	-	-	-	-
Rental income	-	2 107 024	14 046 830	14 468 235	14 902 282	15 349 350	15 809 831	16 284 126
Operating costs	-	(2 000 000)	(2 040 000)	(2 080 800)	(2 122 416)	(2 164 864)	(2 208 162)	(2 252 325)
Working capital investments	-	(30 000)	(30 000)	-	-	-	-	-
Taxes	-	-	(1849 366)	-	(1405 973)	(1486 897)	(1570 334)	(1656 360)
Released working capital	-	-	-	30 000	30 000	-	-	-
Free cash flow	**(62 000 000)**	**(6 922 976)**	**10 127 464**	**(62 332 565)**	**11 403 893**	**11 697 589**	**12 031 335**	**12 375 441**
Cumulative free cash flow	**(62 000 000)**	**(68 922 976)**	**(58 795 512)**	**(121 128 077)**	**(109 724 184)**	**(98 026 596)**	**(85 995 260)**	**(73 619 820)**
Discounted free cash flow (real terms)	**(62 000 000)**	**(6 605 408)**	**9 219 649**	**(54 142 153)**	**9 451 059**	**9 249 762**	**9 077 262**	**8 908 582**
Cumulative discounted free cash flow (real terms)	**(62 000 000)**	**(68 605 408)**	**(59 385 759)**	**(113 527 912)**	**(104 076 853)**	**(94 827 091)**	**(85 749 829)**	**(76 841 247)**

in EUR	8 2030	9 2031	10 2032	11 2033	12 2034	13 2035	14 2036	15 2037
Investment	-	-	-	-	-	-	-	-
Rental income	16 772 649	17 275 829	17 794 104	18 327 927	18 877 765	19 444 098	20 027 421	20 628 243
Operating costs	(2 297 371)	(2 343 319)	(2 390 185)	(2 437 989)	(2 486 749)	(2 536 484)	(2 587 213)	(2 638 958)
Working capital investments	-	-	-	-	-	-	-	-
Taxes	(1745 056)	(1836 502)	(1930 784)	(2 027 988)	(2 128 203)	(2 231523)	(2 338 041)	(2 447 857)
Released working capital	-	-	-	-	-	-	-	-
Free cash flow	**12 730 222**	**13 096 008**	**13 473 135**	**13 861 950**	**14 262 813**	**14 676 091**	**15 102 166**	**15 541 429**
Cumulative free cash flow	**(60 889 597)**	**(47 793 589)**	**(34 320 454)**	**(20 458 504)**	**(6 195 691)**	**8 480 401**	**23 582 566**	**39 123 995**
Discounted free cash flow (real terms)	**8 743 609**	**8 582 237**	**8 424 363**	**8 269 887**	**8 118 715**	**7 970 753**	**7 825 913**	**7 684 110**
Cumulative discounted free cash flow (real terms)	**(68 097 638)**	**(59 515 401)**	**(51 091 038)**	**(42 821 151)**	**(34 702 436)**	**(26 731 683)**	**(18 905 770)**	**(11 221 661)**

Profitability indicators:	NPV	IRR	PI	DPP
	-€ 11 221 660,62	3,5 %	0,92	#N/A

Summary of key factors:	Investment	Discount rate	Inflation	Square meter	Maintenance costs per square meter
	€ 143 750 000,00	5 %	4 %	10000	€ 200,00

Appendix 18. Capital Asset Pricing Model (CAPM) and formula (CFI, 2022b).



Ra = Rrf + [Ba x (Rm – Rrf)]

Where:

Ra = Expected return on a security
Rrf = Risk-free rate
Ba = Beta of the security
Rm = Expected return of the market

Note: "Risk Premium" = (Rm – Rrf)