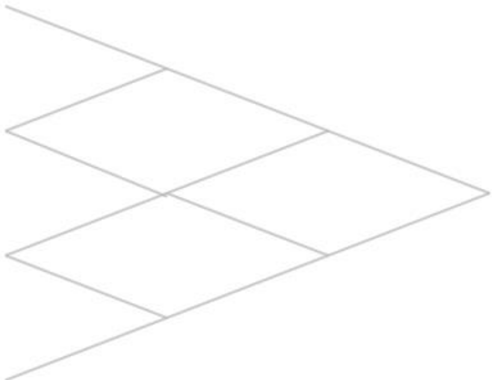
The Future Value of Investing in Adaptivity in Offices

A financial decision model for an investor to value the future value of adaptivity in an office building in the Netherlands by using the Real Options Analysis



P5 Report

Tom van Eerden
4146603

TU Delft

This page intentionally left blank

Personalia

Type	P5 Report
Author	Tom van Eerden
Address	
Phone	
Email	
Study number	4146603
University	Delft University of Technology
Faculty	Architecture
Department	Management in the Built Environment
Lab	Real Estate Management
Degree	Master of Science

Date report	05-04-2018
Date presentation	10-04-2018

Mentors

First Mentor	Prof. Dr. ir. M. H. Hermans (replaced by Dr. ir. L. Volker)
Second Mentor	Dr. ir. R. Binnenkamp (replaced by Drs. P.W. Koppels)
Associate Mentor	S. Başdoğan
Commissioner:	Ir. M. Meijs

Internship

Graduation Company	Brink Groep
Department	Brink Management & Advies
Team	Portefeuillesturing
Supervisors	Drs. J. van der Werf & Ir. E. van Rijn

Table of Contents

Personalia 3

Preface 6

Summary 7

1. Introduction 17

 1.1 The current office market and trends 17

 1.2 Vacancy 18

 1.3 Adaptive capacity 19

 1.4 Research problem 19

 1.5 Problem statement 20

 1.6 Research questions 20

 1.7 Research aim 21

 1.8 Research target group 21

 1.9 Methodology 21

 1.10 Results 22

 1.11 Relevance 23

 1.12 Report structure 23

2. Background of Adaptivity 24

 2.1 Origin of Adaptivity 24

 2.2 Definitions 24

 2.3 Types of adaptive capacity 25

 2.4 Demand and supply model 25

 2.5 Adaptivity in practise 27

 2.6 Adaptive indicators 29

 2.7 Conclusion 32

3. Investing in adaptivity 33

 3.1 The Owner/investor 33

 3.2 Investment motives in general 34

 3.3 Investment motives for adaptivity 35

 3.4 Conclusion motives to invest in adaptivity 38

 3.5 Conclusion 38

4. Valuation methods 40

 4.1 Actions of the investor 40

 4.2 The current valuation methods 41

 4.3 Discounted Cash Flow method (DCF method) 43

4.4 Decision Tree Analysis (DTA) 46
4.5 Real Options Analysis (ROA) 47
4.6 DCF vs. DTA vs. ROA 49
4.7 Monte Carlo Simulation 50
4.8 Conclusion 52
5. The financial model 53
5.1 The conceptual valuation model 53
5.2 The original case 54
5.3 Stochastic part 60
5.4 Results 65
5.5 Conclusion 71
6. Conclusion and Discussion 72
7. Recommendations 75
8. Reflection 76
9. References 78
Appendices 81
Appendix 1-a Qualitative subscription of the adaptive indicators of FLEX 2.0 light 82
Appendix 1-b Quantitative subscription of the adaptive indicators of FLEX 2.0 light 85
Appendix 2-a Financial model – Input data 86
Appendix 2-b Financial model – Historical data and assumptions 87
Appendix 2-c Financial model – Optimization adaptivity 88
Appendix 2-d Financial model – Cash flow original case 89
Appendix 2-e Financial model – Cash flow new model 90
Appendix 3-a Floor plans original case 91
Appendix 4-a Decision Tree Analysis stochastic approach Bergen op Zoom 92
Appendix 4-b Decision Tree Analysis stochastic approach Amsterdam 93

Preface

This report is written in the fourth semester of the master track Management in the Built Environment at the faculty of Architecture at Delft University of Technology. It is my master thesis regarding to the future value of investing in adaptivity in office developments in the Netherlands.

There are multiple reasons for me to do research on investments in implementing adaptivity in office developments in the Netherlands. It is a combination of two aspects I liked since the beginning of my bachelor in the Netherlands: the technical building aspects, mostly learned in the bachelor, and the financial aspects of buildings, mostly learned in the master. A combination of those two aspects is for me the perfect final to conclude my study with.

The starting point for my thesis is the report called ''Gebouwen met toekomstwaarde!'' written by Hermans, Geraedts, Van Rijn, and Remøy (2014). They concluded that the adaptive capacity is considered a crucial component when looking into the sustainability of the real estate stock. Hereby, they developed a determination method to test the adaptive capacity of buildings after an extensive survey of international literature on the characteristics, definitions and assessment instruments of adaptive building and on boundaries of adaptive capacity, sustainability and financial business cases for real estate. The report fulfilled the belief that a building should be able to easily change in the most possible ways of future use, i.e. the future value. They formulated 100+ indicators to display what need to be considered to make an adaptive building. In their report, they suggested some additions for the DCF method instead of designing a new financial model focused on adaptivity.

This report will continue the research to develop a financial model to value adaptivity. With a financial decision model that gives the added financial value of implementing adaptivity in new office buildings the investor is actual willing to invest in adaptivity in office buildings for the future.

My aim is to make a financial decision model that can be used by different companies. In combination with their own data they can simulate what will be their best investments in adaptivity. I think that the requirement of using their own data is necessary to utilize the model in the market, because every company uses his own database of information to calculate with.

The biggest challenge for me was to understand all the different financial models and combining them into one decision model. The study Management in the built environment is mostly focussed on management instead of finance. To link the knowledge of finance with the current literature about adaptivity was an interesting challenge in the process. Finally, the financial decision model could stimulate investors to invest in adaptivity and sustainability. This will lead to a decrease in demolishment's and structural vacancy of office buildings and decrease the miss-use of our raw material. The target of the Netherlands is that 16% of the total energy is sustainable energy in 2023 and this research could contribute to achieve this sustainability goal of the Netherlands.

Through this way, I would like to thank everyone who supported me during my research project, helping me with financial modelling, but also to understand the idea behind investing in adaptivity in practise. I would also like to thank my mentors Marleen Hermans and Ruud Binnenkamp, together with the two experts from Brink Groep, who steered me towards the right direction during the entire research process.

Tom van Eerden

Amsterdam, April 2018

Summary

"The Future Value of Investing in Adaptivity in Offices"

Abstract
With the rapid development of real estate market, due to trends as the change in the way of working and automation/digitalisation of working processes, flexibility is one of the most important tasks for owner/investors of office buildings to invest in. Currently, 60% of the vacant offices are structural vacant. Flexibility could be used as an instrument to prevent future vacant office space. The flexibility to change characteristics of a building during its life cycle is called the adaptive capacity of a building. Adaptability can be regarded as way to make the real estate supply more dynamic and better able to cope with demand dynamics (static supply and dynamic demand) and in this way extend the functional lifespan of buildings. The problem is that real estate investors are hardly interested in investing in office buildings to increase the adaptive capacity. Thereby, is the most used financial method the DCF method which is currently insufficiently used to simulate the future uncertainty in an investment in flexibility on the longer term. This aim of this research is to illustrate how to cope with the future uncertainty in a new financial method. By using a stochastic approach with the Decision Tree Analysis the investors could be stimulated to invest in the adaptive capacity of office buildings and increase the adaptive capacity of a building to respond if the functional demand changes.

Keywords: Adaptivity, Flexibility, Real estate investor, Decision Tree Analysis, DCF method

1. Introduction

In the year 2016, the office market in the Netherlands changed from a downward market to an upward market. In the downward market there was an increasing vacancy, a constant office building supply and a decrease in the demand for office space. In the upward market there is a record of 1,08 million square metres extracted from the office supply, mostly because 74% of the extracted offices were transformed to another function (Dynamis, 2017). The amount of new built premises was in total 200.000 square metres; an increase of a third in comparison to the year 2015. The biggest investment category within the real estate market last year was the office market with 6,6 billion euros for transformations and new developments (Rabobank, 2017a). In short, in the current upward market is an interest in transformations of offices and the investors are prepared to invest in offices in the Netherlands.

A trend on the demand side, or user side, is a decrease of office space due to the change in the way of working. Another trend which resulted in a decrease of office space demand is the automation/digitalisation of working processes. The current trends on the supply side are the creation of future proof real estate and sustainability are supporting to prevent the future vacant office space (Rabobank, 2017). An example of future proof real estate is to build flexible. When there is no demand for office space, the flexibility of a building will help to easily change to another function. Adaptability can be regarded as way to make the real estate supply more dynamic and better able to cope with demand dynamics (static supply and dynamic demand) and in this way extend the functional lifespan of buildings

It is important to make a difference in the current vacancy between structural, lengthy and friction vacancy. Structural vacancy is more than 3 years vacant, lengthy vacancy is between 1 and 3 years vacant and friction vacancy is less than a year vacant. Separation of the vacancy in those three levels will show the increase of structural vacancy and decrease of friction vacancy. In year 2016, 60% of the vacancy is structural (CLO, 2016). The current structural vacancy highlights that in the past wasn't enough interest in investing in building flexible, because the lack of demand in flexibility and the low direct return.

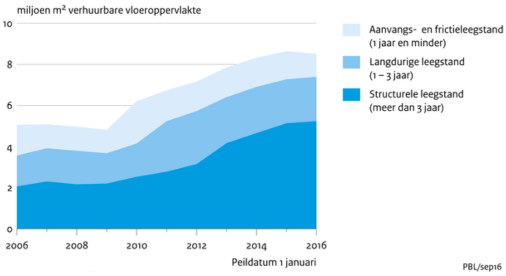


Figure 1: The division of levels in vacancy (CLO, 2016)

Flexibility could be used as an instrument to prevent future vacant office space. The flexibility to change characteristics of a building during its life cycle is called the adaptive capacity of a building. The adaptive capacity is being considered as a crucial component when looking into the sustainability of the real estate stock (Hermans, Geraedts, Van Rijn, and Remøy, 2014, p. 6).

Problem statement

The problem is the high vacancy in the Dutch office market with 60% of the vacant offices are structural vacant. The trend is a decrease in the demand in office space and there are a third more new developments in comparison to last year. The problem for the current vacancy is growing and the question is of the new developments are built for more than one functional life cycle? If the new developments are more flexible to adapt to another function when there isn't any demand for the current function, it could prevent future vacancy. To prevent future vacancy after completion of one functional lifecycle (15 years for example), the present calculating method should be changed to stimulate adaptive building methods. Another part of the problem is that DCF models are currently insufficiently used to simulate the future uncertainty in an investment in flexibility on the longer term. Currently, the demand of flexibility is growing but with the DCF method it is not easy to calculate the flexibility of an office building investment. This will lead to a decrease in demolishment's and structural vacancy of office building. Currently, more than 10% of the total supply of office space is vacant and the structural vacancy is growing. A better approach could be developed to stimulate investing in the adaptive capacity of office buildings and increase the adaptive capacity of a building to transform if the functional demand changes. Hence, the building can respond to the future uncertainty in the market. This research will focus on the building and will take the location into account where necessary.

To solve the problem mentioned above, the main question of this research is as follows:

How to cope with future uncertainty in a DCF method to value the adaptive capacity of office buildings to stimulate investors to invest in adaptivity?

Research aim

The aim of this research is to develop a financial decision model for an owner/investor to value the future value of adaptivity for an investment in an office building in the Netherlands. This model will provide the owner/user the future uncertainties of their investment and the adaptive capacities of the office building. By showing the uncertainties and advantages of investing in adaptivity during the total technical life cycle, the willingness to invest in the adaptive capacity of an office building could be increased. Investments in adaptivity require a long-term perspective because of the focus on the total technical lifespan of a building. The research will be focussed on new developments of office buildings, because of the limitation of the possibility to change construction elements in existing buildings. Adaptivity can be maximized while all layers in a building can be influenced during the design phase what will make it more attractive for investors to invest in. The target group for this research will be the owner and/or investor in real estate with a long term horizon.

Methodology

The research is partly a descriptive research and partly a prescriptive research. This research result in a financial model to value adaptivity based on one case. The case will be simulated, evaluated and compared to the new results of the financial model. The conclusion of the comparison can be seen as an advice to the investor and the advisor of the case.

2. Background of Adaptivity

In this chapter will be elaborated on the background of adaptivity to understand what is meant with adaptivity. This information is needed to answer the sub-question of the next chapter. There are three terms that can be used in terminology related to adaptivity. All three terms describe something different in this research. Adaptability will be used as the require ability to adjust to changing environments. In particular by the way they are created and if they are approachable (Groak, 1992). The term flexibility will be used as the capacity for change in physical circumstances. The definition for adaptivity and adaptive capability used in this research is as follows: Adaptivity or the adaptive capability of a building includes all characteristics that enable the building to maintain its functionality in a sustainable and economical profitable manner during its technical lifespan, during changes in need and other circumstances. The adaptive capacity is being considered as a crucial component when looking into the sustainability of the real estate stock (Hermans et al., 2014, p. 6).

According to the main question of this thesis should be determined what the added value is of adaptivity. The user dynamics and transformation dynamics are crucial in the valuation of adaptivity, because they are determine the demand for adaptivity. If the building, the supply side, has the capability to rearrange, extend and reject, the adaptive capacity is extremely high. These flexibilities should be taken into account by the investor if he will invest in adaptivity and these flexibilities should be implemented in the financial model.

There are three different kinds of adaptivity but only the product flexibility will be used further in this research. Product flexibility contains spatial flexibility, user flexibility, infill flexibility, construction flexibility, structure flexibility, technical flexibility. These types of flexibility will be used to measure the adaptive capacity of an office building and are used in the list of adaptive indicators based on FLEX 2.0 light of Gereadts (2015) and Brink Groep (2018). In the next chapter will be explained what the reasons are to invest in adaptivity.

3. Investing in adaptivity

In this chapter will be elaborated on the subject why to invest in adaptivity. This report is based on the report of Hermans et al.(2014). The conclusion of their report was that adaptivity is a tool to extend the functional lifecycle of the building. On the longer term, adaptivity will be an important precondition for sustainability. But why should investors invest in adaptivity in the first place? The question for this chapter is:

What are reasons to invest in adaptivity and what financial effect has an investment in adaptivity?

In short, there are two main types of investors in real estate. The investor who invest in the building for his own use, the owner-user and there is the commercial investor who is more focussing on the yield. In the end there can be concluded that the commercial investor makes a decision to invest in the adaptive capacity of a building based on the yield and risk. The commercial investor is focussed to retain a maximum yield. Depending on the kind of investor there is a distinction in the risk profile.

The combination of what the investor demands and what the adaptivity could offer answered the question of chapter 3: what are the reasons to invest in adaptivity and what are the financial effects the adaptivity has on the investment? The possibilities of adaptivity are to be capable to rearrange, extend and reject if there is a change in demand of function for example. The demand of the commercial investors are focussed on three aspects: time, risk and yield. If the risk is low and the yield is high it is an interesting investment for the investor. The problem is the long timespan and the risk before it is valuable to invest in adaptivity. Therefore, most of the short term investors are not interested in the investment in adaptivity, but the long term investors are. Based on multiple literature (Geltner, 2006, 2001; Keeris, 2008) the short term investor could be interested in the extra investment in adaptivity, because of an increase in the value. However, in practise it is not feasible. It will only be used if the client demands it. Both in practise and theory, the long term investor has the demand to invest in adaptivity with a long term focus, a low risk profile and a high yield. The demand of the owner-user investor is mostly focused on their own use. The user dynamics could be a valuable addition to their objective to accommodate the organisation. Their focus is to produce a portfolio that is future proof with flexibility included.

Another important reason to invest is the location and the market (Geltner, 2001). The uncertainty of future events are related to the location and the market. The financial model should take into account what kind of location the property is situated. This will influence the decision to invest in adaptivity or not. The same applies for the real estate market. Last decade, the market is very volatile and therefore should this implemented in the financial model as well (Bolgün & Akçay, 2003).

The financial effects of adaptivity depends on the type of investor. For a short term investor the financial consequences are negative and therefore not interesting, except for the second investor that cares about adaptivity. The investment costs are not recovered in their short term operating period. Nevertheless, the long term investor could benefit from the long term operating period. Sometimes the rent for tenants are a bit higher as a result of the split-incentive. From the perspective of adaptivity it is not sufficient to analyse only the investment costs. The positive effects of adaptivity are mostly applicable during the operating phase of the building. The value of adaptivity is measurable when the adaptivity is desired by a change in demand. This can be measured by the rent ability for example.

4. Valuation methods

In this chapter the different valuation methods that could be used to determine the adaptive capacity of an office building will be elaborated. The aim of this research is to develop a financial decision model for an owner/investor to value the future value of adaptivity for an investment in an office building in the Netherlands. One of the problems is the missing ability of those methods to value the adaptive capacity of a building. In the financial models the inputs that are influencing the decision of the investor will be determined. The sub question of this chapter is:

What are the crucial inputs to measure adaptivity and in which of the current valuation methods are these inputs included and what should be added?

As stated in the introduction is this research based on the method of Hermans et al. (2014). They provide a step by step plan as well for the investor. This method is focussed on adaptivity. The combination of the step by step plan of Van Gool (2007) and Hermans et al. (2014, p.21) results in the following steps for an investor to invest in adaptivity:

1. Determine the targets of the investor
2. Formulating the requirements of adaptivity in a building
3. Determine the possibilities and constraints to invest in adaptivity of a building
4. A vision on the future regarding to the adaptivity of the building
5. Formulate the different solutions on the longer term with investment criteria
6. Evaluate the qualities of adaptivity according to the offered solutions
7. Weigh the financial impact of the solutions

This step by step plan will be used to structure the financial model. Together with the crucial inputs mentioned by Hermans et al. (2014, p.43) the following crucial inputs are determined for the financial model in chapter 4:

- be able to calculate over a longer time period. This is not only the investing costs but also the long term operating costs.
- show the probable uncertainties to reduce the risk for the investor.
- respond on the demand for adaptivity, the transformation dynamics and the user dynamics, by change of the type of user/tenant.

First part of the sub-question of chapter 4 is now answered, namely: What are the crucial inputs to measure adaptivity. The second part of the sub-question is: In which of the current valuation methods are these inputs included and what should be added? The aim of adaptivity is to have a functionality during the technical lifespan what result in a long term operating period. Therefore, the comparative method and direct capitalization method are not enough to value adaptivity over a long time span. The cost based method is not applicable to determine the future value but only the current value. The property based method is not complete enough because of the focus on the land. Based on the crucial inputs for a valuation method is the DCF model the best starting point for the financial model complemented by historical data of different variables from the comparable method.

According to Hermans et al. (2014) the DCF method is a possibility to value adaptivity quick and effective but according to Vimpari and Junnila (2016) the use of DCF results is short-sighted decision-making. This won't help to value adaptivity about the long term. Huuhka & Kahdensivu (2016) did a statically and geographic study on demolished buildings. One of their results was that the technical lifespan of a building will be around the 50 years. Therefore, a short-sighted method is not good enough to value 50 years for example. The DCF method is a method that can be used, but has some shortcomings. Therefore, the DCF method will be expanded with the Decision Tree Analysis (DTA) and the Real Options Analysis (ROA) to value the adaptivity. A combination of the DTA and the ROA won't calculate the most valuable path but value the package of possible options within a bandwidth of outcomes. There can be concluded that the Real Options Analysis are taking full consideration of uncertainty, flexibility and irreversibility in a DTA calculation.

5. The financial model

In the previous chapter the basic valuation model is determined, but disadvantages of the DCF method are also identified. In this chapter the financial model will be further elaborated in combination with adaptivity. The aim is to explain how the financial model works through a case test. The question of this chapter is:

How does the valuation model work to value the adaptive capacity of office buildings?

After determination of the right basic valuation method and the reasons why investors should invest, the valuation model can be explained. In chapter 5 is the question how the valuation model works to value the adaptive capacity of office buildings. Firstly, there will be elaborated on the conceptual model of the financial model. This conceptual model is based on the findings in chapter 3 and 4.

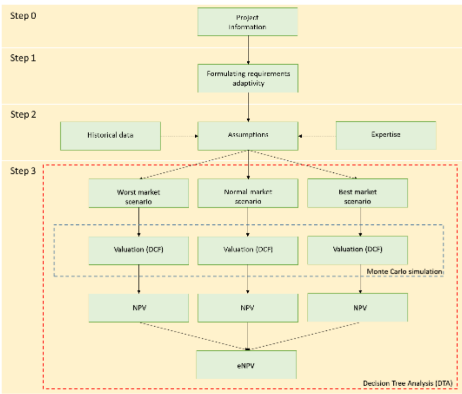


Figure 2: Conceptual financial model (own ill.)

According to the step by step plan of the investor in chapter 4 the investor will start with determining the targets and requirements for a building related to adaptivity. Therefore, the project information is called step 0. Step 1 is formulating the requirements for adaptivity in the building. Afterwards, the investor will use the historical data and his expertise to do assumptions for the calculation. These assumptions are his input for the valuation with the DCF method in step 3. The investor sets up some market scenarios and for each scenario a different DCF will be calculated, resulting in a Net Present Value (NPV). Normally, a DCF calculation will be calculated once per scenario, but in this financial model the calculation will be based on stochastic values (vacancy growth rate, inflation rate & log rent prices). To make it a stochastic calculation the DCF calculation will be done 5000 times for each scenario. Every DCF calculation of these 5000 different calculations results in a NPV. The mean of the 5000 different NPVs of each scenario will be used in the Decision Tree Analysis (DTA). In the DTA the Real Options Analysis will be used to calculate the different options to one expected Net Present Value (eNPV).

After elaboration on the conceptual financial model, a test case will be used to test the financial model based on realistic numbers. Based on the requirements, a certain case is selected that meets all of the requirements. The description of the case and the calculation will follow the conceptual model. The original case was calculated in a traditional way and the financial model of this thesis is based on a stochastic approach. The two approaches are compared to show with the results the effect of a different calculation approach. The results of the comparison showed some big differences. The results will be explained by following the step by step plan of the financial model. Step 0 is about the project information:

Information about the case formulated by investor X	
Location	Bergen op Zoom, North-Brabant, the Netherlands
Function	Office
Year of production	2011
Size (GFA)	2628 m2
Number of floors	3
Purchase costs land	€400.000,-
Expire date tenant	1-1-2026 (15 years)

In the first step, the level of adaptivity need to fill in to score the adaptivity of the building. This is done by the location score table (Brink Groep, 2018) and the adaptivity score table (Geraedts, 2015). The problem of the score that it is qualitative. To calculate with the score, it is needed to make it quantitative. The total adaptivity score of the original case was 64%. The financial model of this research will optimize that adaptivity score to show the optimal investment in adaptivity. The result is that there was not invested in the maximum adaptivity score in the original case. The optimum adaptivity score with the budget of the investor of the case was 72%. This was expected, because the investor didn't use a method to measure the adaptivity within the building but choose randomly the investments in making the building more flexible. However, there can be concluded that the investor could invest smarter in adaptivity to reach a more adaptive building.

Every adaptive score is related to extra investment and transformation costs and therefore also to the NPV of the project. In the figure below is the adaptivity score compared to the NPV of the project in a good market. Again, there is the option office to apartments (6x) used to illustrate what the effects of the adaptivity score has on the NPV. The results of the optimum flexibility in comparison with the NPV:

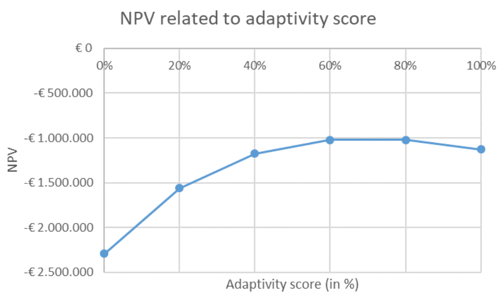


Figure 3: NPV related to the adaptivity score (own ill.)

According to the figure above the NPV is the maximum between 60% and 80% adaptivity. The calculated optimum score of adaptivity strokes with this result, 72%. Important to notice is that the 72% was obtained by optimizing only the investment and transformation costs. In the DCF model the optimization gives a adaptivity score of 67% in a good market. If the optimizer for the adaptivity score will be used in a bad market, the optimization score is 53% and in a moderate market it is 56%. The market effect has a big impact on the adaptivity score. However, the differences in NPVs are small and therefore the 72% will be used as the optimum adaptivity score. In the traditional calculation the optimum score is not applicable.

The second step is about the assumptions for the calculation. The assumptions are based on experience of the investor and historical data. The problem of the original case was that the assumptions were deterministic. The results of the case were deterministic as well and don't show all the uncertainties in the investment of future flexibility. By changing the variables to a stochastic approach, the uncertainty can be showed. The following stochastic variables were added:

> <u>Stochastic vs. Deterministic</u>
> A stochastic or probalistic model relies on probability to obtain its value for future states of the system.
>
> A deterministic model had no randomness involved in generating it future output values. (Leung, 2014)

- Vacancy growth rate (function specific)
- Inflation rate (CPI)
- Log rent price changes (function specific)

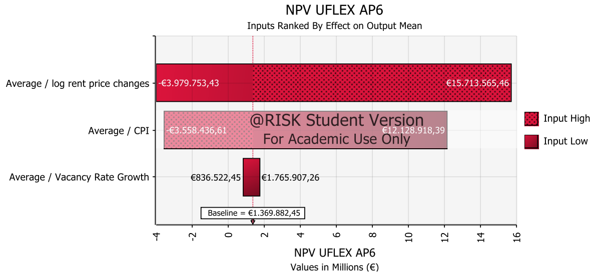


Figure 4: A tornado graph with the influence of the variables, office to 6 apartments (own ill.)

Together with the Monte Carlo simulation and the DTA in step 3, there can be concluded that the change of rental prices and the inflation rate has the biggest influence on the adaptivity score. This should be taken into account by the investor in his investment decision.

The last step is the calculation to the final NPV's in the comparison of approaches. In the figure below the original case is displayed in Decision Tree Analysis. Firstly, there is the choice to investment in a traditional building or a flexible building. After 15 years the choice is to transform to another function or to wait. This DTA was not included in the original case.

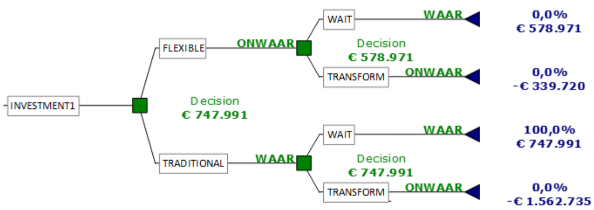


Figure 5: Original case in a DTA (own ill.)

The DTA shows four different NPV's. There are only choices in the DTA without any stochastic values. Therefore, the decision of the DTA shows a Highest and Best Use value, namely the option to build traditional and wait after 15 years. This option has the highest NPV for this moment, but future uncertainties are not included in this DTA. Therefore, the following DTA is made to show a more realistic eNPV. The final tree will show the following eNPV:

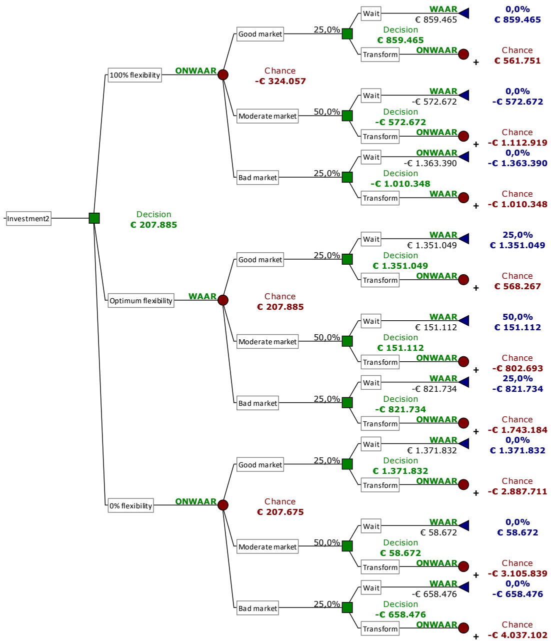


Figure 6: Decision Tree Analysis result stochastic calculation

In the DTA there are different choices to make. Firstly, it is need to choose between: build 100% flexible, optimal adaptivity flexible or not flexible (traditional). This is marked with a green square what means a decision point in time. Than an event occur, displayed as a red circle. The event could be a good market, moderate market or a bad market. Related to those market scenarios is a probability. The moderate market has a probability of 50% and the good and bad market a 25% probability. The reason for this is that the moderate market is the most applicable for the coming years. Depending on the event there is another choice to make. The choice to transform or not. This is after year 15 as mentioned in the original case. Every function is a choice and shows a certain NPV. The "waar" shows the best option within a decision. The decision tree should be read from right to left. The most right numbers for every option are a result from the DCF calculations from step 3. The end decision value most left in the figure above is the eNPV. The ideal path starts from left and follow the tranches with "waar". In the figure below, the results of the traditional approach and the stochastic approach are compared.

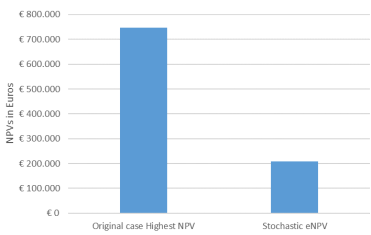


Figure 7: Comparison NPVs of location change (own ill.)

The calculation in step 3 shows for the original case that the flexible building option has for all the functions a positive yield and end balance in comparison with the traditional way of building except for the non-transform option. The stochastic calculation showed that the NPV of the traditional calculation was much higher than the eNPV of the stochastic calculation. The aim of the stochastic calculation was to reduce the risks and uncertainties. By comparison the calculation of the original case with the stochastic calculation it became clear that the future uncertainties were not fully included in the calculation. The highest NPV of the original calculation was much higher in comparison with the stochastic calculation. Depending on the expectations of the investor for the future they should decide in what kind of option they want to invest.

The location characteristics are related to the market conditions. A high demand of office space will influence the rental prices for offices and the vacancy positive. The rental income on offices will be more constant, because of the high demand. The other functions are less demanded. In the figure below a comparison is made between the stochastic eNPV of the original case in North-Brabant and the eNPV of Amsterdam. The calculated eNPV in a DTA for Amsterdam can be found in the appendices.

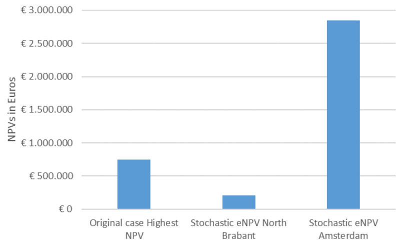


Figure 8: Comparison NPVs of location change (own ill.)

There can be concluded that the eNPV for a prime location for one specific function is much higher in comparison with the eNPV of a location with a various demand of functions. For example, the demand for a specific function like offices is in every scenario positive, even for the bad market scenarios. Therefore is the eNPV much higher in Amsterdam South-axis with one specific demand for offices than in North-Brabant.

6. Conclusion

The value of adaptivity is defined by the user dynamics and transformation dynamics. These dynamics determine the demand for adaptivity. If the building, the supply side, has the capability to rearrange, extend and reject, the adaptive capacity is extremely high. These flexibilities should be taken into account by the investor if he will invest in adaptivity. Reasons to invest in adaptivity are based on three aspects: time, risk and yield. If the risk is low and the yield is high it is an interesting investment for the investor. The financial effects of adaptivity depends on the type of investor. The positive effects of adaptivity are mostly applicable during the operating phase of the building.

There can be concluded that the eNPV for a prime location for one specific function is much higher in comparison with the eNPV of a location with less demand for one specific function. For example, the demand for a specific function like offices is in every scenario positive, even for the bad market scenarios, and therefore is the eNPV much higher in Amsterdam than in North-Brabant. According to the DTA the most valuable option is to invest in a traditional way instead of investing in adaptivity. This could be a problem for the future, after those 30 years, that the office buildings are less suitable of other functions. But with this model the uncertainty is less, because of the positive NPVs in the stochastic model in bad market circumstances.

The answer on the main question how to cope with uncertainty in a DCF method is to add to the DCF method stochastic valuations and the DTA. This shows which variables have influences on the NPV and yield and the DTA lower the risk, because of a good well-calculated overview of all the scenarios in the future. The results are probably more positive for the areas to invest in adaptivity where the demand of a function is uncertain in the future in comparison with a certain function in the future. This financial model shows the risks and the uncertain and optimize the yield. According to the research are that the main motives for investors to invest in adaptivity. Depending on the expectations of the investor for the future they should decide in what kind of adaptivity option they want to invest.

7. Recommendations

In the different chapters of this thesis some assumptions are done to focus on the core of this thesis. However, the results and conclusions could be better if these assumptions were further researched. This chapter elaborates on the recommendations for professionals in practise, further researchers and the end-users. The recommendations for further research are:

- To verify if the ratio of investment costs and transformation costs related to the adaptive indicators are right, it is recommended to do further research with more cases. These case will gather more information about the costs so the quantifying process of the adaptive indicators can be verified.
- To bundle the adaptive indicators into packages, it will be more clear in which of the adaptive indicators the investor should be investing. Especially for the short term investors it could be interesting. To make a generic bundle of indicators for every function, a lot of test-cases are needed. Therefore, this research used only the generic adaptive indicators for the case. Thereby was the function after 15 years unknown.
- To further examine the financial aspects in the financial model to conclude about the environmental impact of not using adaptivity after one functional life cycle.
- To do a qualitative research about the different investors and their motives to invest in adaptivity.
- To do a case study with different locations in the Netherlands and define the impact of the location and the local market on the investment decision to invest in adaptivity in new developments and renovate/transform of existing buildings.

8. References

Bolgün, E., Akçay M,. Barıs, 2003. Risk yönetimi, Scala Publishing, (Book Turkish)

Brink Groep (2018). *Location indicator list made by colleagues.*

CLO. (2016). Leegstand kantoren. Retrieved from http://www.clo.nl/indicatoren/nl2152-leegstand-kantoren

Dynamis. (2017). *Sprekende cijfers: kantorenmarkt '17*. Retrieved from Utrecht

Geltner, D., Miller, N. G., Clayton, J., & Eichholtz, P. (2001). *Commercial real estate analysis and investments* (Vol. 1): Cincinnati, OH: South-western.

Geltner, D. M., Miller, N. G., Clayton, J., & Eichholtz, P. (2006). *Commercial real estate analysis and investments* (Vol. 2). Cincinnati, OH: South-western.

Geraedts, R. (2015). *Afwegingsmodel adaptief vermogen: De match tussen vraag en aanbod*. Delft.

Groak, S. (1992). The idea of building. E & FN Spon, London.

Hermans, M. H., Geraedts, R. P., Van Rijn, E., & Remøy, H. T. (2014). *Gebouwen met toekomstwaarde! Het bepalen van de toekomstwaarde van gebouwen vanuit het perspectief van adaptief vermogen, financieel rendement en duurzaamheid: Eindrapport*. Retrieved from https://blackboard.tudelft.nl/webapps/blackboard/execute/content/file?cmd=view&content_id=_2760075_1&course_id=_56447_1

Huuhka, S., & Lahdensivu, J. (2016). Statistical and geographical study on demolished buildings. *Building Research & Information, 44*(1), 73-96.

Keeris, W. (2008). De halve waarheid is funester dan de onjuistheid. Real Estate nr. 58. pp. 42-47.

Leung, K. C.-K. (2014). *Beyond DCF analysis in real estate financial modeling : probabilistic evaluation of real estate ventures.* Massachusetts Institute of Technology, Massachusetts Institute of Technology.

Rabobank. (2017, 13-6-2017). Rabobank Cijfers & Trends. Retrieved from https://www.rabobankcijfersentrends.nl/index.cfm?action=sector&sector=bouw

Rabobank. (2017a, 13-10-2017). Rabobank Cijfers & Trends. Retrieved from https://www.rabobank.nl/bedrijven/cijfers-en-trends/vastgoed/vastgoedbericht-2017/deelmarkten/kantoren

Van Gool, P., Brounen, D., P. Jager en R.M. Weisz (2007) Onroerend goed als belegging. Groningen/Houten: Wolters-Noordhoff [4th edition].

Vimpari, J., & Junnila, S. (2016). Theory of valuing building life-cycle investments. *Building Research & Information, 44*(4), 345-357.

1. Introduction

Reading guide

In this chapter, a couple of subjects will be elaborated that are affecting my research theme, structure and the research aim. Firstly, the current market trends are based on the research results of Dynamis (2017) and Rabobank (2017). Secondly, the problem analysis and afterwards the problem statement will be defined. The fourth paragraph will introduce the main research question and sub questions. This chapter concludes with the research aim, the expected results and the social value. Every next chapter will start with a reading guide to introduce the chapter and to get an overview of the following chapter.

1.1 The current office market and trends

In year 2016, the office market in the Netherlands changed from a downward market to an upward market. In the downward market there was an increasing vacancy, a constant office building supply and a decrease in the demand for office space. In the upward market there is a record of 1,08 million square metres extracted from the office supply, mostly because 74% of the extracted offices were transformed to another function (Dynamis, 2017). The amount of new built premises was in total 200.000 square metres; an increase of a third in comparison to 2015. Most of the new built premises are located in the Randstad. The biggest investment category within the real estate market last year was the office market with 6,6 billion euros for transformations and new developments (Rabobank, 2017a). In short, in the current upward market is interest in transformations of offices and the investors are prepared to invest in offices in the Netherlands.

The demand side, or user side, of the office market is decreasing due to the change in the way of working. Most of the people with an office-accommodated job are not bound to one office building but are flexible to work offsite in every public place due to internet. This will be supported by the flex-ratio, the amount of workplaces per fulltime-equivalent (FTE), with a decrease of 3% in a year (NFCindex, 2017). The reason for this is the decrease in office-accommodated jobs. Another trend what result in a decrease of office space demand is the automation/digitalisation of working processes. These trends will negatively affect the demand of office space for the coming years. However, the current used amount of lettable floor area (LFA) is the same as last year, despite the decrease in demand of office space. This is because, the upward market cause an increase in office jobs (Cushman & Wakefield, 2017). These amount of office jobs demands office space what result in the same LFA as last year. This disguises the decrease of demand in office space for the future.

The decrease of demand in office space could result in future vacant office space. The current trends in the building environments, the creation of future proof real estate and sustainability are supporting to prevent the future vacant office space (Rabobank, 2017). The sustainability trend is stimulated by the government. Office buildings are obliged to gain an energy label C and the amount of sustainable energy should be 16% of the total energy in 2023 in the Netherlands (Energie-vastgoed, 2017). The accommodation requirements of the government require green sustainable buildings. Therefore, the real estate sector of the Netherlands set up visions and step by step plans about sustainability to fulfil the requirements of the government.

The trend to build future proof could be one of the answers on the future problem of vacant office space and is a sustainable answer. An example of building future proof is to build flexible. When there is no demand for office space, the flexibility of a building will help to easily change to another function. This could be a solution if there is a bigger demand for another function. The flexibility can encourage owners and/or investors of the office building to use the building several user cycles through the total technical life cycle of a building. Using the office building during the total technical life cycle would result in a lower future vacancy. This will lower the loose of rent because of vacancy what is positive for the owner/investor. The current vacancy is the evidence that in the past there wasn't enough interest in investing in building flexible, because of the lack of demand in flexibility and the low direct return. This is besides the location of the office building. In the next paragraph will be explained why vacancy should be reduced to a minimum.

1.2 Vacancy

The current office market in the Netherlands contains a vacancy of 6,4 million square metres, or 13,1% of the total office supply. Based on the market- location- and object specific characteristics of offices is predicted that 33% of the vacant office buildings in the current technical conditions are low potential for lease or sell in the current and future market (Cushman & Wakefield, 2017).

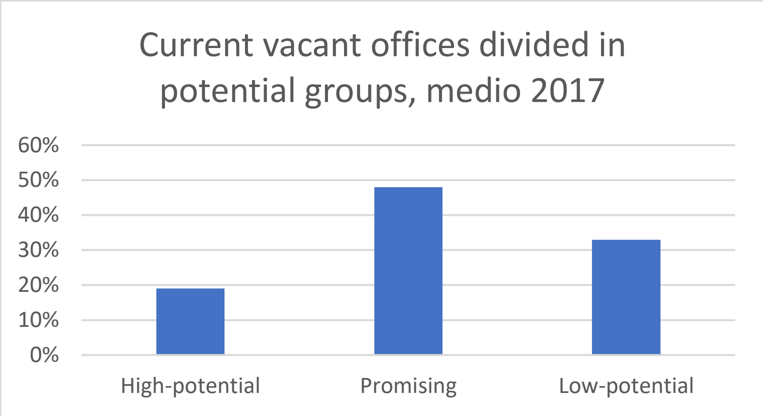


Figure 1: The office supply divided in level of opportunity to sell/rent the building (Cushman & Wakefield, 2017)

It is important to make a difference in structural vacancy (more than 3 years vacant), lengthy vacancy (between 1 and 3 years vacant) and friction vacancy (less than a year vacant). Separation of the vacancy in those three levels will show the increase of structural vacancy and decrease of friction vacancy. In year 2016, 60% of the vacancy is structural (CLO, 2016).

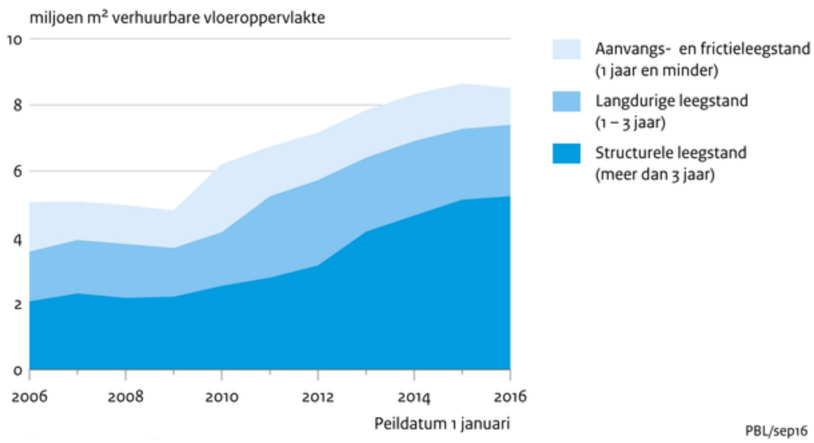


Figure 2: The division of levels in vacancy (CLO, 2016)

Structural vacancy has several causes related to the object, market and location (Cushman & Wakefield, 2017). One of the causes related to the object is the way a building is built. A building could be built for one specific function, for example offices. This is called mono functional and is not flexible to change to another function. If a building is built multifunctional instead of mono functional, the building is suitable for different functions during its technical life instead of one function (Hermans et al., 2014, p.55). The cause for structural vacancy related to the location is if the building is located where there is no demand for offices. The object could be great when there is an upward market, but if there is no demand for the building at that specific location, the building could be vacant for years. The last cause is related to the market. In a crisis, the market is in a downward spiral, there is no demand for office space despite the relative good object and location. However, 60% of the current vacant offices are structural vacant. According to the high amount of structural vacancy raises the question if the owners of office buildings maybe accept the vacancy instead of doing something about it. To answer this question should be looked at the calculation method to find the cause of the acceptation of vacancy. This will be explained further on in the research.

1.3 Adaptive capacity

Flexibility could be used as an instrument to prevent future vacant office space. The flexibility to change characteristics of a building during its life cycle is called the adaptive capacity of a building. The adaptive capacity of a building includes all characteristics that enable the building to keep its functionality through changing requirements and circumstances, during its entire technical life cycle and in a sustainable and economically profitable way (Geraedts, 2015). The adaptive capacity is being considered as a crucial component when looking into the sustainability of the real estate stock (Hermans et al., 2014, p. 6).

1.4 Research problem

The 60% structural vacancy of the total vacancy is the evidence of the lack of interest in future proof built offices in the past. Offices that are able to respond on the dynamic demand in office space use and have the adaptive capacity to change in future use could be a solution to prevent future vacancy. However, real estate investors are hardly interested in investing in office buildings to increase the adaptive capacity. Their time perspective of investments is most of the time only to build for the current demand of users instead to focusing also on the future demand of users. Thereby is it a problem that the additional value of adaptivity is hard to determine (Arge, 2005; Remoy, de Jong & Schenk, 2011). This will be further explained in the next chapter.

A motivation to invest in the adaptive capacity of office buildings from a market perspective is because of the mismatch between the functional lifespan and the technical lifespan of a building (H. T. Remøy, 2010). The functional lifespan of an office building is the time the building meets the demand of the user. A mono-functional building has a short lifespan, because of the single functionality of the building. The technical lifespan is the timespan between construction and demolishment of the building. The structure of the building is built for 100 until 300 years (Brand, 1995), but if the building is mono-functional and the functional lifespan is shorter than the technical lifespan (mismatch) this will not reached. In order to close the gap between the lifespans it is possible to shorten the technical lifespan by demolish the building. Another option is to invest in the functional lifespan of a current office building by transformation or to develop a new building with adaptivity implemented. Adaptivity is a tool to extend the functional lifecycle of the building and on the longer-term adaptivity will be an important precondition for sustainability (Hermans et al., 2014).

Currently, real estate investment decisions are mostly made with the discounted cash flow (DCF) method (Rodermond, 2011). A limitation of the DCF method is the deterministic approach. The DCF method calculate future cash flows for an investment based on the market assumptions and expectations filled in by the investor. Afterwards, the discount rate will be used to calculate the net present value. The problem is that an higher investment in year 1 in adaptivity outweighs the selling price in year 15 for example, because of the time-effect. This has a negative influence on the decision to invest in adaptivity. The initial costs because of the adaptivity will outweighs the selling price after several years.

The investors in the current economy may no longer depend on traditional fundamentals but rather on future expectations (Mun, 2002). These future expectations go together with multiple uncertainties in the future, for example the demand for office space at a certain location. Without a method that taken into account those uncertainties, projects with a longer lifespan, more risks and flexibility will be avoided, because of undervaluing the project's profitability. The reason for this is that DCF methods are deterministic and not stochastic. Change from a deterministic model with no randomness to a stochastic model which relies on probability to obtain its values for future states of the system (Leung, 2014, p. 7).

An example of a method that calculate in a stochastic way is the real options analysis. This approach incorporates a learning model for the investor when some levels of uncertainty are included in the model through time. The real options analysis is designed for the financial market, but several research reports concluded that the application of this real option analysis in the investment of flexibility is suitable for real estate (Blommaert & van den Broek, 2013; Mathews, 2009; Vimpari, Kajander & Junnila, 2014). This flexibility in investments decrease the risks and value the uncertainties for investors in real estate.

1.5 Problem statement

The problem is that most of the current office buildings were not built adaptive, since that 30% of the offices are vacant and 60% of the vacant offices are structural vacant. The trend is a decrease in the demand in office space and there are a third more new developments in comparison to last year. The problem for the current vacancy is growing and the question is of the new developments are built for more than one functional life cycle? If the new developments are more flexible to adapt to another function when there isn't any demand for the current function, it could prevent future vacancy. To prevent future vacancy after completion of one functional lifecycle (15 years for example), the present calculating method should be changed to stimulate adaptive building methods. Another part of the problem is that DCF models are currently insufficiently used to simulate the future uncertainty in an investment in flexibility on the longer term. Currently, the demand of flexibility is growing but with the DCF method alone it is not easy to calculate the flexibility of an office building investment. This will lead to a decrease in demolishment's and structural vacancy of office building. Currently, more than 10% of the total supply of office space is vacant and the structural vacancy is growing. A better approach could be developed to stimulate investing in the adaptive capacity of office buildings and increase the adaptive capacity of a building to transform if the functional demand changes. Hence, the building can respond to the future uncertainty in the market. This research will focus on the building and will take the location into account where necessary.

1.6 Research questions

To solve the problem mentioned in the last paragraph it is necessary to structure the research with a main question and several sub-questions. The main question is formulated as follows:

How to cope with future uncertainty in a DCF method to value the adaptive capacity of office buildings to stimulate investors to invest in adaptivity?

The main question is divided in the following sub-questions to construct an outlined answer:

- *What are reasons to invest in adaptivity and what financial effects has an investment in adaptivity? (Chapter 3)*

A summation of reasons to invest in the adaptive capacity of office buildings. On the long-term adaptive measurements could influence the future value of office buildings. Hence, the adaptive measurements increase the investment. How can the amount of money invested in an adaptive measurement contribute to the future user value and gain income?

- *What are the crucial inputs to measure adaptivity and in which of the current valuation methods are these inputs included and what should be added? (Chapter 4)*

The different methods to value the adaptive capacity will be explored. Currently, the DCF method is the most used method to calculate the investment. However, the current volatility in the market and the uncertainties and risks will probably request for additions to the method. What the additions are should be determined based on the crucial inputs in the method.

- *How does the valuation model work to value the adaptive capacity of office buildings? (Chapter 5)*

The requirements for the model are determined in the last chapter. This chapter will be used to combine the required aspects for the model with the current models to make a valuation model. This model will be explained with a step by step plan. Tested with a case from practise to test the model.

1.7 Research aim

The aim of this research is to develop a financial decision model for an owner/investor to value the future value of adaptivity for an investment in an office building in the Netherlands. Therefore, the owner/investor will get insight in the future uncertainties of their investment and the adaptive capacities of the office building. By showing the uncertainties and advantages of investing in adaptivity during the total technical life cycle, the willingness to invest in the adaptive capacity of an office building could be increased.

As stated before, the demand of office space by the user is changing quickly what will affect the functional life cycles of office buildings. The mismatch between the functional life cycle and the technical life cycle will be bigger instead of reduced if there is not a respond on the changes. Adaptivity could help reduce the gap if there are investors prepared to invest in adaptivity. The research aim is to develop a financial decision model to help the investors. The model should be used for calculating the value of the adaptive capacity for office buildings to extend their functional life span by transformation to another function. The research will be focussed on new developments of office buildings, because of the limitation of the possibility to change construction elements in existing buildings. Adaptivity can be maximized while all layers in a building can be influenced during the design phase what will make it more attractive for investors to invest in.

1.8 Research target group

The target group for this research is the investor in real estate. However, there are several investors in real estate with different constraints and concerns that affect their decision to invest in the real estate market. This research is for the owner and/or investor. Investments in adaptivity require a long-term perspective because of the focus on the total technical lifespan of a building. The time horizon should be important for the investor. Because it is in the far future, a building is built for at least 50 years (Brand, 1995); the risk to invest is higher than short-term investments. Based on these constraints the owner and/or investor in real estate with a long term horizon will be the target group for this research. In general, the owner and/or investor in real estate are the target group who make decisions and sets the requirements based on financial and functional motives for new and existing buildings. They determine the ambitions for investment decisions and are responsible for choices in the building- and operating process. Their decisions can influence the level of adaptivity in an object (Hermans et al., 2014, p.10).

1.9 Methodology

The research is partly a descriptive research and partly a prescriptive research. This research result in a valuation model to value adaptivity based on one case. The case will be simulated, evaluated and compared to the new results of the valuation model. The conclusion of the comparison can be seen as an advice to the investors.

Research design

The research design is divided in two parts, the descriptive part and the prescriptive part. The two dashed red squares in the figure below displays the division in the research design.

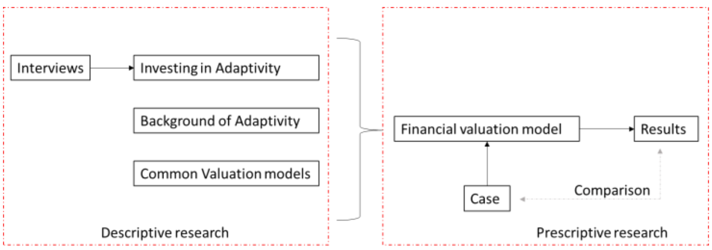


Figure 3: Research Design (own ill.)

Descriptive research

The literature study is the foundation for the rest of the research. According to Kumar and Phrommathed (2005) contains the literature study three different functions:

1. The theoretical background for the research
2. It will help in connecting between what is already been done in research and what are research gaps.
3. It can show the findings that contributed to knowledge. It can help the research findings to integrate with the available knowledge.

The literature study contains the theoretical background of the three subjects in this research. Every subject will be explained in one chapter. After each chapter there will be concluded what is already been done in research and are research gaps. Therese conclusions will be used in the prescriptive part of the research to design a valuation model to value the adaptivity in office buildings. The literature gives an overview of the different financial decision models with their advantages and disadvantages, the definitions used for adaptivity and the interests of investors at the moment.

Prescriptive research

After defined what is the best financial decision model, some additions were used to the valuation model. Based on the literature, there is a basic valuation model that should be added with other valuation methods to value the adaptivity of an office building. The final valuation model is designed in cooperation with the experts of the internship company and with Real Estate financial experts from the TU Delft.

Interviews and experts

To design the financial decision model, it is necessary to understand how investors think about investing in adaptivity. Therefore, different investors were interviewed to understand how they invest, why they could invest in adaptivity and what the crucial aspects are in those investments. The findings of the interviews were used in the process of the development of the financial model as bridge between theory and practise.

Case

To develop a model and calculate the future value of office investments in adaptivity, it is necessary to do a case study. Due to the case, it is possible to give a realistic view of the different building costs, scenarios and uncertainties in an investment in adaptivity. The requirements for the case are as follow:

- The case is an investment in an office by an investor with a long term horizon.
- The case is in the initiation phase where multiple scenarios of flexibility are available with a certain risk.
- The case is concluded with a final advise about flexibility. If there are no outcomes it is not possible to test the financial model and say more about the adaptivity investment.
- The case contains one building or multiple exact the same buildings.

1.10 Results

The result of this research is a financial decision model to determine the future value for an office building with the most adaptive capacity for the future. The financial model shows the future value of adaptivity and clarify the possibilities and uncertainties of adaptivity for an office building for an investor. The financial model contains several scenarios with levels of adaptivity to measure the adaptive capacity of the building. The levels of adaptivity are based on the adaptive indicators for offices of Geraedts (2015). The financial model can be used to value the adaptive capacity of current office buildings by transformation or for new developments with the focus to prevent future structural vacancy of the building.

Based on the findings in chapter 4 and 5 will be determined what the best working financial model is to value the adaptive capacity of office buildings. That could be a DCF method extended by a scenario analysis or the Real Options Analysis. The combination of these analyses will result in a financial decision model to calculate the possibilities of adaptivity and determine the future value of adaptivity for office buildings. Hence, the DCF method is the most common used calculation method, the results of the financial model are compared to the traditional DCF method to conclude the added value of the financial model and the value of adaptivity.

1.11 Relevance

Based on the problem analysis and the expected results the different relevance's of this research can be determined. The social relevance of this research is the prevention of future vacancy in the office market in the Netherlands. As stated before, there is currently more than 10 percent vacancy in the office market and 6,4 million square metres of offices are vacant. An answer could be to invest in adaptivity. When an office building is capable to change with the demand of the users, it will keep its value. Finally, the financial decision model could stimulate investors to invest in adaptivity and sustainability. This will lead to a decrease in demolishment's and structural vacancy of office buildings and decrease the miss-use of our raw material. The target of the Netherlands is that 16% of the total energy is sustainable energy in 2023 and this research could contribute to achieve this sustainability goal of the Netherlands.

The scientific relevance of this research is enhancing of knowledge about other ways to calculate in the real estate sector. When there is an increase in the demand of a certain subject and there is not enough knowledge about it, there is a knowledge gap. Currently, the demand of flexibility is growing but with the DCF method it is not easy to calculate the flexibility of an office building investment. With this research, there is a better approach of value the future value the adaptive capacity of office buildings.

The practical relevance of this research is the use of a case. The report of Hermans et al. (2014) is a determination method for the adaptive capacity of a building but it is not tested. The indicators of Gereadts (2015) are based on several literature studies. The practise side is often reserved about new theoretical research but with the test of a case it could be more attractive for companies to use this financial decision model.

1.12 Report structure

The next chapter will give some more background information about adaptivity before can be understand why there should be invested in adaptivity. Afterwards, there will be elaborated on the reason why there should be invested in adaptivity and how to measure adaptivity. Thirdly, the financial part will be explained briefly by explaining the different methods of valuation and on what kind of investor this research is focussed on. Fourthly, will be elaborated what the requirements for the financial model to value the adaptive capacity of an office building. The last sub question will combine the different existing valuation methods with the requirements to determine adaptivity to one financial model. This model will be explained briefly and tested in practise. The results are a comparison between the traditional DCF method with the new way of calculation. These results will answer the main question how to cope with the future uncertainty and will approve or deny the hypothesis.

2. Background of Adaptivity

Reading guide

In this chapter will be elaborated on the background of adaptivity to understand what is meant with adaptivity in this research and where it is coming from. This information is needed to answer the next sub question why an investor should invest in adaptivity. Firstly, there will be explained what the origin is of adaptivity and why it is an important issue today. Secondly, similarities and the definitions of adaptivity will be explained. Thirdly, there will be examined the history of adaptivity in practise. Finally, there will be concluded what the definition of adaptivity is in this research.

2.1 Origin of Adaptivity

A direct link can be made between adaptive capacity of buildings and sustainability based on the research of Wilkonson & Remoy (2011). Adaptation is inherently environmentally sustainable because it involves less material use, less transport energy, less energy consumption and less pollution during construction. Upgrading performance of existing stock, through adaptation, is the most critical aspect of improving sustainability of the built environment. Referring to Remoy & Wilkonson is adaptation predicated on the goal of achieving and maintaining highest and best use for a building at a given point in time. Adaptivity offers a new economic life for a building at a fraction of the cost of new construction, and with a greater amount of lower-grade space available, there is an opportunity for businesses to occupy better-quality pace as developed countries move out of recession in due course. Their conclusion was as follows: The findings show that opportunities are being overlooked to appreciate and acknowledge the sustainability of this type of adaptation and that there is a need for a rating tool to encourage greater levels of sustainability; and to acknowledge existing levels of sustainability achieved in these projects. A rating tool for the adaptive capacity for buildings could help to stimulate sustainability in the built environment. To understand what the adaptive capacity of a building is, there should be a definition of adaptivity.

2.2 Definitions

This research is about adaptivity but there are in total three overarching terms that seems the same but are different: adaptive building, flexible building and an adjustable building. One by one will be explained what the definition is defined by different literature.

Flexible building

Albers, Dekker, Vermaas & van der Vlis (2011) describe flexibility as the development of buildings with more possibilities to adjust to constant changes. It is the pre-investment of excess and/or abundance. The main target of achieving flexibility is to reduce the costs during the operating phase. The extra investment costs should be compensated with the unpredictable changes user demands, the frequency of these changes and the impact of the physics of the building and the user processes.

"Stuurgroep Experimenten Volkshuisvesting" (SEV), the Dutch organisation for experiments in housing, defines flexibility the possibility to change of a product and/or process characteristic. On one hand is flexibility about spatial flexibility of a building. On the other hand it is about the process behind the building for example the building process, the design and the technical characteristics used (SEV, 2007).

Adjustable building

The two different terms flexible and adjustable are sometimes described the same. Groak (1992) draw a clear distinction between the two terms. Adjustable is about the capacity for different social use, like the different functions. Flexibility is about the capacity for different physical circumstances, like the different architectural circumstances. Adjustable buildings will be achieved by a design of spaces that are multifunctional, particularly in design and accessibility.

Schneider (2007) states that dwellings are flexible if they are capable to respond on the change in housing demand. The underlying cause could be flexibility or adjustability or both. The two terms can be confused with each other but describe the same. But adjustability is most of the time based on user aspects and flexibility is based on design and technique.

Adaptive building

Schuetze (2009) defined the term as easily adjustable to multiple functions or changed requirements, done with components and materials to reuse and permit recycling with a minimal effort and lose of quality. This is about function neutral and adjustable buildings with potential for transformation.

Richard (2010) explains that nobody can predict the future requirements or demands of the future users during the total lifecycle of a building. Therefore, adjustable systems are necessary to develop user friendly buildings that are capable to change with the influence of the first users and adjustments of the next users. The adjustment of spaces in time and decrease rest materials.

Conclusion

The three terms can be used different in this research. The term adaptivity and adaptive capability will be used if there are changes in functions and differences in use. The term flexibility will be used as the capacity for change in physical circumstances. Adaptability will reached by designing spaces that can be used in different ways. In particular by the way they are created and if they are approachable (Groak, 1992).

The definition for adaptivity and adaptive capability used in this research is as follows: Adaptivity or the adaptive capability of a building includes all characteristics that enable the building to maintain its functionality in a sustainable and economical profitable manner during its technical lifespan, during changes in need and other circumstances. The adaptive capacity is being considered as a crucial component when looking into the sustainability of the real estate stock (Hermans et al., 2014, p. 6).

2.3 Types of adaptive capacity

The adaptive capacity can be split into three different types (Gereadts, 2014):

- Organizational flexibility: The capacity of an organization or user to respond adequately to changing demands of the built environment.
- Process flexibility: The capacity to react to changing circumstances, wishes or demand during the initiative, the design and the construction phase.
- Product flexibility: The capacity of a building (the product) to respond to changing circumstances, wishes or demands during the use phase of the building.

An example of the process flexibility is a change in the decision process within the organisation related to the primary production process or core business. An example of organizational flexibility is “Het nieuwe werken” with a change in the way of work (Alberts, 2011). For this research there will be focused on the consequence of this change in the organization. There will be less demand of office space. Buildings with adaptive capacities can easily change to another function. This is an example of product flexibility. Product flexibility contains spatial flexibility, user flexibility, infill flexibility, construction flexibility, structure flexibility, technical flexibility. Only the product flexibility will be used in this research. These different types of product flexibility are used to measure the adaptive capacity of an office building.

2.4 Demand and supply model

To assess the adaptive capacity of a building it is necessary to explain the match between the demand and supply. The demand side is based on the change in housing needs for an office building and the supply side is based on the design of the intended building can facilitate these changing needs.

According to Geraedts (2013) there are two groups affecting the adaptivity capacity of a building (see figure 4). The first group is the owner group, in this case the investor-owner. If there is a change in demand for a function it will affect the owner. The other group is the user of the building, the tenant or also the owner itself.

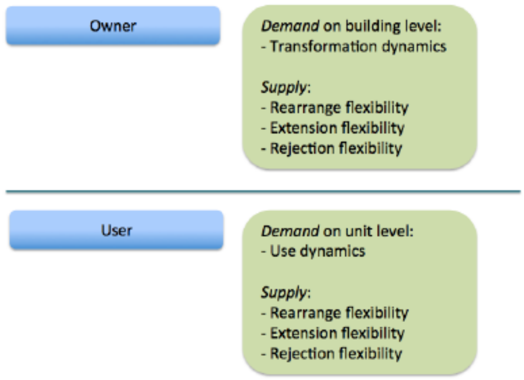


Figure 4: Demand for and supply of adaptive capacity translated to two target groups (Geraedts, 2013, p.7)

The demand side

The demand for adaptivity in a building can be translated to two different aspects: the transformations dynamics and the user dynamics. These dynamics will be explained, because of the relation to the next chapter why an investor should invest in adaptivity.

- Transformation dynamics: This concerns the demands for a building that should be able to accommodate totally different user groups or different functions in the near future. This may lead to specific demands for rearranging the building for different user groups for example.
- Use dynamics: The demands for a building can be formulated by the demands of the users. The building must be able to move along in time with these (changing) demands. This may lead for instance to the demand that the building must be parcelled into smaller or bigger units or that specific facilities can be added to the units or building. This is called use dynamics.

The use dynamics are defined by Albers et al. (2011) as the possibility to fulfil certain requirements of the user to change rooms to another function. Hereby, there are two types of flexibility: The multiple use and the standardisation of rooms. The multiple use is the change of use without changing the interior. An example is a meeting room that can be changed quickly to a flex working space. The standardisation of a room is the change of interior but not the physical environment. Rooms have the same identity with the same technical possibilities for different functions. The standardisation is based on the function with the biggest surface and the equipment.

The supply side

Three spatial/functional and construction/technical characteristics determines if a building is capable to match with the demand:

- Rearrange flexibility: To which degree the location, the building or the unit can be rearranged or redesigned to other spatial and functional requirements. Everything that is part of “rebuilding” should be possible if the rearrange flexibility is better. The interior layer should be changed quite easily. The technical facilities for example, should be easily adaptable to change to a new situation.
- Extension flexibility: To which degree the location, the building or the unit can be extended in a horizontal and vertical way. The end of a series of rooms or facilities should not differ from the rest of the series standard. In this case it is easily to extend the series. The capacity and the dimensions of the facilities are for that reason also important to reach a high extension flexibility.

- Rejection flexibility: To which degree (part of) the location, the building or the unit can be rejected. The reason for this is the reduction of a decreasing value and temporary vacancy. The rejection of a certain part of the building should be done without serious interventions in all the layers of the building.

Conclusion
There are three different kinds of adaptivity but only the product flexibility will be used further in this research. Product flexibility contains spatial flexibility, user flexibility, infill flexibility, construction flexibility, structure flexibility, technical flexibility. These types of flexibility will be used to measure the adaptive capacity of an office building. To measure the adaptive capacity there should be looked at the match between the demand and supply side. The user dynamics and transformation dynamics are part of the demand side and will be necessary to determine if there is a need for adaptivity. If the building, the supply side, has the capability to rearrange, extend and reject, the adaptive capacity is extremely high. These flexibilities should be taken into account by the investor if he will invest in adaptivity.

2.5 Adaptivity in practise
In the definition of Hermans et al. (2014)is the expression technical lifespan used. The crux of adaptivity is not so much on the building costs and investor costs but is a decision for the total technical lifespan of the building. In the 1960's adaptivity was discussed as a means of increasing usability and extending buildings functional lifespan by Habraken (1972). He questioned why the mass construction of post-war buildings was focused on producing quantity of housing with a lack of quality and adaptability. The consequence was a shorter technical lifespan as well as the functional lifespan, because of the only focus on housing. Thus, the lifespan of an asset is determined by a combination of a technical and functional lifespan. The third factor that will influence the total lifespan of a building is the economical lifespan. The economical lifespan is when the benefits of the asset are higher in comparison with the costs. Currently, the investors are hardly interested in the investments of adaptivity in office buildings (H. Remøy, de Jong, & Schenk, 2011). The solution of Habraken was to separate the construction part of a building and the infill part of the building. Consequences of this solution are the flexibility of the installation part. When the installation part is old or not useful for the new function of the building it could be removed. His solution was called "*drager-inbouw".*

During the years, there have been a lot of research about adaptivity in office buildings. A solution comparable with the "drager-inbouw" was the solution of Brand (1995). He designed the "shearing layer" approach. The building was separated in six layers: the site, the structure, the skin, the services, the space plan and the stuff. Every layer could be changed individually without changing another layer. Duffy and Powell (1997) described the adaptive ability from a hierarchal viewing point with the different layers in a building. Stoop (2015) used these layers to order the adaptivity indicators. These indicators will be explained further on in this thesis.

The main focus of Habraken (1972) and Brand (1995) was to divide parts of the building into different lifespans. Habraken made a difference between two layers what was really popular during the seventies in the Netherlands (Prins, Heintz & Vercouteren, 2001). Thereafter was the idea of Brand developed what is still a starting point for researches about flexibility and adaptivity in the real estate sector (Remoy et al., 2011). Beside the research examples of Gereadts (2015) and Stoop (2015) there is an example from Manewa, (2012). Their research was about the economic considerations for adaptability in buildings. They categorised the costs into their 'shearing layers' (Brand 1995) to identify how the initial costs of building layers may vary with their lifespans.

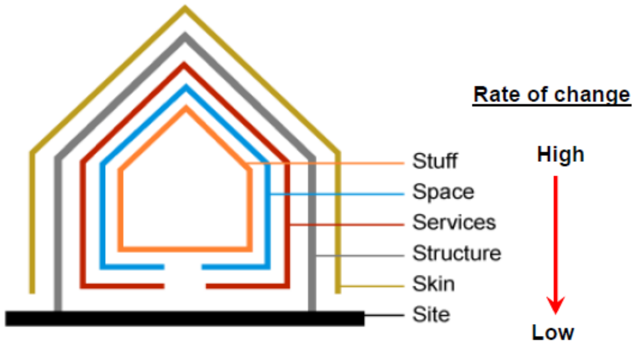


Figure 5: Shearing layers of a building (Brand, 1995)

Kendall (2000) wrote about the interest of the design of a building. The so called “open bouwen” principle is a strategic design and built method that affect the individual client and the user preferences in the building who are adaptable during the design and the user phase when there is a change in demand on the market. With this method it is possible to adapt during changes to social, sustainable and technical preferences. Due to the fact that investors after war only thought short term based on the shortage of houses there were so tightly value engineered, optimized and integrated to current programs of use that the houses were incapable of being adjusted. The problem was the aim to meet *then* current standard of function and technology.

A method that taken into account the possible changes in buildings was the Industrial, Flexibel, Demountable (IFD) method. Started in 1999, it was an integrated application of building and designing modular. By using the components industrially the building could change from function by adjust the modules. In this way there was always a match between the demand of the user and the building (Crone, 2007).

The potential to easily change the building to meet the requirements of future needs is an important assessment criteria for a sustainable building. To value a building it is necessary to take care of the adaptivity, the demountable options for the building and the construction waste of a building. Buildings that are designed and built to respond on future adaptivity will meet these criteria (Geraedts, 2009).

Arge (2005) did a research among ten big developers in Norway with the willingness to invest extra in adaptivity. They concluded that the type of investor with a long term perspective was the one who would invest in adaptivity. The investors who focused on the short term were not interested because of the missing clear return on the short term. This is based on different factors and the willingness to pay analysed. Important for this research is the conclusion of Kendall (2000) that investors with a focus on the short term won’t be adaptive in the future and Arge (2005) concluded that investors with a long term perspective are interested to invest in adaptivity.

Blakstad (2001) describes adaptivity from another point of view. He did a research between the user and the owner in the Building- User relationship over a period of time and concluded that there is an instant mismatch between them. Adaptability is thought to be important in order to reduce mismatches between buildings and their user organisations. During the lifespan of a building the way of working will change. Blakstad (2001) described the follow:

“During the history of office buildings there has been a large variety in office layouts and workplace design. The use of the building and the workplace ideals may change, but the actual building is more durable. Thus, most buildings will meet a change in requirements during their lifetime, to which they have to be adapted. Some existing buildings adapt readily to change, others are more difficult to alter. The building will be adapted if the value of adapting the building into new or future use is thought to be greater than the value of the alternatives and the cost of adaptations. This value can be both financial value and value of use.”

The change of workplace he mentioned is currently a trend. With a better adaptive capacity of the building this will help to change to the new way of working. The implementation of adaptivity in buildings are done in the master thesis of Schenk (2009) where she researched the adaptivity of office buildings into dwellings. This investment can only be done if the investor is prepared to invest in it. In the next chapter will be researched why the investor should invest in adaptivity.

Summary

Habraken (1972) did a research about the structure-infill part. His conclusion was that the infill part should be separated from the structure part. If this will be done it can be replaced for another infill part and is structure in the same condition. This is a method to apply adaptivity in office buildings. Brand (1995) divided this further in 6 layers instead of 2. These layers will be used to compared the different costs of the layers related to adaptivity. The IFD method was the start of an approach to stimulate future thinking. The research of Hermans et al. (2014) is based on this method and this research will built upon this idea.

2.6 Adaptive indicators

As stated in the introduction this research is based on the research of Hermans et al. (2014). They formulated 100+ indicators to determine the adaptive capacity of buildings. The use and transformation dynamics of the latest paragraph are used to order the indicators. To measure the adaptive capacity of a building is the list the perfect tool and will be used in the final model of this research. However, the list of indicators is too specific for this research, because the aim of this research is to give a general advise to the investor about the possibility of the adaptivity of the building. The list of indicators is formulated for the transformation to specific functions. This research will be used to focus on every possible function instead of a specific function. For that reason only the generic indicators are necessary. Firstly shall be explained what the history is about the indicators to understand how the actual indicators are chosen.

History of the indicators

One of the researches of the Hermans et al. (2014) reformulated the list of indicators to 147 indicators in the FLEX 1.0 method (Geraedts, 2014). This method delivered a clear insight in and an overview of aspects that needed to be taken into account when assessing the adaptive capacity of buildings. The user and transformation dynamics that are used in the list of Hermans et al. (2014) are also used in the FLEX 1.0 method to order the adaptive indicators. The next method of Gereadts (2015) called FLEX 2.0 with a reduction of indicators to 83 based on the layers of Brand (1995). He used five instead of the six layers because the inventory is not part of the building. The five layers are: Site, Structure, Skin, Facilities and Space plan/Finishing. The reason of the switch from user/transformation dynamics to the layers of Brand (1995) is not mentioned by Geraedts. A presumption is that his aim was to reduce the number of indicators and therefore chose for another scale for the indicators.

The next step in the development of the method was definitely to develop a very easy and fast to use instrument to assess the adaptive capacity of a building. He reduced the 83 indicators to the 17 most crucial indicators. Each of the 17 indicators has been given a weight in relation to the other indicators (weighting 1 - 3). In this case the weighting is given as a default setting by the author of the method. The users could change this default weighting, but as a result the next described minimum and maximum possible scores and the related flexibility classes would alter immediately. Also each indicator is assessed (assessment level 1 - 4). This leads to a score per indicator and summed up to a total Adaptivity Score (Geraedts, 2016). This method is called FLEX 2.0 light.

At the same time this method was used in two separate research projects for an evaluation with experts in practice. One project concerned the development of school buildings (Carlebur, 2015); the other project was related to the development of office buildings (Stoop, 2015). The main conclusions of these researches were combined to the new method FLEX 3.0 with in total 44 indicators. Based on these researchers there could be concluded that there were 7 general applicable indicators for each building type. This is similar to the theory of Habraken (1972) who determined in his “drager-inbouw” (support-infill) method distinguished the construction levels from the infill level. The general flexibility performance indicators applicable are comparable with the ‘support’ level of the method.

The latest method of Geraedts is called FLEX 4.0. The structure is the same as FLEX 3.0 with the adaptive indicators distinguished in the Shearing Layers of Brand (1995). The difference is that there are 12 general indicators based on the support part of the method of Habraken (1972) and 32 indicators for the infill part and specifically applicable. The assessment values and remarks are comparable with the other FLEX methods.

Choice of adaptive indicators

The choice of the right FLEX method will be based on the aim of this research and the main motives of the investor to invest in adaptivity. The focus for this research is on the initial phase when there is not decided which of the functions in the future will be focussed on. Therefore, only generic indicators can be used to define the adaptive capacity of the building. The focus is on the most crucial indicators for the cash flow. The main motives of the investor to invest is the market value, the rental income and/or the user value. To support all of those three it is necessary to use general indicators.

There are three different levels to observe: the location, building and units. The framework of the research of Geraedts was focussed on the technical side of the building level and removed all the location related indicators from the first indicator list of Hermans et al. (2014). But a fundamental characteristic of the assets’ future cash flow to retain the yield of a building is: location (Geltner, 2006, p.24). The chances of a successful transformation are inextricably linked to the location of the office building. The users demand of the future function, for example housing, is depending on the location. Most of the people are not interested in living at an industrial area full of offices. Therefore is the list of locations indicators added to the list of Geraedts (2015). The weighting of all the location indicators are 1 because of the same importance of every indicator.

According to the history of the different FLEX methods there is focused on the technical side of a building. The indicators related to the location are excluded in FLEX 2.0 light. Therefore, the location indicators mentioned in the adaptivity indicator list of Hermans et al. (2014) will be added to the adaptive indicators of the FLEX 2.0 light (Geraedts, 2016). Thereby will be some additions of location indicators based on the expertise of the graduation company. Eventually, there is a location indicator list and there is the FLEX 2.0 light list. These two lists together will be used to determine the level of adaptivity in a building in this research method.

Assessment method of adaptivity indicators

Together with the Flex 2.0 and 2.0 light method there is an assessment possibly with remarks and values. There are four possible values for the score: 1 = Bad, 2 = Normal, 3 = Better, 4 = Best. Figure 1 shows an example of the four assessment values of indicator nr.11: Surplus of free floor height. The final score is calculated by multiplying the assessment value and the weighting factor for that indicator (see example in figure 6).

11 Surplus of free floor height	Assessment values of the free floor height	Remark	Weighting	Score
How much is the net free floor height?	1. < 2.60 m (Bad) 2. 2.60 - 3.00 m (Nromal) 3. 3.00 - 3.40 m (Better) 4. > 3.40 m (Best)	The higher the free floor height, the better a building can be rearranged or transformed to other functions, the better a building can meet to changing demands of facilities and the quality of the building or units.	1 = less important 2 = important 3 = very important	Score = assessment x weighting

Figure 6: Example of the four assessment values of flexibility indicator nr. 11: Surplus of free height, the assessment values, remarks, weighting and score (Geraedts, 2016).

An example from construction practise to illustrate the different assessment values connected to the flexibility performance indicators is shown in figure 7. The example is about indicator nr. 25: assessibility of facilities components. The left picture is a traditional construction floor (1=bad) and the right image shows a prefab floor with demountable components (4=Best).

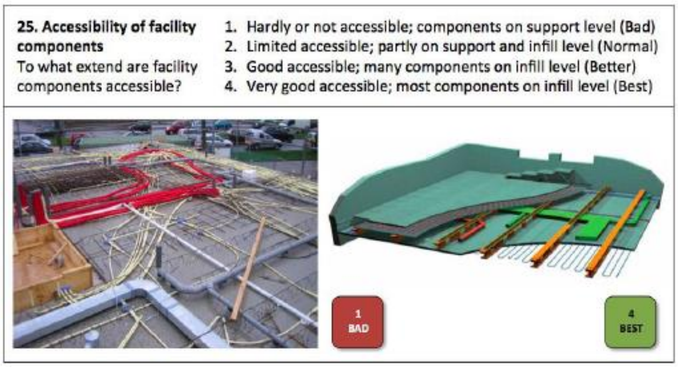


Figure 7: indicator nr. 25: Accessibility of facilities components; left score bad and right score best (Geraedts, 2016)

The FLEX 2.0 light method is a short list of the FLEX 2.0 so the subscriptions of the indicators from the FLEX 2.0 list can be used to fill in the assessment score in the FLEX 2.0 light method. The indicators are divided over the different layers of Brand (1995) and are weighted and defined after a research of many years based on many practical interviews and scientific researches. Therefore, the method can be seen as legitimate for this research. Below is an example of the indicators used in practise by Geraedts (2016):

FLEX LIGHT 2.0				Weighting			Assessment				SCORE
LAYER	SUBLAYER	Nr.	Flexibility Performance Indicator	1	2	3	1	2	3	4	
1. SITE/LOCATION		01(2)	Surplus of site space	1					3		3
2. STRUCTURE	2.1 Measurements	02(5)	Surplus of building space / floor space		2			2			4
		03(11)	Surplus free of floor height			3				4	12
	2.2 Access	04(17)	Access to building: location of stairs, elevators, core		2		1				2
	2.3 Construction	05(21)	Surplus of load bearing capacity of floors			3			3		9
		06(29)	Extendible building / unit horizontal			3		2			6
		07(30)	Extendible building / unit vertical	1			1				2
3. SKIN	3.1 Facade	08(42)	Dismountable facade			3				4	12
4. FACILITIES	4.1 Measurement & control	09(53)	Customisability and controllability of facilities		2		1				2
	4.2 Dimensions	10(56)	Surplus facilities shafts and ducts		2		1				2
		11(57)	Surplus capacity of facilities			3	1				3
		12(65)	Disconnection of facilities components		2				3		6
5. SPACE PLAN/FINISHING	5.1 Functional	13(70)	Distinction between support - infill (fit-out)			3		2			6
	5.2 Access	14(73)	Access to building: horizontal routing, corridors, gallery	1				2			2
	5.3 Technical	15(77)	Removable, relocatable units in building			3	1				3
		16(78)	Removable, relocatable interior walls in building			3			3		9
		17(79)	Disconnecting/detailed connection interior walls; hor/vert.			3				4	12

Total Adaptivity Score:	95
Adaptivity Class:	3

CLASS TABLE Adaptivity Scores	Score Range
Class 1: Not adaptive	17 - 54
Class 2: Hardly adaptive	55 - 92
Class 3: Limited adaptive	93 - 130
Class 4: Good adaptive	131 - 168
Class 5: Excellent adaptive	169 - 204

Figure 8: An example of a calculation for adaptivity in a building with the method FLEX 2.0 light (Geraedts, 2016)

Location indicators		
LAYER	SUBLAYER	Flexibility Performance indicator
Development plan	Development plan functions	Possibilities to change functions in development plan
	Vision municipality	Structural vision of the municipality
Facilities	Parking	Distance to parking facilities
	General	Amount of facilities nearby (within 500m)
	Public transport	Distance to public transport
	Accessibility by car	Distance to main road by car
Surroundings	Air quality	Air quality in surroundings
	Daylight	Obstacles for daylight in surroundings
	Noise	Noise in surrounding of the building
	Wind	Wind nuisance
	Public safety	Safety in the surrounding of the building

Figure 9: The location indicators list (Brink Groep, 2018)

2.7 Conclusion

According to the main question of this thesis should be determined what the added value is of adaptivity. The user dynamics and transformation dynamics are crucial in the valuation of adaptivity, because they are determine the demand for adaptivity. If the building, the supply side, has the capability to rearrange, extend and reject, the adaptive capacity is extremely high. These flexibilities should be taken into account by the investor if he will invest in adaptivity and these flexibilities should be implemented in the financial model. The adaptivity will be measured by the list of adaptive indicators based on FLEX 2.0 light and Brink Groep (2018). In the next chapter will be explained what the reasons are to invest in adaptivity.

3. Investing in adaptivity

Reading guide

In this chapter will be elaborated on the subject why to invest in adaptivity. This report is based on the report of Hermans (et al.,2014). The conclusion of their report was that adaptivity is a tool to extend the functional lifecycle of the building. On the longer term adaptivity will be an important precondition for sustainability. But why should investors invest in adaptivity in the first place? The question for this chapter is:

What are reasons to invest in adaptivity and what financial effect has an investment in adaptivity?

To answer this question it is necessary to define who is investing. Afterwards should be defined why they would invest in general. Thirdly, should be defined what determines the value of an investment for an investor. Fourthly, will be explained what motives could they have to invest in adaptivity. Finally, a comparison can be made, if there is a match between the interests of the investor and the capability of adaptivity. This will answer the question why investors would invest in adaptivity.

3.1 The Owner/investor

As stated in the introduction the owner and/or investor in real estate is the target group for this research. In general, the owner/investor in real estate is the actor who makes decisions and sets the requirements based on financial and functional motives for new and existing buildings. They determine the ambitions for investment decisions and are responsible for choices in the building- and operating process. Their decisions can influence the level of adaptivity in an object (Hermans et al., 2014, p.10). An investor could be the owner of the real estate and could do the management of the building by himself. But the investor can also decide to outsource the management of the building to another company. In this situation there is a company who is in charge of the management of the building, in this case the owner, and there is the company that bought the building, the investor. Therefore, there is a separation between the owner and/or investor. Since the target group of the research is owner/investor, it will be further on the report written as “the investor”.

According to Van Gool (2007) a distinction can be made between two different types of investors. The investor who sees the real estate asset primary as product for accommodation and not particular to gain the highest yield in several years. This is the investor who invest in the building for his own use. An example of this investor is the Government, in the Netherlands the department *Rijksvastgoedbedrijf (RVB)*. The department is the asset manager of all the housing of the Government. The RVB has a few square metres for their own housing and the other square metres are part of the portfolio of the Government. The RVB determines the strategy of the housing for all the other departments of the Government. This is called the owner-user.

The other type of investor is a commercial investor who aims on the highest possible yield. This could be obtained in a short time but could also obtained with a long time horizon. According to Keeris (2008) the commercial investor can be divided in four different kind of investors. The commercial investors are:

- The institutional investor
- The professional private investor
- The private investor
- The speculative investor

In the figure below is shown when they generally invest in the lifecycle of a building and what the value creation is for the real estate asset through time.

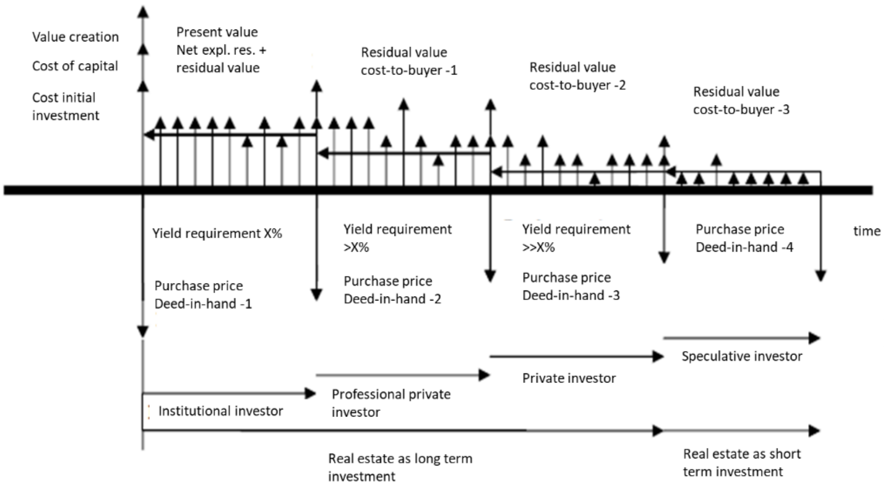


Figure 10: Value creation through time by different commercial investors (Keeris, 2008)

Beside these types of commercial investors there are real estate investment vehicles like the comingled real estate funds (CREF or unit trusts) and the private Real Estate Investment Trusts (REITS whose shares are not traded publically). These are investment vehicles with multiple investors. They provide their investors with an ownership interest in the underlying asset, sometimes leveraged. These type of investor could also be interested in investing in adaptivity depending on their time horizon and aim for example.

In short, there is the investor who invest in the building for his own use, the owner-user and there is the commercial investor who is focussing on the yield. Both kind of investors do have sub-names according to Keeris (2008) but these are the main two type of investors. The focus to invest only on own use or to retain a yield are different kind of motives that will be explained further in the chapter.

3.2 Investment motives in general

According to the literature of Geltner, Miller, Clayton, and Eichholtz (2001, p.125) there are two main motives to invest in commercial real estate. An investor has a value-increase-motif or a cash-flow-motif. The difference between them is the vision in time.

Value-increase-motif
The growth (or savings) objective, which implies a relatively long time horizon with no immediate or likely intermediate need to use the cash being invested. When the investor has the goal to achieve a value increase it is most of the time focused on the long-term. The invested money is not expected to be re-invested on the short term. It is in particular used by intuitional investors and private investors. Most of the time these investors predict that in the future the real estate has a higher value so it can be sold with a positive yield.

Cash-flow-motif
The income (or current cash flow) objective, which implies that the investor has a short-term and ongoing need to use cash generated from the investment. The opposite motif is to make a quick profit on the investment and continuous income. This income will be generated by the periodic rent incomes during the operating phase of the building.

In both motives are yield mentioned as the end result for an investor but in the previous paragraph was also the owner-user mentioned who sees the real estate asset primary as product for accommodation and not particular to gain yield in several years. One of the difference between the different investors is the short or long term focus. Besides the time horizon describes Geltner (2006, p.125) other different major constrains and concerns that affect most investors, particularly in the real estate asset market:

- Risk: The possibility that future investment performance may vary over time.
- Liquidity: The ability to sell and buy investment assets quickly at full value and without much affecting the price of the assets.
- Time horizon: The future time over which the investor's objectives, constraints, and concerns are relevant.
- Investor expertise and management burden: How much ability and desire the investor has to manage the investment proves and the investment assets.
- Size: The amount of capital in need of investment.
- Capital constraint: The absolute constraint on the amount of capital they have available to invest.

There can be made a distinction in this list between constraints and concerns that can be influenced by the investor and things that cannot be influenced by the investor. The constrains and concerns that can be influenced by the investor are the time horizon, expertise, size and capital constraint. In relation to adaptivity is the time horizon far with an aim of multiple functional lifecycles. The expertise and management burden is depending on the kind of investor and his ability and desire. The same applies for the size and capital constraint. The investor does not have influence on risk and liquidity. The liquidity is affecting the market and the risk is affecting the real estate object.

In the end there can be concluded that the commercial investor makes a decision to invest in the adaptive capacity of a building based on the yield and risk. The commercial investor is focussed to retain a maximum yield. Depending on the kind of investor there is a distinction in the risk profile. An institutional investor is focussed on the long term and therefore focussing on a less risk project in comparison with the speculative investor who demands a yield in short term with more risk. The owner-user has as primary goal to focus on the accommodation of the users. Therefore they are not focussing on the yield but more on the risk. To accommodate the organisation a low risk profile is preferred.

Investors view considerations about real estate cash flow and asset values, keeping in mind their own objectives and constraints, the things they care about and worry about in making their investments. These objectives and constraints are therefore fundamental to understanding how real estate values are determined (Geltner, 2006). To understand what the addition is of adaptivity it is necessary to know what the primary goal is of the investor: maximizing the yield, a low risk profile of a project or to accommodate the organisation.

3.3 Investment motives for adaptivity

The investors have a certain motive to invest, regarding to the previous paragraph, to achieve their goal. If an addition to an investment will increase the chance of achieving this goal, it is a valuable addition. The underlying purpose of the investment is the representation of the value of an investment for an investor. An investment in adaptivity should be a valuable addition in the investment for the investor. In the last chapter about adaptivity were the demand and supply side mentioned. The demand side had two aspects: the transformation dynamics and the user dynamics. A combination between the motives to invest and the dynamics could determine the reasons to invest in adaptivity:

- Commercial investor with a short term horizon is focused on the yield of their investment with a high risk profile. If adaptivity could increase the market value, it could be interesting for the investor to invest in adaptivity. Adaptivity is an extra investment what should compensated by a higher market value. Adaptivity results in a building that could serve multiple functions in the future. This will meet the demand for transformation dynamics. Finally, it increases the demand to buy or rent the building and this results in a higher market value.
- Commercial investor with a long term horizon is focused on the yield of their investment with a lower risk profile. Adaptivity has influence on the rental income through the tenants who stay satisfied on

the long term. Thereby, it is possible to accommodate several tenants in the building, because of the adaptivity. This will reduce the risk of vacancy.

- The owner-user is primarily focused on the accommodation of their organisation. Adaptivity will help in increasing the user value by more flexibility in the accommodation of different users. In a portfolio a building could be used by different functions. This will meet the demand for the user dynamics. This could extend the functional use of the building.

Split-incentive

In most cases an office building is an investment object for an owner and the housing for the organisation for the user. Both parties have their own interest in investing in the adaptive capacity. The current user could have interest to invest in the adaptive capacity for example, because he wants to be flexible in technical facilities and implement every year the newest gadgets. According to two experts in the thesis of Stoop (2014, p.48) an extra investment in adaptive capacity should recovered by the owner ánd the user of the building. In this way the split-incentive between both parties could be solved. This should be taken into account when talking about investments in adaptivity.

Interviews

The investment motives for adaptivity are based on theory, but the result of this research, an added financial model to calculate the adaptivity of a building, should be used in practise. Therefore, two types of the commercial investor and two owner-users are qualitative interviewed to verify the motives. The different interviewees have all a director position who have the influence on the investment strategy of the investor. The companies of the interviewees are chosen based on their investments in office buildings and the desire to transform a property. This transformation could be in the future or transforming a vacant building. Based on these interviews and the theory of this chapter the sub-question of this chapter will be answered.

The short term investor

An example of a short term investor in the Netherlands is the company called: Cairn Real Estate. It is part of the German parent concern NPC. It is a short term investor and asset manager in offices but also other real estate functions. They are a short term investor because of the short time horizon of 3 to maximum 5 years. Their core business is investing in vacant properties and transform or renovate the building to new offices with a good branding. Adaptivity is only included if the client has the demand to have a more adaptive building. They will always invest with another company to reduce the risk. Mostly, the forward funding model (FFM) will be used to become the owner of the building after completion. The FFM is a joint venture with a developer. Based on the agreements between the investor and the developer, the investor will invest every period a certain amount of money in the development. After completion the property is owned by the investor. The reason for this model is reducing the risk for the developer. The risk for the investor will be bigger what most of the time results in a bigger yield.

After the transformation or renovation, the property will commonly be sold to an institutional investor with a long term horizon that demands a good constant income over the years. In comparison with the institutional investor is the risk much higher for the short term investor. However, the yield is also higher and the time horizon is shorter. These three subjects are the most important for the short term investor, the risk, yield and time horizon. Beside those terms, there are some subcategories like sustainability for example. This subcategory is only interesting for the short term investor if it is demanded by the client during a development.

The main problem of the short term investors is that the objective for them is to have a liquid market and a high yield in short term. These aspects are not in line with the aspects to invest in adaptivity. The short term investor expect for the coming years no change in the way of thinking about adaptivity. They will probably use it in the future when the market demands it. Currently, it is not part of their investment strategy, because it doesn’t result in a positive yield on the short term.

Institutional investor
A Dutch institutional investor is NewSteenInvestments (NSI), listed in a stock exchange. Since 2017, NSI their strategy is to become a specialist in the office market. Therefore, their strategy is to invest in offices on the 7 prime locations of the Netherlands: G4, Eindhoven, Leiden and Den Bosch. These prime locations are based on a big data analysis and a real estate analysis in the Netherlands. Their expectations are to raise their stock-market value by this strategy. All their properties are owned by themselves. Their strategy is to invest in vacant office buildings or with a short term contract. Afterwards, they search for new tenants and make the building fully let again. This will be done by implementing their concept called HetNieuweKantoor (HNK) or another flexible concept like a multitenant concept. Their goal is to optimize their business case in 7 years after completion of renovation or transformation. After the 7 years will be reviewed what to do with the building. It could be sold or kept by the investor, depending on the yield. However, a future proof investment and a sustainable yield is more important than the divided. Their focus is on the long term. An investment decision depends on the amount of investment. If the investment costs for property A are 100 and the return is 8 and for property B the investment costs are 50 and the return is 7, they will choose for property B. Their aim is to exist over 20 years as well. Every investment should be well calculated and with a focus on the future. This strategy is strongly related to risk. Because of their aim on the long term, their risk is lower in comparison with the short term investor.

To achieve their goal to do a future proof investment, an important factor, besides the risk and yield, is flexibility. The investment in flexibility will not only based on numbers, but also on the location, the users in the area around the property and the history of the property. The reason for them to invest in flexibility is if there is a change in the market. In that case, they have the possibility to transform or renovate with a small investment to a functional building that is demanded. In their opinion is more flexibility not related to more uncertainty. The rental income is higher and the diversity of tenants will reduce the friction vacancy. If the tenant demand an extra investment in flexibility with a short payback period, the rent will be higher.

Government (owner-user)
The governmental actors are an example of the owner-user type of investor. In the Netherlands, there are two big real estate organisations related to the Government: the National Police and the real estate company of the Government (Rijksvastgoedbedrijf, RVB). The difference between them is the focus on the owner or user. Both parties are interviewed and this will be discussed.

Before the National Police organisation was founded in 2013, there were 26 different divisions with their own real estate strategy. Every division could decide where to invest in within their division. Therefore, every user within the division had their own very specific building for their function. In this situation, the focus was on the user-perspective. Currently, there is a shift from the user to the owner-perspective as well by an increase in scale and centralisation. However, the functionality of the building for the user is the most important. They are working on a compact portfolio with an uniform quality and implementing flexible working places. Their primary goal of the National Police is that their housing supports their primary process as organisation. Their primary process is to keep the citizens of the Netherlands safe. The goal for the organisation is to reform the portfolio that is useful for the biggest possible group of users in the future, because they expect the organisation to change due to organisational and political influences. The buildings should be generic as possible to accommodate different users. To develop more generic buildings, adaptivity can be applied in the future, because adaptivity ensures the future value of a building. Within the housing portfolio, the National Police has multiple specific functions. They want to prevent to build specific buildings for those functions and In the primary process, the financial aspect is also important, because the National Police is a public organisation.

The aim for them to implement adaptivity is focused on the operating costs, because of the demand by the Government to reduce costs. The reason to focus on the operating costs is because a higher investment in adaptivity will be recovered during a long term operation. Currently, some adaptive measures are including the possibility to sell parts of a building in the future by making the right choices in the design phase and taking apart courant and less courant functions in a way that the value of the building increases. They are less focused on the yield of the portfolio in comparison with other investors, but more on their own accommodation to support their primary process.

The RVB is the asset manager of all the housing of the Government. Within the owner-user perspective is the RVB more the owner. They use only a small part of the portfolio itself. Most of their tenants are from the same organisation, the Government. They are using infinite contracts with a termination period of a year. This is a benefit for the tenants, because of the flexibility to change from location.

There are multiple platforms within the organisation. One of them is offices, part of the ministry of external affairs. They are the client of the RVB but the risks are for the RVB. This will influence some of the financial decisions of the RVB to invest extra in adaptivity. Their primary goal is to house the Governmental organisation. In the crisis, they had the assignment to reduce the costs. This is done by reducing the amount of employees and real estate. In this process there wasn't any focus on adaptivity or investing in the future. Therefore, some properties were sold, but could be useful in the future for them and other buildings were kept but didn't have the demanded flexibility to change in the future. Currently, they acknowledge that flexibility is important for the future. Therefore, they are implementing adaptivity step by step. Their expectations are a decrease in the demand of workplaces. Office buildings will have the function in the future of a meeting place for the organisation instead of a working places. Their focus for the future is to invest in adaptivity and circularity within their portfolio.

3.4 Conclusion motives to invest in adaptivity

Based on the different motives there can be concluded that adaptivity will be an addition to the investment. The three aspects that are influencing the additional value of investing in adaptivity are: time, risk and yield. Based on theory the short term investor could be interested in the extra investment in adaptivity, because of an increase in the value. However, in practise it is not feasible. It will only be used if the client demands it. The value for a long term investor is a constant income and an actual yield at the end of the investment. The risk or uncertainty of the future is the most important factor for them. If the risk can be lowered through more transparency by a model it could be valuable for them. The Government is mostly focused on their own use. The user dynamics could be a valuable addition to their objective to accommodate the organisation. Their focus is to produce a portfolio that is future proof with flexibility included. This conclusion will be combined with the next chapter to make a valuation model to value the adaptive capacity of a building.

3.5 Conclusion

In this chapter is defined what type of owner and/or investors are in the real estate and their the constraints and concerns in general. In addition, there is defined which groups are affecting the adaptive capacity of a building. The combination of what the investor demands and what the adaptivity could offer should answer the question of this chapter. The question of this chapter was:

What are reasons to invest in adaptivity and what financial effect has an investment in adaptivity?

The commercial investors are focused on the yield. The most important constrain and concern is the risk of a project for an investor. If the risk is low and the yield is high it is an interesting investment for the investor. The problem is the long timespan and the risk before it is valuable. Therefore, most of the short term investors are not interested in the investment in adaptivity, but the long term investors are. Their characteristics are long term focus, a low risk profile and a high yield.

There are two groups affecting the adaptivity capacity of a building, the owner/investor and the user. The owner/investor is related to the transformation dynamics. If there is a change in the demand of the function this affects the owner/investor. The owner/investor and the user are related to the user dynamics. If there is a change in the demand of the user this will affect them both. To measure the transformation and user dynamics there are several adaptive indicators defined by Hermans et al. (2014) and Geraedts (2016). If there is a high score on the transformation- and user dynamics the adaptive capacity of a building is high. The adaptive capacity can lower the risk for an investor in the future, because of the high flexibility of the building. The reason to invest in adaptivity is because of the probably lower risk and higher yield and a future proof building.

Another important reason to invest is the location and the market. The uncertainty of future events are related to the location and the market. The financial model should take into account what kind of location the property is situated. This will influence the decision to invest in adaptivity or not. The same applies for the real estate market. Last decade, the market is very volatile and therefore should this implemented in the financial model as well. This will be further explained in the next chapter.

4. Valuation methods

Reading guide

In this chapter the different valuation methods that could be used to determine the adaptive capacity of an office building will be elaborated. The aim of this research is to develop a financial decision model for an owner/investor to value the future value of adaptivity for an investment in an office building in the Netherlands. One of the problems are the missing ability of those methods to value the adaptive capacity of a building. In the financial models the inputs that are influencing the decision of the investor will be determined. The sub question of this chapter is:

What are the crucial inputs to measure adaptivity and in which of the current valuation methods are these inputs included and what should be added?

In the previous chapter the objectives, concerns and constrains of the investor are determined. This chapter elaborates on how an investor operates and what the investor does to determine the value of an asset. First will be explained how investors operate. By examining how an investor acts and operates on the asset market it is possible to understand what the requirements should be for the financial model. Afterwards is explained which of the current valuation models are used in general by an investor to value an investment. To determine the different variables in the calculation of an investment in an office building, it is necessary to elaborate the different financial models used by the investors to valuate a building. After every financial method will be concluded which model can also be used to determine the value of adaptivity. Therefore, there will be focussed on the variables that could be used as input for the final research model.

4.1 Actions of the investor

Investors buy and sell capital assets, thereby making up both the demand and supply side of the capital markets. They are the demand side because of the search for real estate assets to invest in and the supply side once they bought an asset. Through the process of buying and selling, investors determine the market values of capital assets, that is, the prices at which these assets trade (Geltner, 2001). To determine the price of the asset, the investors consider the fundamental characteristics of the assets' future cash flow prospects, like the location mentioned in the previous chapter.

The investment decision are made in the initial phase of a project based on hard and soft information (French, 2001). In this phase the owner/investor determine if an object has a future value on the short ánd long term, i.e. the highest possible yield during the owners period. It can be argued that definitive inputs are the hard information in the decision process. Yet, the soft parameters within the decision-making process will influence the decision as well. Soft parameters are related to behavioural issues. Many of the benefits of investments are not estimates of real prices, but based on shadow pricing techniques measuring 'willingness to pay', an example of a soft parameter. The soft parameters distinct the investor from each other.

Based on the previous chapter the investor could have the objective to obtain a high market value, a constant rental income or an user value for the organisation. Hereby, he develops his own investment strategy. Van Gool (2007) characterises 5 steps during the investment process of an investor in real estate:

1. Determine the targets of the investor:
    a. The yield on short and long term
    b. The acceptable risk
    c. The amount of loan capital
    d. Ethical norms
2. Determine the possibilities and constrains
    a. The size of capital

   b. The investment possibilities
   c. The current portfolio
   d. The knowhow and expertise of the investor
   e. The availability of an own management organisation
   f. The availability for loans
3. A vision on investments in the future
   a. The expectations of developments in the economic, political, social, legal and fiscal areas
   b. The expectations of real estate markets and ideas about the development of different real estate investment categories
4. Formulate the investment strategy on the longer term with investment criteria's
   a. The preferred yield on the longer term in combination with the risks
   b. The preferred division of investment categories. For example the division of purchase and sale of real estate, the qualities of the real estate and the amount of investments.
   c. The preferred management/operation organisation and the criteria for operation, like the quality of tenants
   d. The preferred leverage, i.e. the way of financing with loan capital
   e. The currency strategy for investments in foreign countries.
   f. The fiscal structure
5. Determine the investment strategy for the short term
   a. The acquisition strategy with the criteria for purchase
   b. The disposition strategy with criteria of sale
   c. The management strategy with the criteria during operation

These steps are formulated for investors that invest in real estate in general. This research is about the investment in adaptivity. Some of the steps are a bit different in comparison with a general investment. As stated in the introduction is this research based on the method of Hermans et al. (2014). They provide a step by step plan as well for the investor. This method is focussed on adaptivity. The combination of the step by step plan of Van Gool (2007) and Hermans et al. (2014, p.21) results in the following steps for an investor to invest in adaptivity:

1. Determine the targets of the investor
2. Formulating the requirements of adaptivity in a building
3. Determine the possibilities and constraints to invest in adaptivity of a building
4. A vision on the future regarding to the adaptivity of the building
5. Formulate the different solutions on the longer term with investment criteria
6. Evaluate the qualities of adaptivity according to the offered solutions
7. Weigh the financial impact of the solutions
8. Based on the most efficient business case determine the best offered solution regarding to the future value of the building.

To determine the future value of the adaptive building there are different kind of valuation methods. In the next paragraphs will be explained what kind of valuation methods there are.

4.2 The current valuation methods

The analyses of valuation methods that are currently used by investors are based on the literature of Scarrett (2008), Lusht (2001) and Rodermond (2011). The first two did some research on valuation methods in general and Rodermond (2011) did research about the different valuation methods used by investors to valuate vacant office buildings.

There are three different traditional financial methods:

1. The comparative method
2. The cost based method
3. The income based methods

For some of them are additional methods. Firstly will be shortly explained what the basic methods are. After each method will be concluded if the method is (partly) useful for the final financial method. This conclusion will be based on the advantages and disadvantages to value adaptivity.

Comparative method

This method is based on the comparison of market values and transactions of comparable properties. The transaction prices of the comparable properties will be corrected by the differences with the current property. All these comparisons will result in an assumption of the value of the property. The bigger the data of transactions and market values the better it can be calculated. The comparative method is mostly used in residential market if there is an owner/investor. Some disadvantages of this method is the subjective way of choosing a comparable, use of it and analysis of the comparable. Some market changes could be overlooked without the right market information or analysis.

This method will be used in this research by using the historical data of different variables, for example the rental prices, vacancy rates, growth rates etc. Furthermore, to determine future values of a property there is an additional method necessary in this thesis.

Cost based method

The cost based method is also based on the idea to compare properties, but with this method the value of a building will be corrected by the depreciation. An important difference between the cost based method and the comparative method is that the comparative method is based on direct market evidence of transactions, but the cost based method is just a rough estimation of the market value. It is an estimation of the value to re-built a building. The cost based method is only applicable if it is a well-balanced market.

This cost based method is too rough and not intended to predict future values but only valuate the current value of the property. The cost based method is not be recommended for this thesis.

Direct capitalization method

There are two types of income based methods. The Discounted Cash flow and the Direct capitalization method. The direct capitalization method uses the capitalization rate of a commercial property to calculate the value. By dividing the property's first year net operating income by the capitalization rate, the value is established (Geltner et al., 2001). This method is a quick calculation for the market value but doesn't take into account all the risks, uncertainties etc. This is necessary for the financial decision model to make a good overview of the scenarios.

The direct capitalization rate will only be used in this research to estimate the value of the property if it will be sold. This is only a small part of the total valuation of the property.

Discounted Cash Flow method (DCF-method)

The other income based method is the Discounted Cash Flow. Based on the rental income in cash flows over several years the market value will be calculated. One of the conclusions of Rodermond (2011) was that 93% of the appraisals are performed using income based methods. The DCF method incorporates time and reversion cash flows in the calculation of the market value. Most investors have a much shorter investment plan in comparison with the technical building span. Therefore the DCF methods assumes a finite holding period at the end of which it is assumed the property will be sold (Lusht, 2001). According to Grevelink (2015) results a combination of the direct capitalisation method and input based on conformity with the market discount rate the most reliable value.

In comparison to the other methods is this method the most useful one to calculate the value of a building over a longer period. Thereby is it widespread in the real estate business. This method will be used in this research as well and there will be more on elaborated in paragraph 4.3 about the advantages and disadvantages.

Residual method
A property based method is the residual method. The total value is based on the residual value and the property on the ground. The residual value can be calculated with the income based method and the property on it with the comparative method. The total value minus the property value gives the residual value. The residual value is mostly used by developers to calculate the value of land and the municipality use this method to value the land for leasehold.

The residual value method is not applicable for this research because the aim of this research is not to calculate exclusively the land value but the property value. This is including the land.

Highest and Best Use method (HBU-method)
The highest & Best Use (HBU) method is a valuation method in which the building is valuated in its most appropriate use. When there are multiple scenarios like transformation, consolidation or sell, the best scenario would be chosen. It is argued that valuations should include a HBU, at least as an alternative to the traditional valuation. The HBU is rather a method of residual value calculation than completely novel approach (Rodermond, 2011).

Currently, this method is used to choose between the different scenarios of flexibility. However, the scenario approach of the highest and best use will not include all the possible options in one value but is in the end one value. To value the adaptive capacity of a building it is also useful to value different options together.

Conclusion
To conclude what the best valuation method is to value the adaptivity of a building, the method should meet the requirements of the previous chapter. The requirements were that the method should:

- be able to calculate over a longer time period. This is not only the investing costs but also the long term operating costs.
- show the probable uncertainties to reduce the risk for the investor.
- respond on the demand for adaptivity, the transformation dynamics and the user dynamics, by change of the type of user/tenant.

The aim of adaptivity is to have a functionality during the technical lifespan what result in a long term operating period. Therefore, the comparative method and direct capitalization method are not enough to value adaptivity over a long time span. The cost based method is not applicable to determine the future value but only the current value. The property based method is not complete enough because of the focus on the land. Based on the crucial inputs for a valuation method is the DCF model the best starting point for the financial model complemented by historical data of different variables from the comparable method. A combination of the direct capitalization method and the discount rate of a DCF method will be used to determine the actual market value in the financial rate to calculate the price to sell an office building.

4.3 Discounted Cash Flow method (DCF method)

The DCF method is one of the income based methods that value the cash flow of a property by using different kind of variables. In this paragraph will be explained what the advantages and disadvantages are of the DCF method.

The goal of the calculation with the DCF method is to discount the cash flow from future operations and the sale of the asset. The question is what the discount rate should be to discount the future expectations. To determine the market value of the asset should the discount rate be equal to the market discount rate. The market discount rate is based on a market analysis of comparable transactions of the same assets in the market (Van Gool & Rodermond, 2011).

The procedure of the DCF method consists three steps according to Geltner (2001, p.203):

1. Forecast the expected future cash flows
2. Ascertain the required total return.
3. Discount the cash flows to present value at the required rate of return.

These three steps to use the DCF method can be mathematical summarized into:

$$W = \sum_{t=1}^{n} \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_t}{(1+r)^t} + \cdots + \frac{EV_n}{(1+r)^n}$$

In which:

W = market value

CF = cash flow (periodical net rental income)

n = amount of terms

r = market-based discount rate

t = time (in years)

EV = end value at time n

The valuation is about the balance between the cash outflow and cash inflow through time. The rental income of the tenants could be lowered if there is vacancy in the building. The vacancy is based on the vacancy rate from historical data and will be corrected by the vacancy growth rate. The rental income will be corrected by the inflation rate through years. The constant costs are the operating expenses, for example the maintenance costs. These expenses will be corrected by the inflation rate through years. An initial cost in the cash flow is the transformation costs. The different rates in the future are all based on the behaviour of the rates in the last 10 years.

The time span is the period where the yearly cash flow will be used to calculate the market value. Theoretically has the time span no influence on the value. However, it is important to mention that a short time span result in an end value that could be more consequences for the market value in comparison with a longer time span. The end value will be determined by the market rent on term n divided by the exit yield on term n. Mathematical is the formula:

$$EV = \frac{market\ rent_n}{exit\ yield_n}$$

In which:

EV = end value (exit value)

Market rent = ‘normalised’ gross cash flow

Exit yield = capitalisation rate

According to Lugard (2009), Veenstra (2006), Berkhout, Bouwens, Hamers & Tansens (2006), Smeenk (2016) it is very difficult to determine the end value. The exit yield will be determined by the capitalisation method at t=0 in combination with an aging premium. The premium is depending on the time span of the calculation and should be higher when the time span is longer. The exact determination of the exit yield is one of the difficulties for the valuation expert or investor.

Another difficulty is the determination of the market discount rate. Normally, the market discount rate is based on risk free rate and the risk premium (Van Gool et al., 2013):

$$market\ discount\ rate = risk\ free\ rate + risk\ premium$$

The risk free rate is based on a 10 years Dutch Government bond. The risk premium is divided in several risks: the asset class specific risk, the object specific risk, and the segment specific risk. These risks are depending on the location of the object and the object itself. For this research is the asset class real estate, the segment specific risk is offices and the object specific risk is depending on the case.

Based on the general working of the method there are three points that limits the DCF method according to (Vlek, van Oosterhout, Rust, van den Berg & Chaulet, 2015, p.152):

- The DCF method is deterministic. It calculates future cash flows for an investment based on the market assumptions and expectations. Then the discount rate will be used to calculate the net present value. The outcome is the end result of the assumptions. However, the cash flows of investments are in fact not deterministic but stochastic, because of the uncertainty in the future. This is not included in the DCF calculation. Scenario analyses and sensitivity analyses will show some of the risks but are fixed to a certain timespan.
- The DCF method is using a fixed timespan for the calculation. The flexibility that is needed in the current time is not included in the DCF method. During the calculation of a lifecycle of a building it is not possible to change some variables, for example when an event can occur what will influence the decision of the owner/investor. Some examples of events are a delay of the project, change of the functions or extension of the building volume. These possibilities are not included in the DCF-method. With the DCF-method will the next phase defined in the beginning of a phased project occur at the moment that was predicted.
- There is not a theoretical basic for the discount rate variable in the DCF-method. The discount rate depends on the vision and the aim of the owner/investor. Risk is the only variable that is included in the discount rate. If the investment has a high risk profile it result in a high discount rate as well. The problem is that the a upwards potential will be discounted the same as a downwards potential. This results in a low valued upwards potential possibilities.

These disadvantages will increase as the project has a longer durability, high risks and flexibility is included. This is applicable to the investment in adaptivity. As a result that the project will be undervalued with negative influence on the investment decision. Miller and Park (2002) describe the same limitations of a DCF-method.

1. The method ignores flexibility because it is a static model
2. Deterministic values without uncertainty
3. The investment decisions are displayed as now or never without assuming a delay in the project.

The DCF method works with deterministic situations without any uncertainty. For the future value of a building there are a lot of uncertainties and therefore more stochastic values.

Stochastic vs. Deterministic

A stochastic or probalistic model relies on probability to obtain its value for future states of the system.

A deterministic model had no randomness involved in generating it future output values. (Leung, 2014)

To overcome these limitations there will be three different models explained that are all extensions on the DCF-method. The three methods are the Decision Tree Analaysis (DTA), The Real Option Analysis (ROA) and the Monte Carlo Simulation.

4.4 Decision Tree Analysis (DTA)

In the table below is an example of a calculation with the decision tree analysis. If there is an investment of 100 euro and there is a volatile market (like the current market). Due to the volatile market is the present value in a good upstream market 120 and in a downstream market 80. The estimated chance of an upstream market is 60% and a downstream market 40%. Assume that the investment increase every year with 8% and the discount rate is also 8%. The difference between the DCF and the DTA is that in the DCF the investment is done in t=0. In the calculation with the DTA will the investment postponed with 1 year. This gives the investor the flexibility to choose to invest or not after 1 year. The calculation will be as follows:

DCF	60% UP	40% Down		DTA	60% UP	40% Down
Investment t=0	-100	-100		Investment t=1	-108	-108
PV t=0	111,1	74,1		PV t=1	120	80
PV t=1	120	80		NPV t=1	12	-28
NPV	11,1	-25,9		NPV	11,1	-25,9
eNPV	6,7 =(0,6x11,1)	-10,4 =(0,4x-25,9)		eNPV	11,1 =(0,6x11,1)	0 =(0,4x0)
eNPV DCF =	-3,7	=(0,6x11,1)+(0,4x-25,9)		eNPV DCF =	6,7	=(0,6x11,1)+(0,4x0)

Figure 11: Difference between DCF and DTA (Vlek et al., 2015, p.153)

The biggest difference between the DCF method and the DTA method in this example is the moment of investment decision. In the DTA will be decided that with a downstream market not to invest, because the NPV is negative. Therefore, the expected NPV (eNPV) is 0. In the DCF method the investment is done in year 0 and therefore the loss of minus 10,5 should be accepted by the investor. The results are marked by a black box. With a upstream market will be decided to invest with the DTA method. The DTA will most of the time be displayed by a tree to show the decision steps as shown in the figure below.

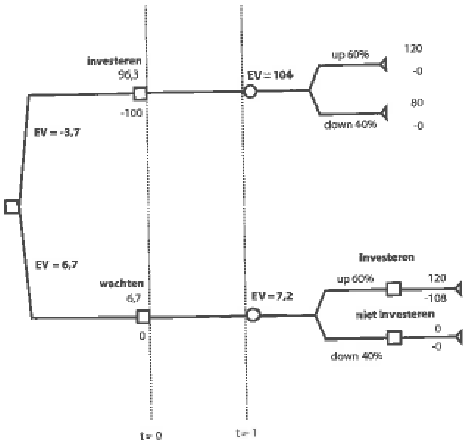


Figure 12: DTA in a tree diagram (Vlek et al., 2015)

Upgrade

In this example are only two sub branches but decision trees can be really extensive with a lot of decision (squares) and event nodes (circles). Only the decision nodes can be influenced. DTA is really helpful to calculate possibilities and decision in future use of a project but there are also some disadvantages:

- In the DTA are project systematic risks implemented and market specific risks in the same calculation. But these two risks are very different. The project systematic risk is related to the project and can be influenced but the market specific risk is an external risk and cannot be influenced. This is not included in the DTA.

- DTA is based on subjective chances. These chances are determined by the management in a project. This is acceptable if the risks are specific, because of the lack of market information. But the market risks cannot be determined subjectively. These risks are objective and based on market characteristics.
- The determination of the discount rate for the DTA is questionable. For example, in the previous example the calculation with the DTA was a call option: the option to wait for a year without investing. A call option is a levered product and has a higher risk in comparison with the real estate asset. When the underlying value changes are the consequences that the call option will change even bigger. In a downward market of the last example was the underlying value decreased with 20%: from 100 to 80, the value of the call option is than 0. The risk related to call options should result in a higher discount ratio. Thereby, the risk in the beginning of the DTA is bigger in comparison in the end, because of all the possibilities in the beginning but are limited in the end. This should result in a higher discount rate in the beginning of the option in comparison to the end.

The Real Option Analysis (ROA) is a theoretical framework that will solve the last two points of the disadvantages of the DTA. The first disadvantage should be solved by a hybrid solution with a combination of two technics. This is not applicable in this research. Before the ROA will be explained the definition of risk will be highlighted.

4.5 Real Options Analysis (ROA)

The real options method has been identified in the literature as a quantitative means to evaluate the flexibility inherent in the decision-making process. The problem with a DCF model is the need to have a certain cash flow model to calculate the future value. Without the certainty, the value is based on assumptions and the bigger the assumptions are the bigger the error. With the real option method, the manager will be able to bundle several possible outcomes into a single investment and make discretionary decisions to invest in highly uncertain capital expenditures. These outcomes are based on separate time periods, uncertainty levels and multiple mutually exclusive options. To valuate a property, the manager need to estimate the cash flows and uncertainties of each possible outcome. This result in an awareness by the manager of the benefits generated by strategic investments (Miller & Park, 2002).

Back in the 80's of the last century were the first theories about the Real Options Analysis developed. The reason that it is not implemented by the practitioners is time. Academia thought about the DCF method around 1950's based on theory. The practitioners adapted the method in 1980. This was just the beginning of the adaption. According to Gitman and Vandenberg (2000) the DCF method wasn't adapted by 70% of the U.S. firms until 1997. The real options are invented around 25 years ago and are now slowly adopted.

ROA is based on the theories with financial options but differ a lot in most of the core issues. In the financial theories there are two different kind of options. The call option as explained before: an option with the right (not an obligation) to buy the underlying value (S) for the price agreed in advance (X) during the whole maturity. This option is called the American option. The other option is the put option: the right to sell the underlying value for the price agreed in advance at the end of a period. This is called the European option. There is another option, called the Bermuda option, where it is possible to use the right only at determined moments (Hull & White, 1990).

The right for the option taker buys, he pays the option premium. The option publisher has the duty to disburse (with a call option) or to buy (with a put option) the underlying value to the option taker for the price (X). If it is a public tradable option should the option publisher guarantee, if it is not a public tradable option it is the responsibility of the parties to make a contract. The option taker will only apply the option if he is in-the-money. The option is in-the-money if the intrinsic value (W) is bigger than 0. Based on the price (X) and price (S) will result in the following equation (Vlek et al, 2015):

$$W_{call} = \max(0; S - X) \quad en \quad W_{put} = \max(0; X - S)$$

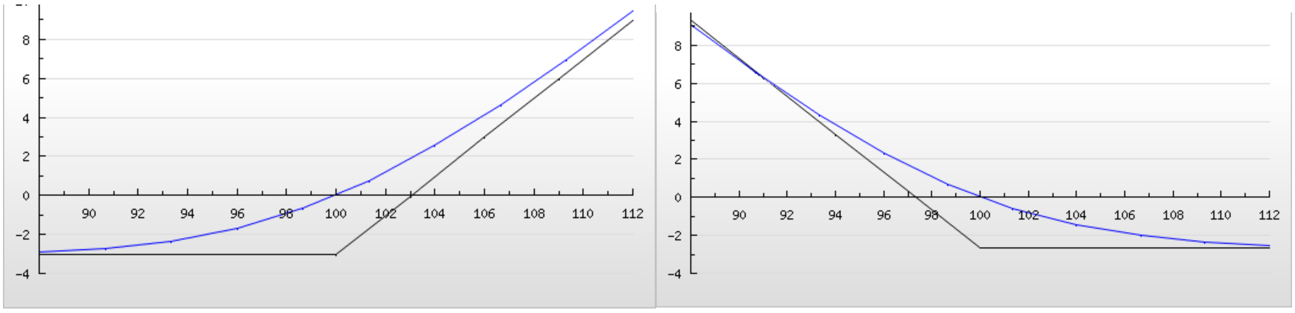


Figure 13 and 14: The call (left) and put (right) with the blue line as intrinsic value and the black line as time (Option-Price, 2017)

The option will only be applied if the intrinsic value is positive. At that moment the option taker has the following possibilities: he wait (with a call option) or he applies the option. If the intrinsic value is at the end of the maturity zero, the option taker will expire the option. The profit is the difference between the value of the intrinsic value and the premium price of the beginning. If he applies the option he loses as maximum the payed option premium. The variables time and interest should be included in that calculation because of the time difference between beginning and end of the period.

There are several methods to calculate the value of an option. The most used method is the Black & Scholes option model (Black & Scholes, 1973). The reason for this method is because of the independency of risk and also the risk-aversion. This model will be used by worldwide stock exchanges to calculate the value of the options. The disadvantage of the Black & Scholes method is that it is only applicable for European options and the volatility is constant during the maturity. The big advantage of the method is the possibility to calculate in continues periods and are not dependable of discrete periods. But this model is not understandable for non-mathematics. Therefore, the mathematical calculations won't be explained in this research.

Within the real options method there are three different approaches defined by Miller & Park (2002): discrete- and continuous-time approach. The multinomial lattices constitute the discrete-time approach and closed-form equitation's, stochastic differential equitation, and the Monte Carlo simulation compromise the continuous-time approach. In figure 15 below are the different approaches displayed with their advantages and disadvantages. The approaches are selected for general finance investment decisions and not in particular for the real estate.

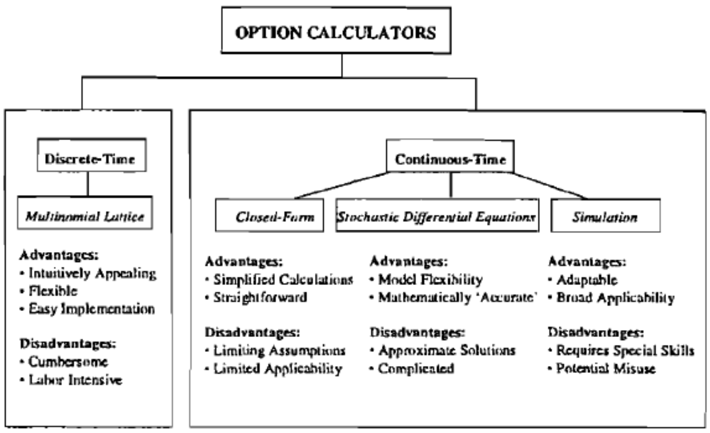


Figure 15: Numerous Real option approaches for option calculation (Miller & Park, 2002, p. 117)

The discrete time approach can be compared with a dice. The options on a dice are fixed and there is not an intermediate value like 3,5. This is the same in the multinomial lattice, in this research the decision tree. The most important issue in the calculation is the risk-neutral approach to determine the value of an option.

Suppose there is the possibility to choose between an amount of 40 euro now or after throwing a coin with 50% chance on 100 euro. A risk-averse person would should for 40 euros now and a risk-seeker would try the coin with 50% chance for 100 euros. The risk-neutral person wouldn't matter if the expected value and the current value are the same. Then there is the possibility to make use of a risk-free interest rate. This will be used in the Real Options Analysis. The cash flows with a high risk will be neutralised and corrected by the cash flows with a risk-neutral probability. Afterwards the option will be valued.

4.6 DCF vs. DTA vs. ROA

The different methods are explained with all the advantages and disadvantages so now the essential differences can be formulated. The DCF model has a discount rate that includes the possible growth in value over time and includes the projection of future revenues, expenses and net operating income over an assumed holding period. The more values are assumed, the more sensitive the estimated value will be to errors. The problem of the DCF model is the usages of past rent levels to calculate future income. This result most of the time in a non-realistic market value.

ROA is based on the risk of the underlying value, defined by volatility, what is the result of the market specific risks. The market specific risks cannot be valued with the ROA, because of the bandwidth of different possible outcomes. DTA is only focused on a certain package of outcomes related to a possibility chance. ROA won't calculate the most valuable path but value the package of possible option within a bandwidth of outcomes. This is illustrated in the figure below (Vlek et al., 2015):

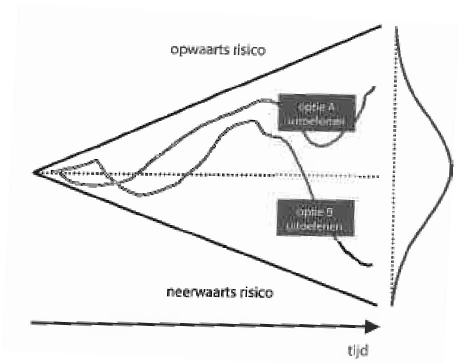


Figure 16: ROA and the uncertainty within a bandwidth (Vlek et al., 2015, p.164)

In figure 16 is the uncertainty displayed within a bandwidth of upward and downward risks. The curve at the right of the figure shows that extremes are less present in comparison with the values in the middle. In the option calculations will this result in a decision tree. The winding line in the figure give a possible path in time. The path that will be chosen is unknown. But there are some options that will be applied if a certain condition will accomplished. From that moment more information will be available. These options will be valued. This is different in comparison with the DTA which are only based on chances. If there is no volatility the winding lines will be horizontal and a DCF model is enough. This will be the same if there are no options.

In this research the methods ROA and DTA will be combined. This will result in a model with DTA outcomes dependable on specific risk combined with the outcomes of ROA. A simple figure is shown below to explain the combination of the two methods.

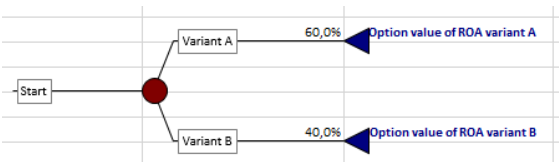


Figure 17: Combination of the DTA with values of ROA

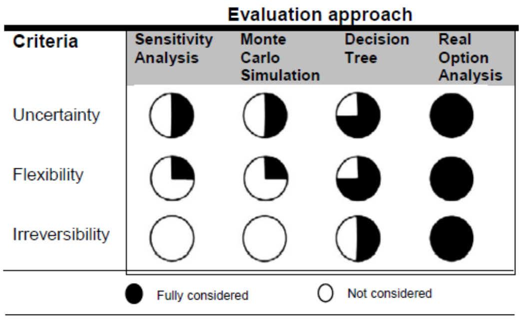


Figure 18: Risk and uncertainty considerations of evaluation (Hulsmann, Grapp & Wycick,, 2007)

In the figure above a summary of what is considered in the different approaches. There can be concluded that the Real Options analysis are taking full consideration of uncertainty, flexibility and irreversibility in a calculation.

4.7 Monte Carlo Simulation

The Monte Carlo simulation is a simulation technique to asses all kinds of scenarios by using the computing power of random numbers. In a simulation are 5000 iterations. Every iteration will start with different parameters selected with randomness. The parameters are based on the analyses that result in data and assumptions. The outcome of the simulation is a certain possibility and likelihood of 95% what the NPV of the real estate investment would be.

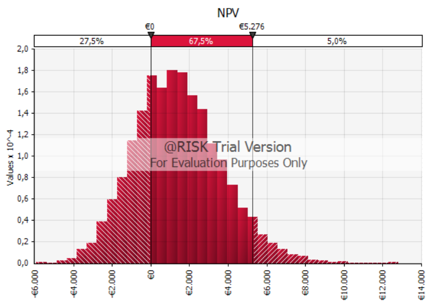


Figure 19: Example of outcome Monte Carlo Simulation (own ill.)

However, the Monte Carlo Simulation has some disadvantages. In the calculations of Monte Carlo is no human intervention implemented. In the current DCF model is most of the time calculated to ten years in the future. In the 5th year as a crisis occur the investor could decide to sell his property, but this is not included in the simulation. In the Monte Carlo Simulation will be calculated to the tenth year. This result in a big loss for the investor. In the figure below is displayed in the black circle that these calculations are not realistic.

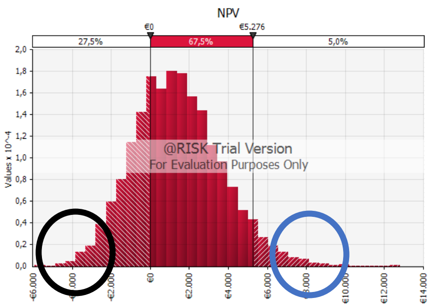


Figure 20: Negative and positive result of Monte Carlo Simulation (own ill.)

Also in the most positive calculations of the Monte Carlo Simulation there is a disadvantage. The investor will probably want to sell it earlier when there is an up market and there is an opportunity to sell it before the market will change. Again, this is not possible because of the simulation is based on ten years. In the blue circle of figure 8 are the positive results presented.

Sensitivity analysis

At a certain moment when the financial model calculated different scenarios it is necessary to do a sensitivity analysis and compare it with the preconditions of the initiator. It considers if the scenarios are effective to use and applicable compared with the chance that the demand of users is changing. Every scenario should be tested if it is applicable compared with the chance and impact. The Monte Carlo simulation will do these sensitivity analysis 5000 times what will result in a tornado figure below. This figure shows the most sensitive parameter. Based on this information there can be anticipated if the parameter changes during time.

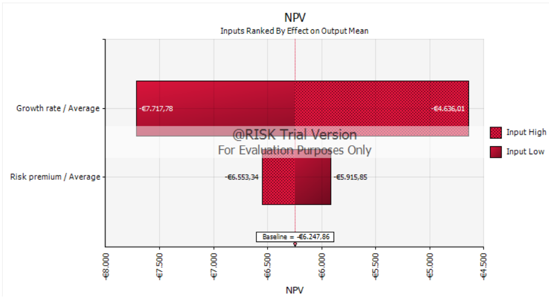


Figure 21: Tornado diagram for sensitivity analysis (own ill.)

Uncertainty

The investor deals a lot with uncertainty while make the decision of an investment. While doing an investment in a project it is never be certain what the outcome will be. According to (Park & Herath, 2000), who did a research about varying levels of uncertainty, the deviation of investments will depend on uncertainty. The value of an option comes from both the uncertainty of the investment environment and from the decision-maker's ability to take action to make the most of the opportunities created by that uncertainty (Miller & Park, 2002, p. 111). The ROA is to quantify the risk and uncertainty for multiple scenarios by removing some subjectivity and replace it with objectivity based on the market values. The error of uncertainty will be decreased and minimize the need to identify the decision-maker's utility function and the company's risk-adjusted discount rate.

According to (Bolgün & Akçay, 2003) the beginning of the 90's was the start of a big shift in the trading volume in world's financial and real estate markets. There was a big increase due to the fact of globalisation, faster communication and technical advancements. Countries entering international markets and advancements in alternative investment tool to improve the dynamism and competition in markets. In figure 22 the real estate investments projects are examined through time. There can be concluded that a significant rise in risk is the trend in the last decennia. Therefore, the market volatility should be included in the financial model.

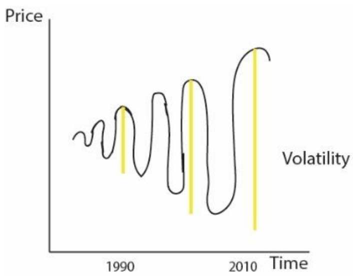


Figure 22: Risk in markets from the 90's to today (Bolgün & Akçay, 2003)

From the perspective of an investor the object is to retain the yield of an object. By retaining the value of a building and attractiveness for the next user, the revenues from the real estate will be guaranteed (Hermans et al.,2014, p.15). The investor sees real estate as the potential future cash flow. A fundamental characteristic of the assets' future cash flow to retain the yield of a building is: location (Geltner, 2006, p.24). The chances of a successful transformation are inextricably linked to the location of the office building. The users demand of the future function, for example housing, is depending on the location. Most of the people are not interested in living at an industrial area full of offices. Therefore, the location and market should be taken into account by the investor and should be included in the financial model.

4.8 Conclusion

The question of this chapter was as follows:

What are the crucial inputs to measure adaptivity and in which of the current valuation methods are these inputs included and what should be added?

From the perspective of adaptivity it is not sufficient to analyse only the investment costs. The positive effects of adaptivity are mostly applicable during the operating phase of the building. The value of adaptivity is measurable when the adaptivity is desired by a change in demand. This can be measured by the rent ability for example.

Hermans et al. (2014) setup an outline for a financial model to calculate the adaptivity in buildings. Therefore, it is necessary to have a quick and effective financial model with the crucial inputs included. The sustainability in a project can be calculated with the different lifespans of a building. The choice between the functional lifespan and the technical lifespan is essential. As stated before it is important to look at the user's value as well as the final value of the building. The initial investment costs are higher but the future value of an adaptive building will be higher as well. At the end of a lifespan there will be a residual value of the building that need to be included in the financial model. Another suggestion is to implement the circular economy in the DCF model.

The comparative model, the cost-based method, the direct capitalization method and the residual method are therefore not applicable. According to Hermans et al. (2014) the DCF method is a possibility but according to Vimpari and Junnila (2016) the use of DCF results is short-sighted decision-making. This won't help to value adaptivity about the long term. Huuhka & Kahdensivu (2016) did a statically and geographic study on demolished buildings. One of their results was that the technical lifespan of a building will be around the 50 years. A short-sighted method is not good enough to value a building with a functionality for 50 years for example. The DCF method is a method that can be used, but has some shortcomings. Therefore, the DCF method will be expanded with the Real Option Analysis (ROA) to value the adaptivity. ROA won't calculate the most valuable path but value the package of possible options within a bandwidth of outcomes. There can be concluded that the Real Options analysis are taking full consideration of uncertainty, flexibility and irreversibility in a calculation.

There can be concluded that the model should:

- be able make a calculation over a longer time period. So it is taking to account not only the investment costs but also the long term operating costs.
- show the probable uncertainties to reduce the risk for the investor.
- respond on the demand for adaptivity, the transformation dynamics and the user dynamics, by change of the type of user/tenant.

5. The financial model

Reading guide

In the previous chapter the basic valuation model is determined, but disadvantages of the model are also identified. In this chapter the financial model will be further elaborated in combination with adaptivity. The aim is to explain how the financial model works through a case test. The question of this chapter is:

How does the valuation model work to value the adaptive capacity of office buildings?

Firstly, there will be elaborated on the conceptual model of the financial model. This conceptual model is based on the findings in chapter 3 and 4. Secondly, the original case will be introduced with the inputs for the financial model. The original case is calculated in a traditional way with a DCF method but without valuation of adaptivity. Therefore, the calculation will be simulated with exactly the same input and output, but with the financial model of this research and adaptivity scored included. Through the case will be explained what the different decision steps were for the financial model. Afterwards, when the traditional way is explained, there will be some additions on the traditional way of calculating to illustrate the effect of a different way of calculating on the valuation of adaptivity. Finally, the outcome will be presented and can be concluded what the addition of the model in the valuation of adaptivity is.

5.1 The conceptual valuation model

In figure 23 is the conceptual model displayed of the financial model. The financial model is based on the step by step plan of an investor in adaptivity in combination with the different findings of the last chapter about the financial methods.

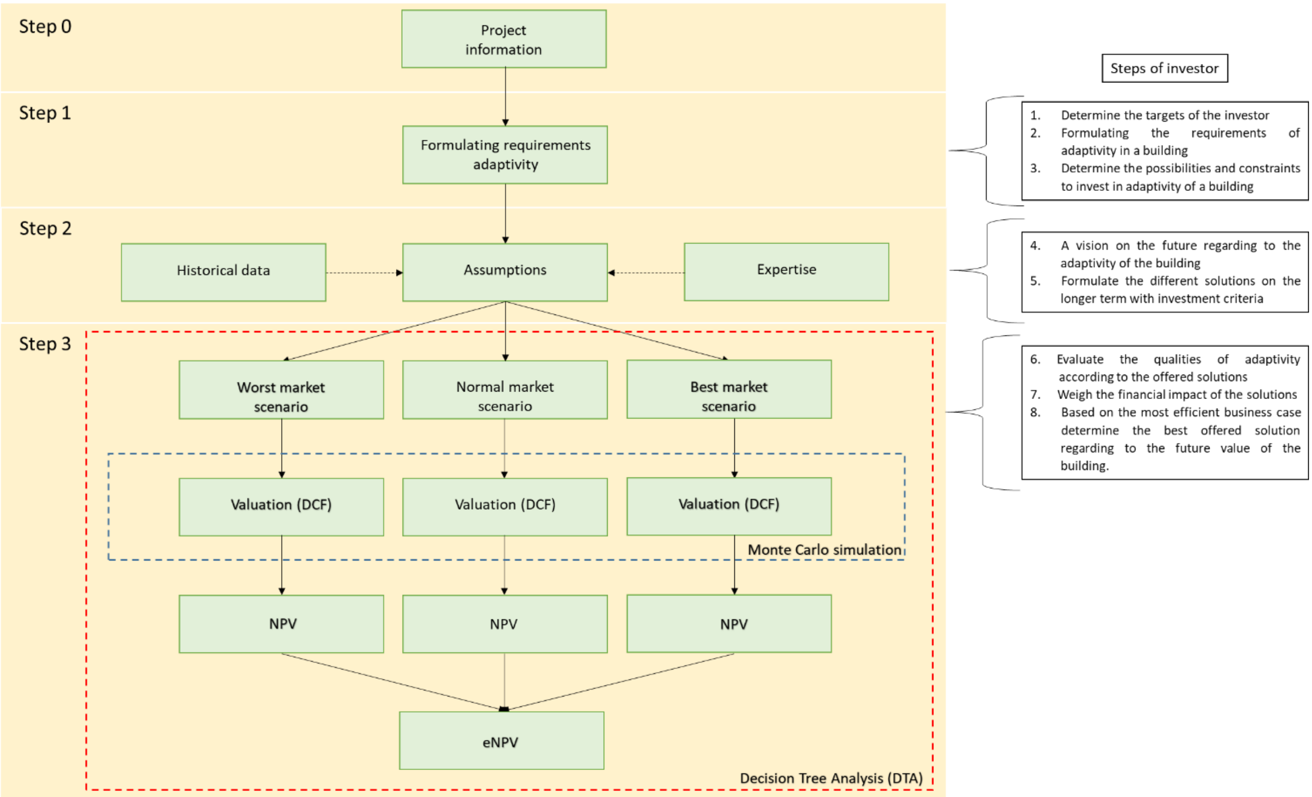


Figure 23: Conceptual valuation model (own ill.)

According to the step by step plan of the investor in paragraph 4.1 the investor will start with determining the targets and requirements for a building related to adaptivity. Therefore, the project information is called step

0. Step 1 is formulating the requirements for adaptivity in the building. Afterwards, the investor will use the historical data and his expertise to do assumptions for the calculation. These assumptions are his input for the valuation with the DCF method in step 3. The investor sets up some scenarios and for each scenario a different DCF will be calculated, resulting in a Net Present Value (NPV). Normally, a DCF calculation will be calculated once per scenario, but in this financial model the calculation will be based on stochastic values. To make it a stochastic calculation the DCF calculation will be done 5000 times for each scenario. Every DCF calculation of these 5000 different calculations results in a NPV. The mean of the 5000 different NPVs of each scenario will be used in the Decision Tree Analysis (DTA). The aim of the DTA is to simply the different scenarios in one model and determine an optimum from the different scenarios. The different scenarios could be even split by probability or one scenario is more likely than others. In the DTA the Real Options Analysis will be used to calculate the different options to one expected Net Present Value (eNPV).

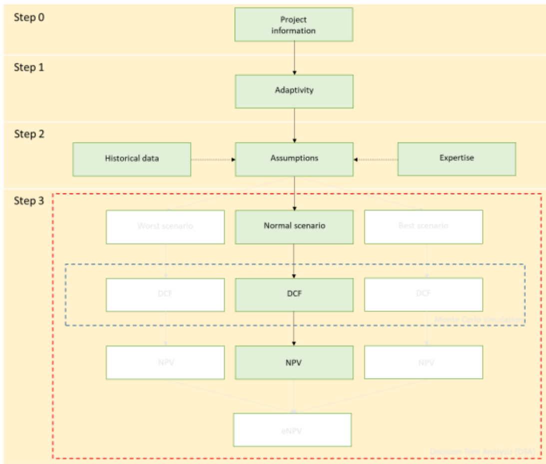
In the next paragraphs will be explained by a case which inputs are required, which assumptions are made in the model, how the model works in throughput and what the outcome is. The conceptual model will be the guideline to understand what is happening in the financial model.

5.2 The original case

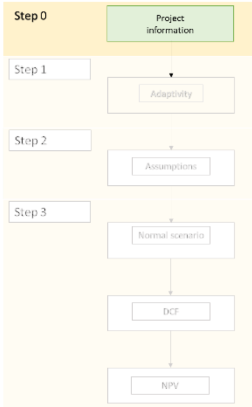
A case study research is concerned with the complexity and particular nature of the case in question (Bryman, 2012, p.66). In this research it is about the adaptive capacity of an office building that should be valued. The complexity with adaptivity is that every office building has a certain level of adaptivity. To conclude if a building is more adaptive in comparison with the another design it should be compared with each other. Therefore a critical case is needed that had already an outcome and conclusion about the adaptive capacity of the building. Hence, it is possible to improve the adaptivity. According to Bryman (2012) a critical case is chosen on the grounds that it will allow a better understanding of the circumstances in which the hypothesis will and will not hold. In the case is concluded that a certain level of adaptivity will affect the future value, but to understand this the financial model of this research is needed to explain it. Therefore, the requirements for the case from practise are:

- The case is an investment in an office by an investor with a long term horizon.
- The case is in the initiation phase where multiple scenarios of flexibility are available with a certain risk.
- The case is concluded with a final advise about flexibility. If there are no outcomes it is not possible to test the financial model and say more about the adaptivity investment.
- The case contains one building or multiple exact the same buildings.

Based on these requirements a certain case is selected that meet all of the requirements. The description of the case and the calculation will follow the conceptual model. The case is calculated in a traditional way and therefore the highlighted steps in the financial model will be explained. Afterwards, the additions of the financial model will be explained.



Step 0: Project information



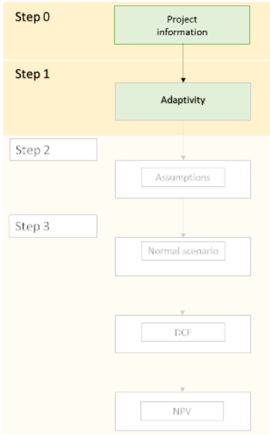
The case is situated in Bergen op Zoom, North-Brabant region, in the Netherlands. It was initiated by investor X and proposed to advisor Brink Groep in 2011. This project consists of one building, which were owned by company X. The investor had the question how to cope with the financial consequences of building a flexible building in comparison with a traditional building. Normally, location aspects are very important for the valuation of a real estate object but in the case it is not taken into account because of the fixed development plan. Therefore is the outcome simplified from the reality. However, the outcome gives a realistic view on building flexible in comparison with building traditional. The first tenant was contracted for 15 years what resulted in a vacancy rate of 0% for the first 15 years. After the 15 years contract, they didn't calculated with a vacancy rate as well. The investor has no uncertainty about a new tenant over 15 years.

Figure 24+25: Location (Google maps, 2017) & Office building "de Schelde" (Vrederust, 2017)

Information about the case formulated by investor X	
Function	Office
Year of production	2011
Size (GFA)	2628 m2
Number of floors	3
Monumental status	No
Plot size	2000 m2
Purchase costs land	€400.000,-
Current tenant	GGZ West North-Brabant
Expire date tenant	1-1-2026 (15 years)

This information will be the input for the financial model. Based on the table above the first tenant was a certainty for the first 15 years. After the contract expires the function of the building is not certain. Therefore, the next step is to determine what the adaptivity of the building is, especially for the period after the expire date of the tenant.

Step 1: Formulating adaptivity within the case



The adaptivity in the case is implemented for flexibility in the period after the expiration of the contract of the tenant. The investor demands a building that could be flexible for different functions in the future. Therefore, the advisor and the architect made some different designs for other functions and calculated the costs for the transformation for those functions. In this case the investor didn't set up specific requirements for adaptivity. It was a test case for the investor what the difference of costs are if the investment is higher in the beginning and a lower transformation costs instead of the traditional way of building.

The adaptivity in this case wasn't scored by the advisor, so therefore the adaptivity score is filled in for them. According to chapter 3 the total adaptivity score consists of the model of Geraedts (2015) and the location indicators combined. Together these scores will be used to score the adaptivity of all the scenarios.

The first part of the total adaptivity score is about the location indicators. In this case is the location fixed instead of flexible and therefore is the location score the same for every future function in the building. In the table below are the different indicators scored.

		Location indicators	
LAYER	SUBLAYER	Flexibility Performance indicator	Score
Development plan	Development plan functions	Possibilities to change functions in development plan	4
	Vision municipality	Structural vision of the municipality	2
Facilities	Parking	Distance to parking facilities	4
	General	Amount of facilities nearby (within 500m)	1
	Public transport	Distance to public transport	1
	Accessibility by car	Distance to main road by car	4
Surroundings	Air quality	Air quality in surroundings	2
	Daylight	Obstacles for daylight in surroundings	2
	Noise	Noise in surrounding of the building	3
	Wind	Wind nuisance	3
	Public safety	Safety in the surrounding of the building	4
TOTAL			30

Figure 26: Location score for the case (own ill.)

Most of the scores can be related to the project information. For example the possibility to change function in the development plan. This was a demand from the investor. The layer facilities can be explained by the map in figure 26. Interestingly, only the facilities by car are very good. This may affect other functions on the future. The surroundings scored moderate, except for the public safety that scored the highest possible score. This could be positive for the future function housing for example.

The second part of the total adaptivity score is about the adaptive indicators related to the building. By Geraedts (2015). The adaptive score for the building is related to the function of the building. As stated before is the function of the first 15 years in the case office. After those years the function could be every function. Hence, to prevent too much tables with all the different adaptivity scores the focus will be on the transformation from office to housing. This transformation option is one of the calculated options in the original case. The calculation and the scoring method will be the same for the other functions. Currently, housing is probable the function with the highest demand in the future in the Netherlands and suitable for this location (ABF research, 2018). In the table below is the adaptivity of the case based on the project information and calculations of the case. There is a distinction in the score between the traditional and the flexible way of building due to the demand of the investor. The weighting of the indicators are for both options the same, because the focus of the investor is on the cost comparison.

		TRADITIONAL					FLEXIBLE				
#	Indicator	Weighting		Assessment value		Score	Weighting		Assessment value		Score
1	Surplus of site space	1	x	4	=	4	1	x	4	=	4
2	Surplus of building space / floor space	2	x	2	=	4	2	x	2	=	4
3	Surplus free of floor height	3	x	2	=	6	3	x	4	=	12
4	Access to building: location of stairs, elevators, core building	2	x	1	=	2	2	x	3	=	6
5	Surplus of load bearing capacity of floors	3	x	3	=	9	3	x	4	=	12
6	Extendable building / Unit horizontal	3	x	2	=	6	3	x	4	=	12
7	Extendable building / Unit vertical	1	x	3	=	3	1	x	4	=	4
8	Dismountable facade	3	x	2	=	6	3	x	3	=	9
9	Customisability and controllability of facilities	2	x	2	=	4	2	x	3	=	6
10	Surplus of facilities shafts and ducts	2	x	2	=	4	2	x	3	=	6
11	Surplus capacity of facilities	3	x	2	=	6	3	x	3	=	9
12	Disconnection of facilities components	2	x	2	=	4	2	x	2	=	4
13	Distinction between support - infill	3	x	2	=	6	3	x	3	=	9
14	Acces to building: horizontal routing, routing, corridors, gallery	1	x	1	=	1	1	x	4	=	4
15	Disconnectible, removable, relocatable units in building	3	x	4	=	12	3	x	4	=	12
16	Disconnectible, removable, relocatable interior walls	3	x	1	=	3	3	x	4	=	12
17	Disconnecting/detailed connection interior walls; hor/vert.	3	x	1	=	3	3	x	2	=	6
				36		83			56		131

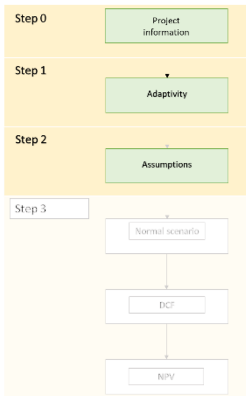
Figure 27: Adaptive score of the function apartment 6x (own ill.)

Some of the indicators are scored the same in the traditional way of building and in the flexible way of building, for example indicator 1 and 2. The reason for this could be that the indicators are related to the location what is the same for both options. The scores of the indicators 3 till 11 are all higher for the flexible option due to the extra flexibility. The only high score of the traditional option is for indicator 15 due to the relocatable units that are implemented as flexible option.

The highest total score possible for adaptivity is 248. The total scores for the traditional and flexible built building are:

	Traditional	Flexible
Location adaptivity score	30	30
Adaptivity score Geraedts	54 +	131 +
	84/248	161/248

Step 2: Assumptions in the case



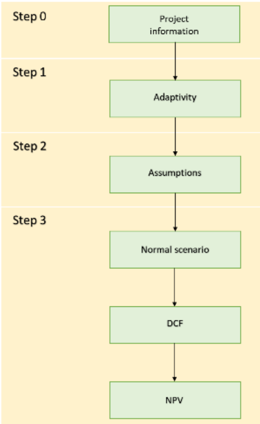
The assumptions of the case are based on the project information mentioned before, the historical data required by market research and on the expertise of the investor and advisor. Based on the project information is known that the first tenant signed for a contract of 15 years. The first 15 years there is no vacancy because of the tenant. After the 15 years the problem is that the function is unknown. Therefore, all different kind of functions and scenarios were taken into account in the case. The advisor made a selection of different functions that were suitable for this location based on logic. The operating time is set on 30 years in consultation with investor X. The transformation will be in year 15 after the contract has expired. The following functions are used as transformation scenario after year 15 (floor plans see appendix 3-a):

- Dementia apartments
- Service apartments
- Healthcare apartments
- School
- Apartment (6x per level)
- Apartment (8x per level)

For every function is a cash flow developed, but due to the readability of this thesis only one of the functions will be scored for adaptivity and valuated. As mentioned before that will be housing. The function apartment with 6 apartments on one level will be further calculated as an example for the other functions. Hence, the transformation from office to apartments is the most common transformation in the Netherlands over the last decade and therefore very useful as an example (Rodermond, 2011).

Based on the historical data, the advisor made some assumptions on different kind of rates, i.e. the inflation rate and vacancy rate. The historical data and the rates are attached in appendix X. The rents of office and housing are also based on historical data and are influenced by the inflation rate.

Step 3: Calculation of the original case



The last step is the calculation to the final NPV's of the traditional way of building and the flexible way of building. The advisor did a financial-economical approach of the different scenarios with after year 15 a transformation to another function. Based on the benefits; the rental income, and the costs; the investment costs, the transformation costs and the operating costs, a DCF calculation is made. Each scenario has his own DCF model and results in a NPV. For the exact numbers the appendix can be read.

The flexibility in the case is translated into extra investment costs in the construction part and lower transformation costs after 15 year. The traditional built option has lower investment costs and higher transformation costs. The actual calculations are showed in the appendix. The cash flow through the years of the flexible and not flexible built option for one function is showed in figure 28. In the next figure 29 are all the function options combined.

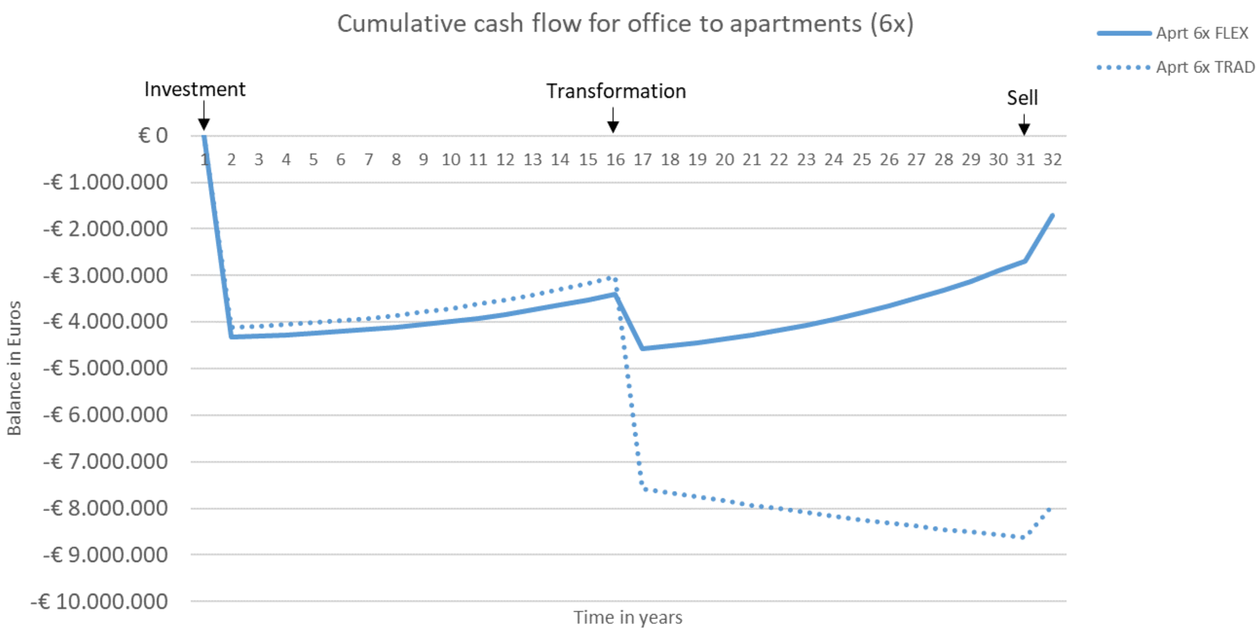


Figure 28: Cumulative cash flow for office to apartments (6x), Brink Groep (2011)

In figure X is the cumulative cash flow shown for office to apartments (6x). There is a distinction made between the traditional way of building (dashed line) and the flexible way of building (solid line). For both scenarios there is a decreasing line in year 1 due to the investment. The investment in the flexible building is higher in comparison with the traditional building. In year 16 there is a transformation to the function apartments (6x). The transformation costs of traditional way of building is much higher in comparison of the flexible way of building. After the transformation the line of the traditional building is even more decreasing. The reason for this is the cumulative cash flow is including the interest. A lower rental income in comparison with the interest result in an even more decreasing cash flow. In year 31 the building will be sold what result in a bit more positive result at the end of the balance.

In the figure below are all the different scenarios combined in one graph. Every scenario has his own cumulative cash flow with a traditional building (dashed lines) and a flexible building (solid lines).

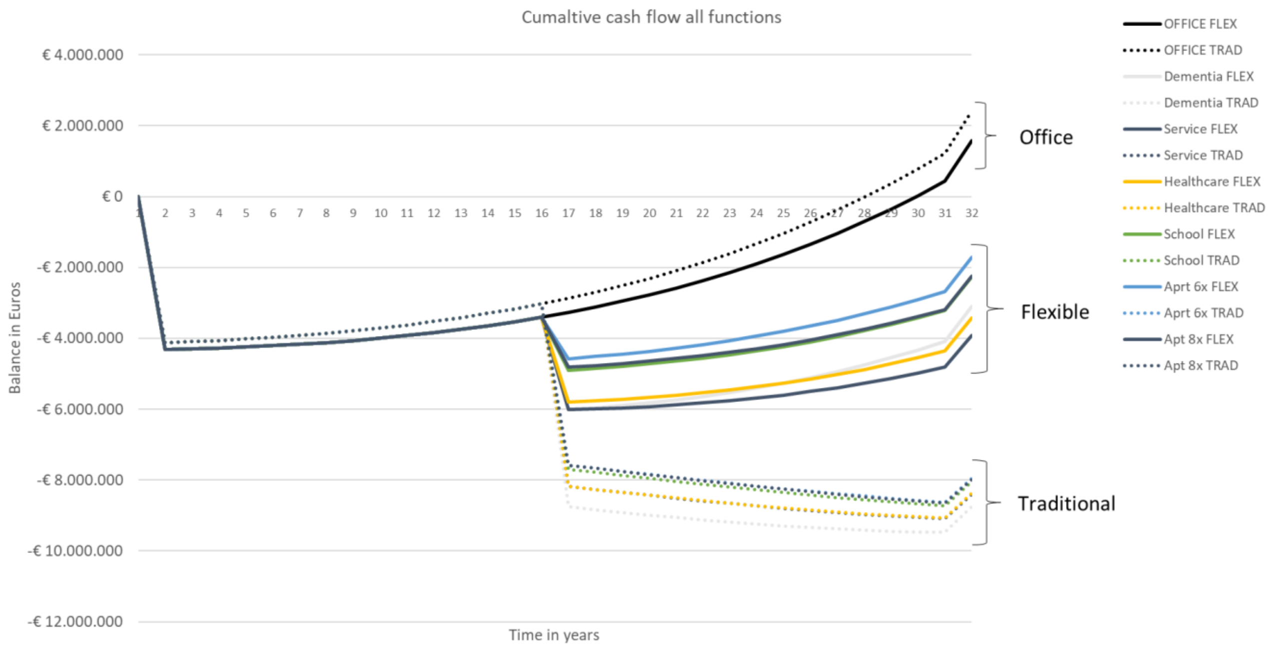


Figure 29: Cumulative cash flow for all the functions (Brink Groep, 2011)

In figure 29 is the behaviour of all the scenarios with a function change in year 16 the same. The flexible buildings have a lower transformation costs and end up higher after 30 years in comparison with the traditional buildings. There is one exception between these scenarios. That is the scenario where there is not a function change. The function of the building will be for 30 years office without any transformation costs included. The result of this scenario is that both, the traditional and flexible buildings, ending higher after year 30 in comparison with the other scenarios and even positive. The biggest difference is that the traditional way of building ends up higher instead of the flexible option. In all the other scenarios the flexible option ended higher. This result can also be noticed if the balance results between the different scenarios will be compared:

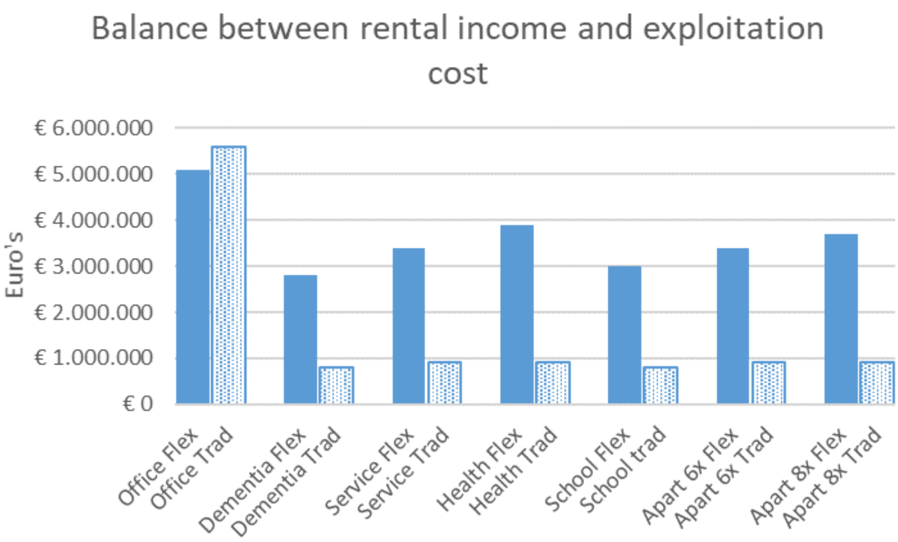


Figure 30: Financial overview all functions (own ill.)

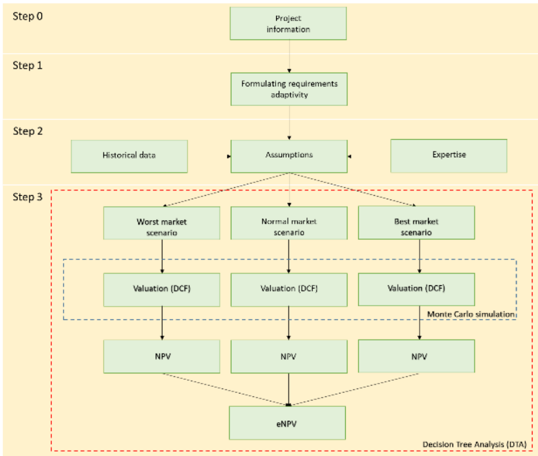
In figure 30 is the same remarkable result notable. The balance between income and costs are always higher for the flexible buildings in comparison with the traditional building in the transformation scenarios. The reason for this is the extra investment in adaptivity in the flexible building but the option to transform is not used. In the scenario where office stays the function the balance of traditional is higher in comparison with the flexible option. The reason for this is that the flexible building more expensive in comparison with the traditional building. The same applies to the yield.

Based on the motives to invest in flexibility would the commercial investor probably choose for the traditional way of building and no transformation to another function. This option has the highest balance and therefore the highest yield. If this calculation will be done with stochastic numbers it will probably give another outcome.

Conclusion

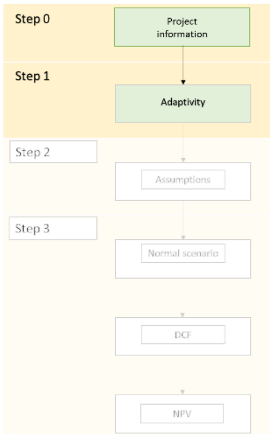
The results of the original case are showed and observed. Important to notice is the negative net present value at the end of all the calculations. However, the yield and balances are all more positive for the flexible building in comparison with the traditional building except for the not transform option. The question is if the financial model of this report could show a positive NPV for a flexible building. The advice of the advisor wasn't about the highest NPV option, but only to show the financial consequences of the different building options. Depending on the expectations of the investor for the future they should decide in what kind of option they want to invest.

5.3 Stochastic part



In this paragraph all the different additions to the calculation method will be explained step by step. Step 0 with the project information will be the same, because the same case will be used. Therefore, it is not mentioned in this paragraph. The adaptivity score will also be the same, because nothing changes in the location of the design of the building. However, it is possible to optimize the adaptivity score when the indicators are quantified. The assumptions will be complemented with some more input variables. The final step with the calculation will be stochastic with 3 scenarios and using the Monte Carlo Simulation and Decision Tree Analysis. Finally, it results in an expected Net Present Value (eNPV). This can be compared with the other NPVs of the original case.

Step 1: Quantifying adaptivity



In the original case the adaptivity is scored for the function office to apartments (6x), for traditional building and flexible building. However, to calculate the adaptivity score certain investment and transformation costs are related to the score. These costs depending on the level of adaptivity. In the original case the adaptivity is randomly defined by the advisor. The advisor didn't use a table to determine the level of adaptivity. In this thesis the table of Geraedts (2015) is used to define the adaptivity. The problem is that the table is qualitative instead of quantitative. As mentioned before are investors focussed on a yield and want to understand why they invest extra in adaptivity. The flexible building is more adaptive than the traditional building but are the investment and transformation cost reasonable in comparison to the level of adaptivity. Therefore, there is an addition to the model of Geraedts (2015) to optimize the adaptivity score with a minimum investment.

The optimization of the adaptivity score will be done by linear modelling. The FLEX 2.0 light method of Geraedts (2015) is the basic for the input of the linear model. The adaptive indicators are numbered, weighted, limited and minimalised by the FLEX method. The addition to the model of Geraedts (2015) of this thesis is to make the method quantitative. The advantage of a quantitative method is that it is adjustable and optimisable. By using the knowledge and expertise of the internship company and the given calculations of the case it is possible to make it quantitative. In three steps will be explained how to make the adaptive score quantitative.

The first step to make it quantitative is to define the costs of investment and transformation in comparison with a non-flexible building. A non-flexible building can be defined as a building with the lowest score possible for the method of Geraedts: 40 (every indicator score 1, times the weighting). The investment and transformation cost related to this building can be assumed by using the “Kengetallenkompas Bouwkosten” (De Groot, 2013). In combination with the adaptivity scores and the investment and transformation costs of the case, a graph can be made (see figure X).

The second step is to make the adaptivity score a percentage to illustrate better to the investor what the adaptivity score is. The percentages are calculated by using the adaptivity score and divide that by the maximum adaptivity score for a building. In the figure below is the linear line of the investment costs related to the percentage of adaptivity.

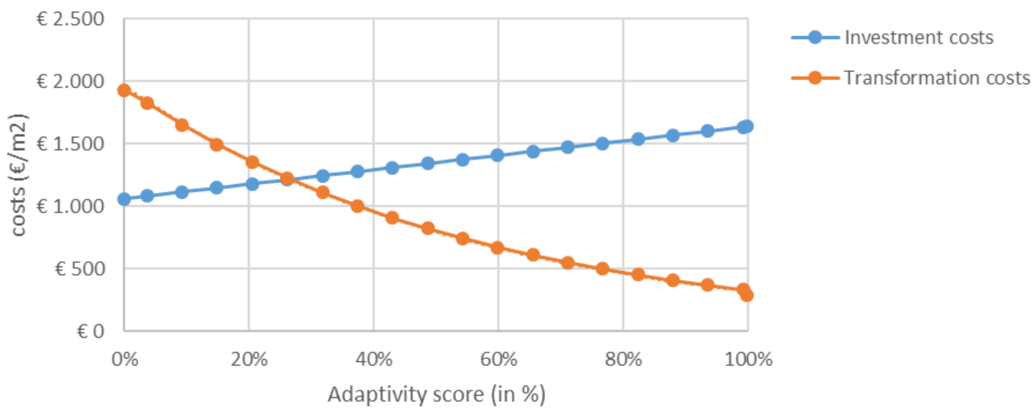


Figure 31: Investment and transformation costs related to adaptivity percentage (own ill.)

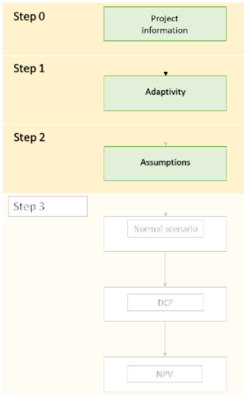
The third step is to relate the costs to the different indicators. Every indicator in the list of Geraedts (2015) is numbered with an extra cost per step. This list with costs related to the indicators is attached in appendix 2-b. Afterwards, the adaptivity scores of the original case can be used to understand what the extra costs are. In the figure below the adaptivity score of the original case is used. There are two additions in this table. The first one is that the adaptive score is translated to a percentage (orange box). The second step is that every indicator score has an extra investment cost attached. All the extra costs summed together give a total extra cost (yellow box) related to an adaptivity percentage.

		TRADITIONAL							FLEXIBLE					
#	Indicator	Weighting		Assessment value		Score	Extra cost %		Weighting		Assessment value		Score	Extra cost %
1	Surplus of site space	1	x	4	=	4	10%		1	x	4	=	4	10%
2	Surplus of building space / floor space	2	x	2	=	4	4%		2	x	2	=	4	4%
3	Surplus free of floor height	3	x	2	=	6	0%		3	x	4	=	12	30%
4	Access to building: location of stairs, elevators, core building	2	x	1	=	2	0%		2	x	3	=	6	8%
5	Surplus of load bearing capacity of floors	3	x	3	=	9	8%		3	x	4	=	12	15%
6	Extendable building / Unit horizontal	3	x	2	=	6	2%		3	x	4	=	12	8%
7	Extendable building / Unit vertical	1	x	3	=	3	2%		1	x	4	=	4	3%
8	Dismountable facade	3	x	2	=	6	3%		3	x	3	=	9	9%
9	Customisability and controllability of facilities	2	x	2	=	4	1%		2	x	3	=	6	2%
10	Surplus of facilities shafts and ducts	2	x	2	=	4	1%		2	x	3	=	6	2%
11	Surplus capacity of facilities	3	x	2	=	6	0%		3	x	3	=	9	2%
12	Disconnection of facilities components	2	x	2	=	4	0%		2	x	2	=	4	0%
13	Distinction between support - infill	3	x	2	=	6	6%		3	x	3	=	9	12%
14	Acces to building: horizontal routing, routing, corridors, gallery	1	x	1	=	1	0%		1	x	4	=	4	2%
15	Disconnectible, removable, relocatable units in building	3	x	4	=	12	5%		3	x	4	=	12	5%
16	Disconnectible, removable, relocatable interior walls	3	x	1	=	3	0%		3	x	4	=	12	5%
17	Disconnecting/detailed connection interior walls; hor/vert.	3	x	1	=	3	0%		3	x	2	=	6	2%
				36		83	41%				56		131	116%
						41%							64%	

Figure 32: Adaptivity score case with extra costs (own ill.)

The last addition of this thesis to the method of Geraedts (2015) is to relate the adaptivity score to the NPV and optimize the adaptivity score with a maximum NPV. With the optimization model it would be possible to optimize the adaptivity score and minimalize the costs. This prevents unnecessary investments in adaptive indicators to score higher and the investor will benefit from the advantages of the adaptive capacity in the future. To determine the NPVs a DCF model is needed to value the adaptivity. This will be explained in the next paragraph. Firstly, some more assumptions will explained.

Step 2: Other input variables



In the original case the advisor calculated with deterministic variables based on historical data and expertise. Some examples of these variables are the inflation rate and the interest rate. These variables are fixed and don't change in the future. The financial model of this research uses stochastic values. Therefore, for every variable a standard deviation, an average, a minimum and a maximum is determined based on historical data. Besides the input variables of the original case calculation there are some extra variables to determine more accurate the expected NPV. In the financial model are the following variables determined as uncertainty variable:

- Vacancy growth rate (function specific)
- Inflation rate (CPI)
- Log rent price changes (function specific)

The vacancy rate is added because of the uncertainty over 15 years instead of the original case. The inflation rate will be simulation of the 5000 different to determine more exact the NPV. The same applies for the house and office log rent price changes. The house and log rent prices are the logarithm of the historical data of rent prices. To prevent non-realistic outcomes, the variables are correlated to each other.

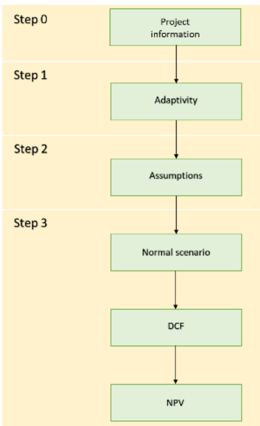
For example if there is a negative growth rate, the economy is shrinking what affects the willing to invest by investors. The vacancy rate won't increase because of the uncertainty at the market. Thereafter, there is a relation with this uncertainty and income of rents, direct costs, building costs, etc. Eventually, the income will decrease and the costs will increase.

The following variables are correlated with each other:

@RISK Correlations	Average / log rent price chang	Average / NL House rents in $	Average / Vacancy Rates in L	Average / CPI in I13
Average / log rent price changes in F13	1			
Average / NL House rents in C30	0,53	1		
Average / Vacancy Rates in L13	-0,44	-0,34	1	
Average / CPI in I13	-0,79	-0,32	0,25	1

Figure 33: correlations (own ill.)

Step 3: Stochastic calculations



The latest step in the financial model is to calculate the actual eNPV. As stated before is the eNPV based on different scenarios. Besides the scenarios per function, there are also scenarios for a good, moderate and a bad market. The markets are defined by the different variables. If it is a good market, there is a higher demand for functions and therefore the vacancy is low and the inflation a bit higher in comparison with a bad market. The moderate market is the current market with the variables used by the original case. A weighted average of the scenarios is the eNPV.

With every different market scenario a DCF will be calculated. In these DCFs the stochastic values will be used. Another addition in this process is the Monte Carlo Simulation.

Monte Carlo Simulation

According to the conceptual model the addition to the standard DCF is the Monte Carlo Simulation. In chapter 4 is explained that the Monte Carlo Simulation will be used to multiply the calculations 5000 times and make a sensitivity analysis. The Monte Carlo simulations are calculated by the program @Risk. Every DCF calculation will be simulated 5000 times to generate a mean Net Present Value (NPV).

To show what the affect is of the Monte Carlo Simulation in the case, the scenario with the transformation from office to apartments will be used. Every market scenario has also a DCF calculation. Therefore, only the good market scenario NPV in the figure below:

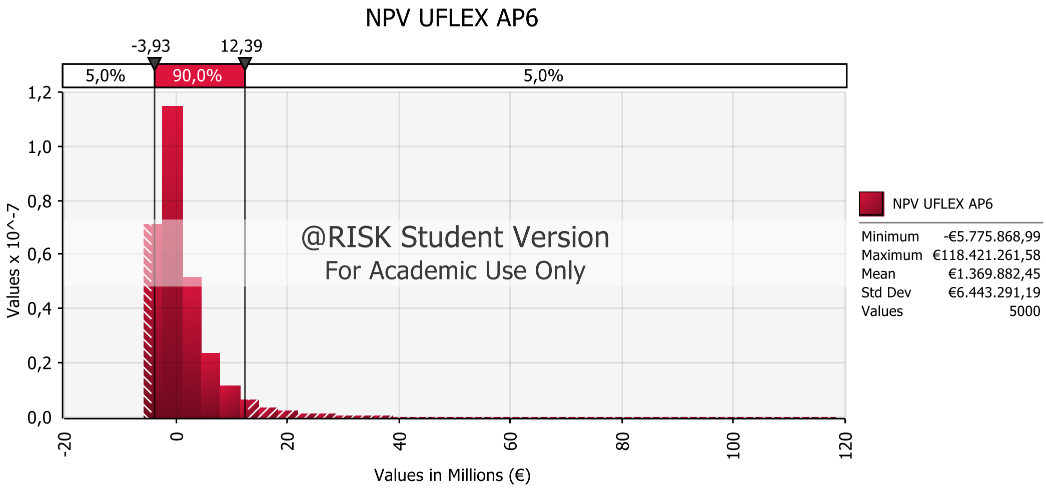


Figure 34: Result of a Monte Carlo Simulation

The results of a Monte Carlo Simulation can be presented in probabilities. For example in this figure the NPV is 90% of the 5000 times between -3,93 and 12,39. In the end, the mean of the Monte Carlo Simulation will be used as NPV in the Decision Tree Analysis.

Together with the multiple calculations, a tornado graph can made with the influence of the different stochastic variables on the NPV. This sensitivity analysis is very helpful for an investor if he needs to decide where to invest in. Again the same scenario and market scenario will be used to illustrate what will happen in the calculation. See figure 35:

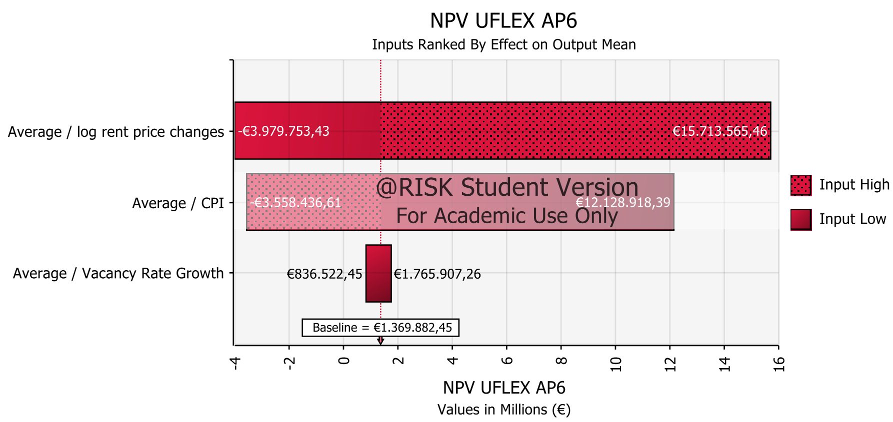


Figure 35: Example of a tornado graph, office to 6 apartments (own ill.)

There are two variables with the most influence on the NPV of office to apartment (6x). The change in rental prices and the inflation. Both of them are affecting the operating costs in the end. The vacancy growth rate is minimal in comparison to the other two variables. If there is a big change in some of those variables in the future the investor could anticipate on that.

The Monte Carlo Simulation is to reduce the uncertainty in a certain calculation. It will show the sensitivity of different variables in relation to each other and the sensibility per variable. As stated before are the market scenario's to simulate the characteristics of a location. However, there are some variables related to the location that are specific related to the building in the current situation and therefore not included in the calculation. An example is the possible changes of a zoning plan by the Municipality. If the Monte Carlo Simulation is done for every function scenario and every market scenario, it is possible to set up a Decision Tree Analysis. This will result in a final eNPV.

Decision Tree Analysis

The decision tree is the latest step in the calculation. Every mean Net Present Value (NPV) of an option that is simulated 5000 times is linked to the decision tree. In the DTA all the previous steps are included. The latest choice in the DTA is to choose between wait or transform. The option "wait" refer to the option to not transform and keep the function of office. In the other option "transform" are all the different functions included. These functions are not all showed because of the focus to show a generic transform option. The exact function is not certain and therefore all the different functions are bundled as the "transform" option. However, every function has its own NPV and probability that it could be transformed to that function. The average of the functions is represented as transform option.

The investor has the choice to invest in of the three options. Two of those options are based on the original case, but are minimalised and minimalised; traditional building (0% flexibility) and a flexible building (100% flexibility). The other option is the optimum option. For this option the adaptivity score is optimized in step 1 by calculating the maximum adaptivity score for several constraints. These constraints could be for example: maximum costs, minimum NPV or yield, less risk during construction time or focussing on only a few functions instead of in general. This optimizer is included in the financial model.

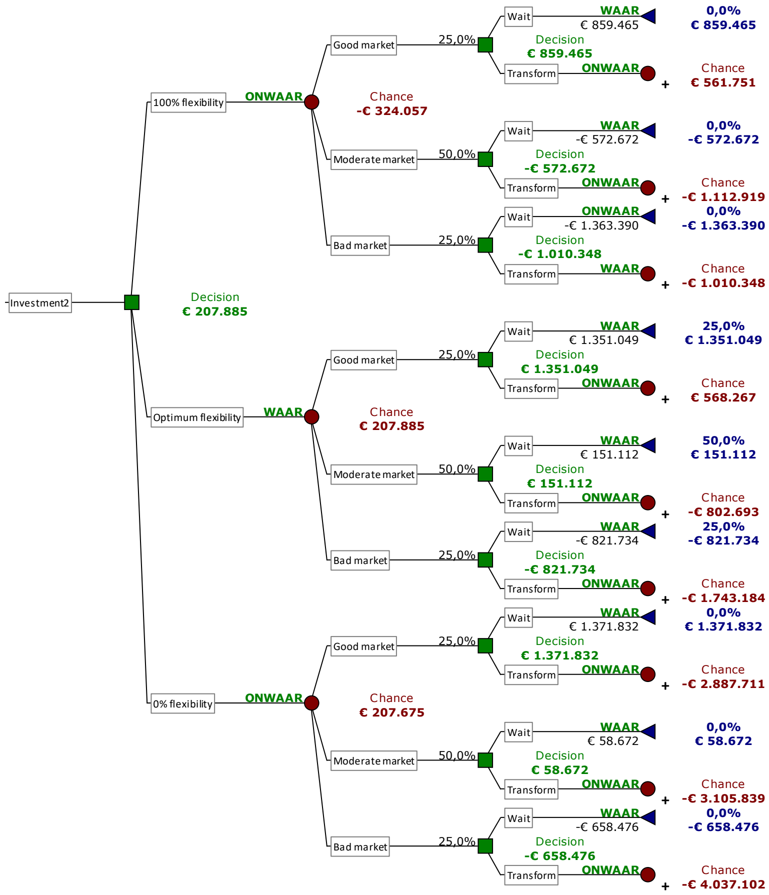


Figure 38: Decision Tree Analysis (own ill.)

In the DTA there are different choices to make. Firstly, it is need to choose between: build 100% flexible, optimal adaptivity flexible or not flexible (traditional). This is marked with a green square what means a decision point in time. Than an event occur, displayed as a red circle. The event could be a good market, moderate market or a bad market. Related to those market scenarios is a probability. The moderate market has a probability of 50% and the good and bad market a 25% probability. The reason for this is that the moderate market is the most applicable for the coming years. Depending on the event there is another choice to make. The choice to transform or not. This is after year 15 as mentioned in the original case. Every function is a choice and shows a certain NPV. The "waar" shows the best option within a decision. The decision tree should be read from right to left. The most right numbers for every option are a result from the DCF calculations from step 3. The end decision value most left in the figure is the eNPV. The ideal path starts from left and follow the tranches with "waar".

Conclusion

The aim of this paragraph was to explain the working of the financial model. This is explained by using a conceptual model as guide line. The original case was calculated with a traditional way of calculation. The additions to these calculations should result in a less uncertainty for the investor to make a decision. The different methods of chapter 4 were very useful as additions to the DCF model for example. In the next paragraph will be explained what the results are.

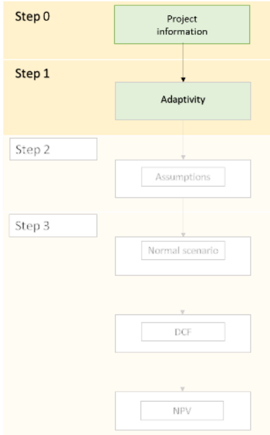
5.4 Results

This paragraph is about the results of the comparison between the original case and the additions of the new financial model. According to chapter 3 the value for a long term investor is a constant income and an actual yield at the end of the investment. The risk or uncertainty of the future is the most important factor for them.

If the risk can be lowered through more transparency by a valuation model it could be valuable for them. Therefore, the results will focus on the core of this research; adaptivity and the uncertainty of the investor.

The results will be presented by explaining differences in yield, risk and adaptivity score related to the case. The structure of the financial model will be used as structure to explain the results. Starting with step 1: optimizing the adaptivity with minimum costs. Afterwards, the optimum will be implemented in the Decision Tree Analysis to show what the expected NPV could be. This will be compared to the original case.

Results of step 1: Optimizing adaptivity score



The investor is focussed on the yield and lower risk for an investment. In the case a random investment in adaptivity was chosen, because they didn’t use a table to score the adaptivity. Therefore, the results are focused on the costs, adaptivity score and yield. The linear program that will be used, named Evolver, part of the @Risk package of Pallisade. In this program the following constraints can be determined based on the model of Geraedts (2015):

- The adaptive indicator score is limited to 4 and a minimum of 1:
  $1 < N_n < 4$
- Each indicator has a weight (1-3), summed up maximum to 51:
  $1x\ N_1\ \&\ 2x\ N_2\ \&\ 2x\ N_n\ \&\ ... \leq 51$
- The adaptivity score is limited to 204
  $1x\ N_1 + 2x\ N_2 + \ 2x\ N_n + \ldots \leq 204$
- The adaptivity score is minimum 17
  $1x\ N_1 + 2x\ N_2 + 2x\ N_n + \ldots \geq 17$

Based on the original case there are three variables that can be optimized: the investment cost, the adaptivity score and the NPV (yield). In this step, there is an optimization of the adaptivity score with the same extra investment costs as the original case, 116%. The result of the optimization is shown in the right figure below. The program found in 9.854 of the total 10.000 tries the optimum score. In total there are 17 different indicators in the model of Geraedts (2015). The first two adaptive indicator scores are fixed because of the location. The other 15 can be optimized.

FLEXIBLE					
Weighting		Assessment value		Score	Extra cost %
1	x	4	=	4	10%
2	x	2	=	4	4%
3	x	4	=	12	30%
2	x	3	=	6	8%
3	x	4	=	12	15%
3	x	4	=	12	8%
1	x	4	=	4	3%
3	x	3	=	9	9%
2	x	3	=	6	2%
2	x	3	=	6	2%
3	x	3	=	9	2%
2	x	2	=	4	0%
3	x	3	=	9	12%
1	x	4	=	4	2%
3	x	4	=	12	5%
3	x	4	=	12	5%
3	x	2	=	6	2%
		56		131	116%
				64%	

Optimal					
Weighting		Assessment value		Score	Extra cost %
1	x	4	=	4	10%
2	x	2	=	4	4%
3	x	2	=	6	0%
2	x	4	=	8	14%
3	x	4	=	12	15%
3	x	4	=	12	8%
1	x	4	=	4	3%
3	x	3	=	9	9%
2	x	4	=	8	4%
2	x	4	=	8	3%
3	x	4	=	12	5%
2	x	4	=	8	2%
3	x	4	=	12	21%
1	x	4	=	4	2%
3	x	4	=	12	5%
3	x	4	=	12	5%
3	x	4	=	12	5%
		56		147	116%
				72%	

Figure 39: optimization score for adaptivity in comparison with the flexibility option (own ill.)

In the left figure the original case is displayed with the flexible option with a score of 131 or 64%. The extra investment costs are 116%. The optimizer shows that a score of 147, or 72%, could be scored with the same extra investment costs of 116%. This is interesting if the investor demands a maximum adaptivity score for a maximum amount of investment. The biggest change in the figures is the change of adaptive indicator 3. In the figure below is shown what the impact is of the extra costs of all the different indicators.

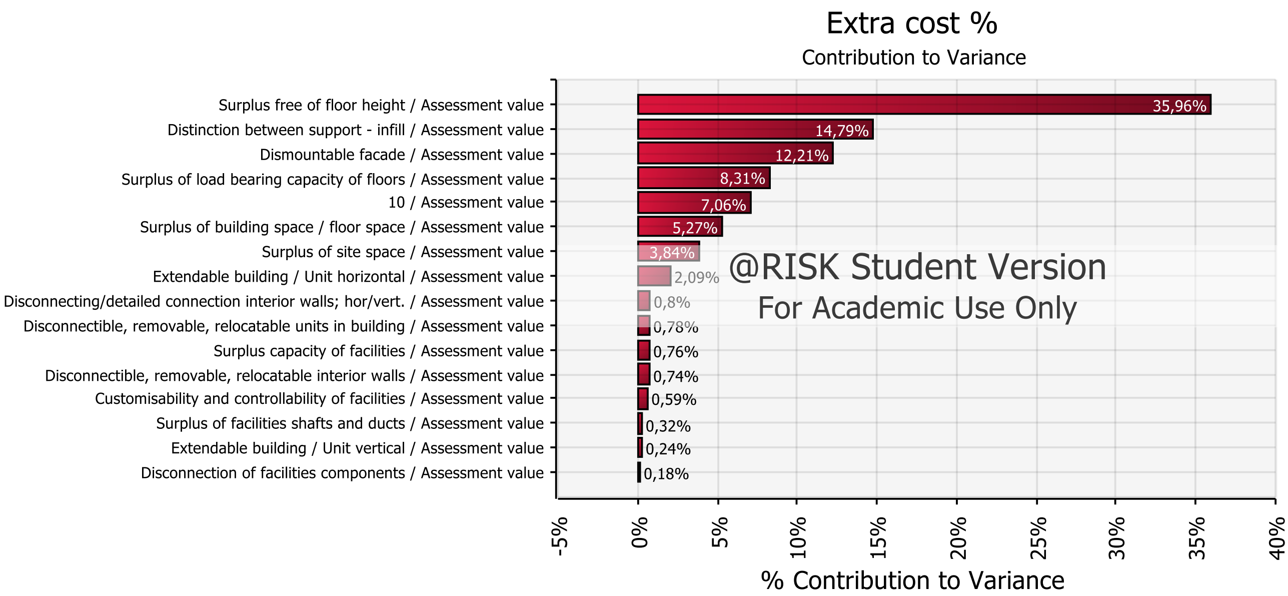


Figure 40: Contribution of indicators to variance (own ill,)

The contribution of the indicator 3, called surplus free of floor height is more as twice as big in comparison with the second indicator with the most influence. This explains the change in adaptivity score with the same investment costs. Another tornado graph shows the impact of the indicators during the extra cost choice.

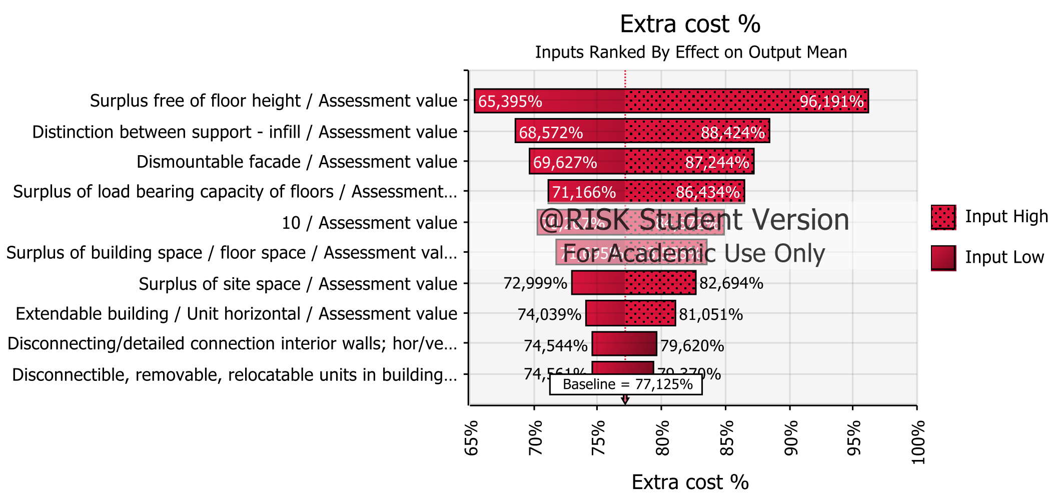
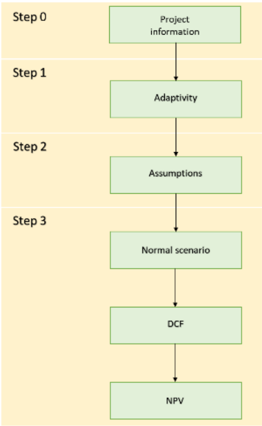


Figure 41: The input of the indicators ranked by effect on the extra costs (own ill.)

Again the third indicator about the surplus of free floor height is higher than all the other indicators. Especially for the extra costs higher than the base of 77,125%, the mean of all the simulations. Indicator number 10 is an interesting indicator, because of the lower rank in the figure but with a higher input on the low extra costs in comparison with the indicators that are ranked higher. This indicator can be used for the lower extra costs.

Another option is if the investor demands the optimum yield of an investment with low investment cost and a high score for adaptivity. In that case the DCF calculation should be used to calculate the NPV and the eNPV. This will be presented in the next paragraph.

Results of step 3: Optimizing NPV related to adaptivity



As mentioned before is the investor focused on risk and yield. The yield of a project is directly related to the NPV of a project. In the case of this thesis there is a certain adaptivity score for the flexible building option. In the previous paragraph, this score is optimized with the same costs. However, every adaptive score is related to an extra costs and therefore also to the NPV of the project. In the figure below is the adaptivity score compared to the NPV of the project in a good market. Again, there is the option office to apartments (6x) used to illustrate what the effects of the adaptivity score has on the NPV. The results of the optimum flexibility in comparison with the NPV:

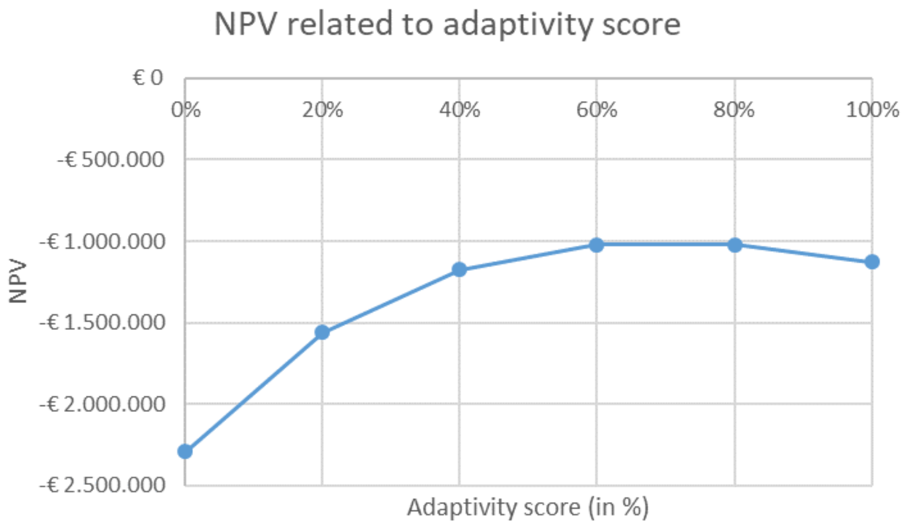


Figure 42: NPV related to the adaptivity score (own ill.)

According to the figure above the NPV is the maximum between 60% and 80% adaptivity. The calculated optimum score of adaptivity strokes with this result, 72%. Important to notice is that the 72% was obtained by optimizing only the investment and transformation costs. In the DCF model the optimization gives a adaptivity score of 67% in a good market. If the optimizer for the adaptivity score will be used in a bad market, the optimization score is 53% and in a moderate market it is 56%. The market effect has a big impact on the adaptivity score. However, the differences in NPVs are small and therefore the 72% will be used as the optimum adaptivity score. In the traditional calculation the optimum score is not applicable.

In the figure below the original case is displayed in Decision Tree Analysis. Firstly, there is the choice to investment in a traditional building or a flexible building. After 15 years the choice is to transform to another function or to wait. This DTA was not included in the original case.

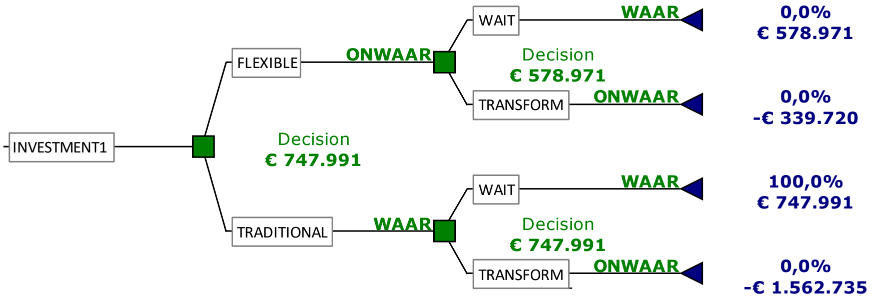


Figure 43: Original case in a DTA (own ill.)

The DTA shows four different NPV's. There are only choices in the DTA without any stochastic values. Therefore, the decision of the DTA shows a Highest and Best Use value, namely the option to build traditional and wait after 15 years. This option has the highest NPV for this moment, but future uncertainties are not included in this DTA. Therefore, the following DTA is made to show a more realistic eNPV. The final tree will show the following eNPV:

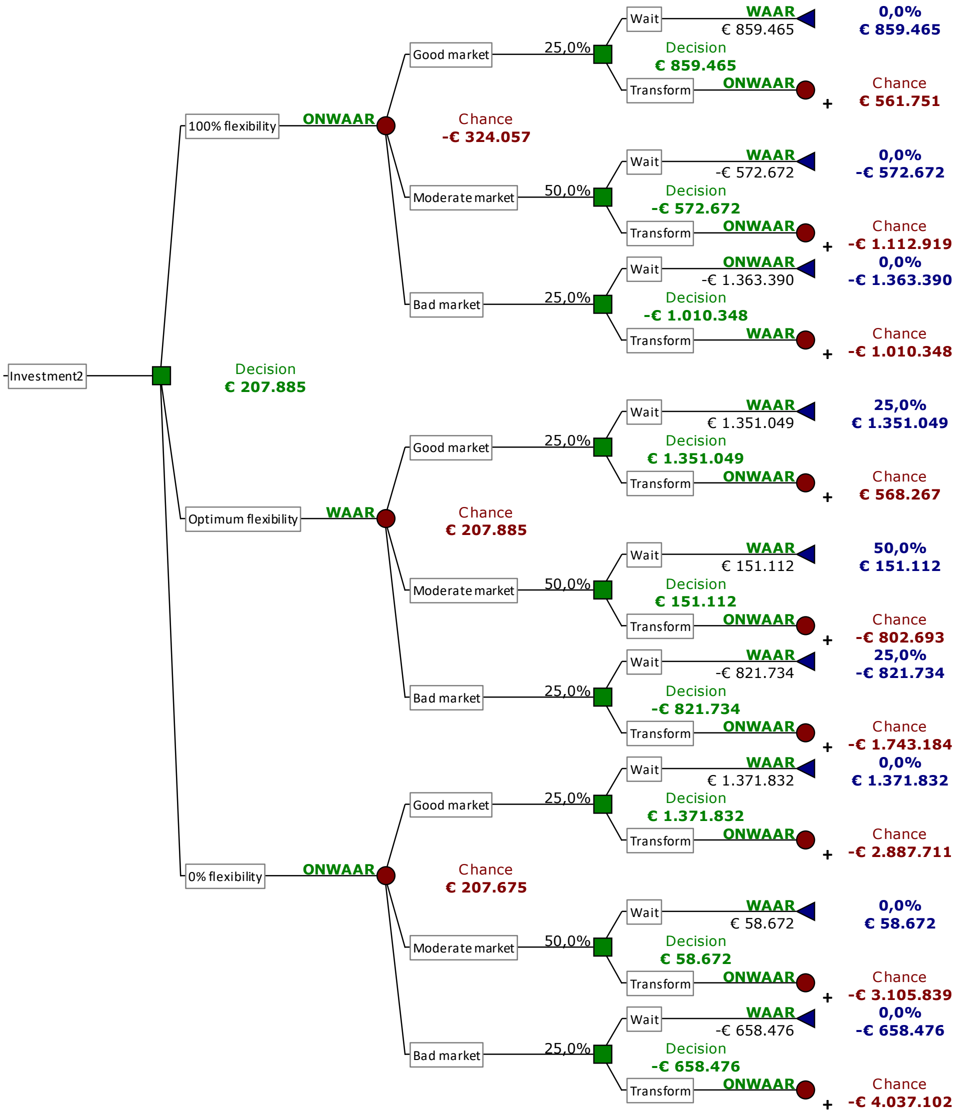


Figure 44: The DTA with additions to the case (own ill.)

In the figure above is the eNPV determined over all the different scenarios. This is the eNPV over the cash flow time of 30 years. Following the "waar" steps from left to right shows that investing in the optimum flexibility is a bit higher in comparison with the traditional way of building. However, the best choice in every scenario is to wait after 15 years except for one option. If the option of 100% flexibility will be chosen and there is a bad market, there can be concluded that the NPV of transformation is higher in comparison with the wait option. This supports the idea that transformation after investment in adaptivity is more effective.

In the table below is the comparison of the retrieved eNPV compared to the original case and the new valuation model. There can be concluded that the stochastic eNPV is much lower in comparison to the original case. This suggests that the original case is much more positive in comparison with the stochastic way of calculation. The risks and uncertainties are les valued in the original way what results in a higher NPV.

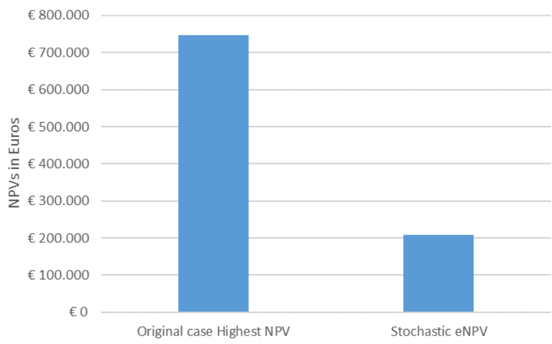


Figure 45: Comparison NPV of the original case with the new calculation (own ill.)

The latest step to test the model is to change the location. The research was mostly focused on the building and showed the necessary location aspects. However, the location of a property is influencing the choice to invest in adaptivity according to chapter 2 and 3. Therefore, the next step is to test if the financial model will work if the location of the case will be changed. The assumptions are based on the historical data, but it is only an indication of the truth. Further research is needed to verify the differences.

On a prime location for offices could be invested in adaptivity without any result because of the low demand of other functions. But an investment in an office building at a location in the periphery could boost the value of the property positively. The original case was located in North-Brabant, outside the Randstad and not on a prime office location. Therefore the location in the next calculation will be Amsterdam on the South-axis. This location is the prime location for offices. The demand of offices is really high in this area and therefore it could be that the outcome is not to invest in adaptivity.

Calculation NPV other location

This calculation is based on the same information as the original case. The only difference is that the variables related to the location are changed. As mentioned before has the market a big influence on the adaptivity score and the NPV. The location characteristics are related to the market conditions. A high demand of office space will influence the rental prices for offices and the vacancy positive. The rental income on offices will be more constant, because of the high demand. The other functions are less demanded. In the figure below a comparison is made between the stochastic eNPV of the original case in North-Brabant and the eNPV of Amsterdam. The calculated eNPV in a DTA for Amsterdam can be found in the appendices.

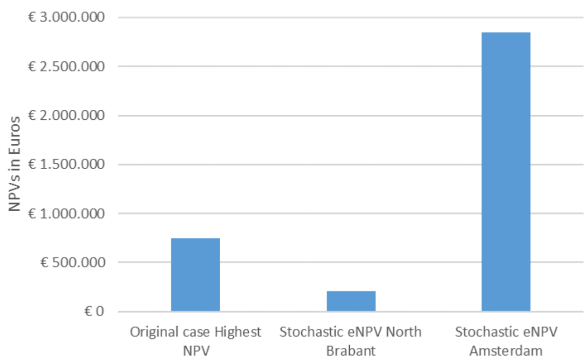


Figure 46: Comparison NPVs of location change (own ill.)

There can be concluded that the eNPV of a prime location for offices is much higher in comparison with the eNPV of a location with less demand for one specific function, because of the specific demand for one function. The demand for offices is that in every scenario positive, even for the bad market scenarios, and therefore is the eNPV much higher than in North-Brabant. According to the DTA the most valuable option is to invest in a traditional way instead of investing in adaptivity. This could be a problem for the future, after those 30 years, that the office buildings are less suitable of other functions. But with this model the uncertainty is less, because of the positive NPVs in the stochastic model in bad market circumstances.

5.5 Conclusion

The results of the comparison between the calculation of the original case and the stochastic way showed some big differences. By following the different steps of the valuation model will be concluded what the effects are of the stochastic way of calculation. The sub-question of this chapter was:

How does the valuation model work to value the adaptive capacity of office buildings?

This question is answered by a step by step plan through the valuation model. In the first step , the optimization of the adaptivity score, it became clear that there was not invested in the maximum adaptivity score in the original case. Therefore, there can be concluded that the investor could invest smarter in adaptivity to reach a more adaptive building.

The second step was about the change of variables to a stochastic approach. Together with the Monte Carlo simulation and the DTA in step 3, there can be concluded that the change of rental prices and the inflation rate has the biggest influence on the adaptivity score. This should be taken into account by the investor in his investment decision. The calculation in step 3 shows for the original case that the flexible building option has for all the functions a positive yield and end balance in comparison with the traditional way of building except for the non-transform option. The stochastic calculation showed that the NPV of the traditional calculation was much higher than the eNPV of the stochastic calculation. The aim of the stochastic calculation was to reduce the risks and uncertainties. By comparison the calculation of the original case with the stochastic calculation it became clear that the future uncertainties were not fully included in the calculation. The highest NPV of the original calculation was much higher in comparison with the stochastic calculation. Depending on the expectations of the investor for the future they should decide in what kind of option they want to invest.

Another effect that the DTA showed was about the market. A good market showed that it is better to invest in a higher level of adaptivity in comparison with a bad market. This is logical because of the positive market circumstances for future investments. The market effect is related to the location. The last calculation was about the change in location. This change in location illustrated that investing in adaptivity is more useful in an area where there is more uncertainty about demanded functions in the future in comparison with a location where there is enough demand for one function.

The financial model is based on the original case with a new development of a building. However, this financial model is also applicable for transformation of existing buildings. The biggest difference is that the impact of changes by adaptive indicators are reduced to a minimum. For example, the construction layer of the building is less changeable, because existing construction is less flexible. Thereby is the demolition of useless parts of the building a cost variable that will influence the impact of adaptivity. This need to be taken into account by the investor when transform an existing building.

6. Conclusion and Discussion

In this chapter the main question of this research will be answered by a final conclusion. In the conclusion will be referred to the literature, mentioned in the previous chapters, to discuss their findings and explain the research gaps. This research was about developing a new financial model to value the adaptivity in office building and cope with the uncertainties related to the investment in adaptivity. The financial model should give investors insight in the possibilities of investing in adaptivity and stimulate them to invest in adaptivity. The main question of this thesis is as follows:

How to cope with future uncertainty in a DCF method to value the adaptive capacity of office buildings to stimulate investors to invest in adaptivity?

The second chapter of this research was about the background of adaptivity. Multiple researches studied adaptivity in different ways. Important to mention is the definition of adaptivity used in this research: "Adaptivity or the adaptive capability of a building includes all characteristics that enable the building to maintain its functionality in a sustainable and economical profitable manner during its technical lifespan, during changes in need and other circumstances." The adaptive capacity is being considered as a crucial component when looking into the sustainability of the real estate stock (Hermans et al., 2014, p. 6). A discussion point is if the investment in adaptivity is sustainable. If the adaptive capability of a building wouldn't be used and it remains one function, it is not sustainable to use more materials. The probable consequences of this incident are not taken into account in this research and is recommended for further research.

According to Geraedts (2013) there are two types of owners affecting the adaptivity capacity of a building, the owner/investor and the user. The owner/investor is interested in the transformation dynamics. If there is a change in the demand of the function of a building, this affects the owner/investor. The owner/investor and the user are both related to the user dynamics. If there is a change in the demand of the user, this will affect them both.

To measure adaptive capacity there should be looked at the match between the demand and supply side. The user dynamics and transformation dynamics are part of the demand side and will be necessary to determine if there is a need for adaptivity and are crucial in the valuation of adaptivity. If the building, the supply side, has the capability to rearrange, extend and reject, the adaptive capacity is high. These flexibilities should be taken into account by the investor and thereby these flexibilities should be implemented in the financial model. The adaptivity will be measured by the list of adaptive indicators based on FLEX 2.0 light (Geraedts, 2015) and Brink Groep (2018). A discussion point about the FLEX 2.0 light method is that the study is focussed on the building. According to Geltner (2001), the location is also an important part in the valuation of a building. To fill this research gap, a new list of indicators for the location is established with Brink Groep (2018).

The combination of what the investor demands and what adaptivity could offer, answered the question of chapter 3: what are the reasons to invest in adaptivity and what are the financial effects the adaptivity has on the investment? The possibilities of adaptivity are to be capable to rearrange, extend and reject if there is a change in demand of function for example. The demand of the commercial investors are focussed on three aspects: time, risk and yield. If the risk is low and the yield is high, it is an interesting investment for the investor. The challenge is the long timespan and the risk before it is valuable to invest in adaptivity. Therefore, most of the short term investors are not interested in the investment in adaptivity, but the long term investors are. Based on multiple studies (Geltner, 2006, 2001; Keeris, 2008) the short term investor could be interested in the extra investment in adaptivity, because of an increase in the value. However, this argument is disputed in practise. The feasibility of an increase in value by adaptivity will be unsure, and probably a short term investor will only invest in adaptivity when the current client demands it. Both in practise and theory, the long term investor has the demand to invest in adaptivity with a long term focus, a low risk profile and a high yield. The demand of the owner-user investor is mostly focused on their own use. The user dynamics could be a valuable addition to their objective to accommodate the organisation. Their focus is to produce a portfolio that is future proof with flexibility included.

Another important reason to invest is the location and the market (Geltner, 2001). The uncertainty of future events is related to the location and the market. The financial model should thereby take into account what the kind of location where the property is situated. This will influence the decision to invest in adaptivity or not. The same applies for the real estate market. Last decade, the market is very volatile and therefore this should be implemented in the financial model as well (Bolgün & Akçay, 2003).

The financial effects of adaptivity depends on the investor. For a short term investor the financial consequences are negative, because the investment is high and the return will take place on the long term. The investment costs are not recovered in their short term operating period. Nevertheless, the long term investor could benefit from the long term operating period. Sometimes even the rent for tenants are higher as a result of the split-incentive. From the perspective of adaptivity it is thereby not sufficient to analyse only the investment costs. The positive effects of adaptivity are mostly applicable during the operating phase of the building. The value of adaptivity is measurable when the adaptivity is desired by a change in demand. This can be measured by the rent ability for example.

Together with the requirements for a financial model mentioned by Hermans et al. (2014, p.43) the following crucial inputs are determined for the financial model in chapter 4. The financial model should:

- be able make a calculation over a longer time period. So it is taking to account not only the investment costs but also the long term operating costs.
- show the probable uncertainties to reduce the risk for the investor.
- respond on the demand for adaptivity, the transformation dynamics and the user dynamics, by change of the type of user/tenant.

First part of the sub-question of chapter 4 is thereby answered, namely: What are the crucial inputs to measure adaptivity? The second part of the sub-question is: In which of the current valuation methods are these inputs included and what should be added? According to Hermans et al. (2014) the DCF method is a possible model to value adaptivity in a quick and effective manner, but according to Vimpari and Junnila (2016) the use of DCF results is short-sighted decision-making. This won't help to value adaptivity about the long term. Huuhka & Kahdensivu (2016) did a statically and geographic study on demolished buildings. One of their results was that the technical lifespan of a building will be around 50 years. Therefore, it can be discussed if a short-sighted method, like the DCF method, is enough to value adaptivity. The DCF method is a method that can be used, but has some shortcomings. Therefore, the DCF method will be extended with the option theory to value the adaptivity in a better way.

Building and testing the financial model

After determination of the right basic valuation method and the reasons why investors should invest, the valuation model is tested on a case. In chapter 5 the question is how the valuation model works to value the adaptive capacity of office buildings. This question is answered by using a case. The original case was calculated in a traditional way and the valuation model of this thesis is based on a stochastic approach. The results of the comparison between the calculation of the original case and the stochastic approach showed some big differences. The conclusion can be separated in the three different steps of the valuation model.

In the first step, in the optimization of the adaptivity score, it became clear that in the original case there was not invested in the maximum adaptivity score. Therefore, there can be concluded that the investor could invest smarter in adaptivity to reach a more adaptive building.

The second step was about the change of variables to a stochastic approach. Together with the Monte Carlo simulation and the DTA in step 3, there can be concluded that the change of rental prices and the inflation rate has the biggest influence on the adaptivity score. This should be taken into account by the investor in his investment decision. A difference with the traditional approach is that the stochastic approach results in an expected NPV (eNPV) instead of a standard NPV due to the option theory. The calculation in step 3 compares the two different approaches. The original approach shows that the flexible building option has for all the functions a positive yield and end balance in comparison with the traditional way of building except for the option of non-transforming. The stochastic approach showed that the NPV of the traditional calculation was much higher than the eNPV of the stochastic calculation. The aim of the stochastic calculation was to reduce the risks and uncertainties. By comparison the calculation of the original case with the stochastic calculation, it became clear that the future uncertainties were not fully included in the calculation. The highest NPV of the original calculation was much higher in comparison with the stochastic calculation. Depending on the expectations of the investor for the future they should decide in what kind of option they want to invest.

A discussion point in the original case is the choice to value the building without re-selling the building at the end of the operating time. This choice results in a negative NPV for most of the transformation option, because of the transformation costs. The non-transforming option doesn't have those transformation costs and are therefore most of the time positive. One of the reasons for investors to invest in adaptivity could be to have a higher value of the building at the end of the operating period. This is not included in the current financial model, because the focus was on the investment and transformation costs and the operating period through the years.

Another effect that the DTA showed was about the market. In a good market, it is better to invest in a higher level of adaptivity in comparison with a bad market. This is logical because of the positive market circumstances for future investments. The market effect is related to the location. The last calculation was about the change in location. This change in location illustrated that investing in adaptivity is more useful in an area where there is more uncertainty about the demanded functions in the future, in comparison with a location where there is enough demand for one function.

There can be concluded that a traditional way of calculation can be used to invest on locations with a clear function demand on short term perspective. The decision to invest in adaptivity won't change with the stochastic calculation. However, if there is uncertainty about the demand for a function in the future, it is more useful to use the new valuation model with stochastic values. This model shows that investing in adaptivity could be a solution even if the market is bad and it is not necessary to transform. A traditional model wouldn't show that. According to the interviews, the financial model can be used in the initiative phase of a building process by a long term investor. The Government is mostly focussed to produce a portfolio that is future proof with flexibility included. This financial model to value adaptivity could help them as well.

After the results, there can be concluded that the original advice of the advisor to the investor wasn't about the highest NPV option, but to show the financial consequences of the different options. Depending on the expectations of the investor for the future they should decide in what kind of option they want to invest. They presented the cumulative cash flows as result. These figures are interesting but misleading, because the highest NPV is for a traditional way of building.

The answer on the main question how to cope with uncertainty in a DCF method is to add stochastic valuation and the DTA to the DCF method. This shows which variables have influences on the NPV and yield and the DTA lower the risk, because of a good well-calculated overview of all the scenarios in the future. The results are probably more positive for the areas to invest in adaptivity where the demand of a function is uncertain in the future in comparison with a certain function in the future. This valuation model shows the risks and the uncertain and optimize the yield. According to the research are that the main motives for investors to invest in adaptivity.

7. Recommendations

During the study some assumptions are done to focus on the core of this thesis. However, the results and conclusions could be better if these assumptions were further researched. This chapter elaborates on the recommendations for professionals in practise, further researchers and the end-users. The recommendations will be structured by the following subjects: Adaptivity, investing in adaptivity and the financial model.

As mentioned in chapter 2, there has a lot of qualitative research been done about adaptivity. Nevertheless, the quantitative research about adaptivity is underexposed. This thesis started with quantifying the adaptive indicators of Geraedts (2015). During this process, the assumptions about the investment costs and transformation costs are only based on one case and the generic number of Bouwkostenkompas (De Groot, 2013). To verify if the ratio of investment costs and transformation costs related to the adaptive indicators are right, it is recommended to do further research with more cases. These case will gather more information about the costs so the quantifying process of the adaptive indicators can be verified.

Another recommendation about the adaptive indicators of Geraedts (2015) is to determine which of the adaptive indicators is related to a certain function. Some of the adaptive indicators are only important for housing while other indicators are only applicable to retail. To bundle the adaptive indicators into packages, it will be more clear in which of the adaptive indicators the investor should be investing. Especially for the short term investors it could be interesting. Their short term operating period doesn't have the flexibility to cover the extra investment for all the different functions. However, it could be useful if the short term investor could invest only in two different functions. This lower the extra investment in adaptivity and the choice of functions for the future are more clear. A difficult point in this further research is that every investors demands their own specific package of indicators. To make a generic bundle of indicators for every function, a lot of test-cases are needed. Therefore, this research used only the generic adaptive indicators for the case. Thereby was the function after 15 years unknown.

As stated in the conclusion is it a discussion point if the investment in adaptivity is fully sustainable. There is a chance that the investment in extra materials wouldn't be used during the technical life cycle of a building. The environmental consequences are not known. Is it sustainable to use extra material that is circular but won't be used for 50 years? For this research the financial aspects are included in the financial model, but should be further examined to conclude about the environmental impact for example.

The reasons to invest in adaptivity are studied in this research. The findings are based on literature and practise. For the practise part, different practitioners were interviewed. Every practitioners represented one of the investors that were defined by the literature. In practise there are a lot more different types of investors in comparison to the 3 defined types of this research. This research was a quantitative research, but a recommendation is to do a qualitative research about the different investors and their motives to invest in adaptivity.

The last recommendation is about the financial model. In this research the aim was to focus on the building aspects and included location aspects where possible for new developments. An example is the study of the location indicators. One of the results of this research was about the change of location. If the change of location had influence on the investment decision for the investor to invest in adaptivity or not. Based on the project information of the case it had an influence. However, it was only one change of location and based on one development project. The change of location to the Amsterdam South-axis was expected due to prime location for offices at the moment. For further research, it is recommended to do a study with different locations in the Netherlands and define the impact of the location and the local market on the investment decision to invest in adaptivity for new developments and renovate/transform of existing buildings.

8. Reflection

This research about the future value of investing in adaptivity in office building has led to a financial model that can be used to consider the investment in adaptivity in real estate developments. The financial model is a result of a literature study and a test case which has been analysed. Together with the financial experts of my internship company and from the TU Delft, we accomplished this product. This reflection reviews this research process, the methodology and the final results.

In the beginning of my graduation process, I read in the graduation booklet the possibility to do a financial research on adaptivity. During my master, I missed the financial input in the different courses so I decided immediately to choose for that subject. In the course Quantitative Research Operations, I learnt about the quantitative side of the research field and choose to do a quantitative research about the financial feasibility of adaptivity. Thereby, a financial method was mentioned in the course, called the Option theory. This sounded perfectly to apply on the problem to value the adaptivity. Unfortunately, the Option theory was not further explained in that course. Therefore, I had to find the useful literature by myself and read a lot about it. A considerable amount of the Options theory literature demands mathematical knowledge, which I lacked due to my pre-education. I lost my focus on the particular problem related to adaptivity and learned a lot about the Option methodologies with all kind of differential partial equations. This results of the literature study were not useful for my thesis, nor applicable to adaptivity. Reflecting on this literature study process, I should have made more definitive decisions about the focus of my research in an early stage of the process. Thereby, it was helpful if I used the current knowledge as a basic and from there on broaden it with new knowledge about the Option theory. The consequences of this lack of definitive decisions were a constantly change of main research questions and a generic aim what was comparable to change the whole real estate investment sector. The exploration of the Option theory was really interesting, but delayed my research process.

After my P2, I started with a graduation internship what opened the possibilities to talk to experts and led to valuable insights. This changed the whole structure of the report in a positive way. There were more definitive decisions made and narrowed the focus of the research. It resulted in a clear structure of the report and methodology. In this stage of the process the methodology became clear and was decided to do some interviews and one case. Some interviews were conducted, but only the interviews with the different investors were used in the report. It should have been more helpful to focus from the start of the period of interviews on the investors instead of interviewing also an appraiser and financial experts of the Option theory. The choice of the case could have been made faster if the definitive definitions were defined in an earlier stage of the process. The specific search for a real estate development case with flexibility included within the internship company wasn't helping as well.

Reflecting on the methodology, it stated from the beginning with a combination of a descriptive research, the literature study, and a prescriptive research, the financial model with case. The problem was that the focus was more on the prescriptive research without defining the definitions in the descriptive part. This delayed the process, but after a while the literature study and the financial model became closer by defining the definitions. In the end of the research it was only linking the theoretical knowledge of the literature study to the trial and error knowledge of the financial model. The results are therefore clear, but could be more in-depth if the assumptions for one case were defined by multiple cases. Due to the time to find a case, it was not possible to do another case. However, the financial model is a new way of thinking and with the DTA the overview for the investors should be more clear. The next step is to test this among the investors if they are interested and understand what is happening in the model. The only thing they have to do is analyse their options and decide. Currently, the demand of flexibility is growing but with the DCF method it is not easy to calculate the flexibility of an office building investment. With this research, there is a better approach to value the future value of adaptivity in office buildings.

The end product is a financial model that is comparable with a DCF method and stochastic additions. The DCF method is the most common used method and therefore well-known by the investors. The model can be used easily by the real estate investors after following the different steps. The biggest advantage of the model is the uncertainty is shown by the model. If the investor knows the uncertainty during his investment he will probably invest more certain. However, there are also some limitations of the financial model. The adaptivity part of the model is based on FLEX 2.0 from Geraedts (2015). That model is focussed on the technical side of the building and used some assumptions for the weighing of the indicators. My additions to make it quantitative is based on one case and Dutch key figures of building costs (Bouwkosten kompas). This quantitative method should be validate with a lot more cases to determine the exact investment- and transformation costs per adaptivity score. In the financial model is a common DCF method used with some uncertainties and risks based on the case. As mentioned before are these uncertainties and risks related to the building. The location aspect with its uncertainties and risks are implicated where possible. However, the assumptions related to the location are not complete. The local rental prices of the different functions are shown with their uncertainties and risks, but the zoning plan with future work related to accessibility, public spaces, housing are not included in the model. According to the recommendations, the development of a complete financial model with location uncertainties and risks is further research needed. The same applies to investors with a specific demand in future functions. If the investor demands a future building with only housing and retail, it will affect the adaptive indicators. Some specific indicators are needed instead of the general indicators in the current model.

In short, the financial model is compatible for the investor who is interested in a long term investment with the aim to develop a future proof building. To validate the financial model, there a lot more cases needed with different locations and input. If it was easier to find the different cases during one internship, I would definitely make use of that to test the financial model. For now is that a big opportunity for further research!

9. References

ABF research (2018). Retrieved on 3-1-2018 from https://www.capitalvalue.nl/nieuws/woningtekort-loopt-verder-op-en-groeit-tot-2020

Albers, B., Dekker, K., Vermaas, R., Vlis, P. van der (2011). Flexibiliteit van de interne fysieke omgeving. Den Haag, Directoraat Generaal Organisatie Bedrijfsvoering Rijk: 43.

Arge, K. (2005). Adaptable office buildings: theory and practice. *Facilities, 23*(3/4), 119-127.

Basdogan, S., Remoy H. & Binnenkamp R. (2017). flexible market, invvestment and space, triangular strategy for office investments. Delft: TU Delft.

Berkhout, T.M., J.F.M.C. Bouwens, R.J.A. Hamers en P.R. Tansens (2006). Determinanten van eindwaarden in de vastgoed verkend . Property Research Quarterly , september 2006, 6-14

Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. The journal of political economy, 637-654.

Blakstad, S. H. (2001). *A strategic approach to adaptability in office buildings.* Norwegian University of Science and Technology, Trondheim.

Blommaert, T., & van den Broek, S. (2013). Vertrouwen als bron van winst: de harde resultaten van soft control. Business Contact.

Bolgün, K. E., & Akçay, B. (2003). Risk Yönetimi. *Scala yayıncılık*.

Brand, S. (1995). *How buildings learn: What happens after they're built*. New York: Penguin Group US.

Brink Groep (2011) Case Fase 10. Rotterdam

Brink Groep (2018). *Location indicator list made by colleagues.*

Brooks, C., & Tsolacos, S. (2010). *Real estate modelling and forecasting*: Cambridge University Press.

Bryman, A. (2012). Social research methods. Oxford: OUP.

Carlebur, O. F. D. (2015). Beoordelingsmethode voor schoolgebouwen in het primair-en voortgezet onderwijs.

CLO. (2016). Leegstand kantoren. Retrieved from http://www.clo.nl/indicatoren/nl2152-leegstand-kantoren

Crone, J. (2007). Leren door demonstreren. De oogst van zeven jaar IFD bouwen. Rotterdam: SEV Realisatie.

Cushman&Wakefield. (2017). *Factsheet kantoren- en bedrijfsruimtemarkt januari 2017*. Retrieved from AMsterdam

De Groot, I. B. (2013). KengetallenKompas Bouwkosten. Den Haag: IGG Bointon de Groot.

Duffy, F., & Powell, K. (1997). *The New Office*. London: Conran Octopus.

Dynamis. (2017). *Sprekende cijfers: kantorenmarkt '17*. Retrieved from Utrecht

Energie-vastgoed. (2017, 13-6-2017). Energielabel C kantoren. Retrieved from http://www.energievastgoed.nl/dossiers/energielabel-c-kantoren/

French, N. (2001). Decision theory and real estate investment: an analysis of the decision-making processes of real estate investment fund managers. Managerial and decision economics, 22(7), 399-410.

Gehner, E., & De Jong, I. (2011). Risicomanagement vraagt om innovatie.

Geltner, D., Miller, N. G., Clayton, J., & Eichholtz, P. (2006). *Commercial real estate analysis and investments* (Vol. 1): South-western Cincinnati, OH.

Geraedts, R. (2009). Future Value of Buildings. 3rd CIB International Conference on Smart and Sustainable Built Environment. A. v. d. Dobbelsteen. Delft, The Netherlands, Delft University of Technology.

Geraedts, R. (2013). Adaptief Vermogen; tussenrapport 130613. Delft, CPI TUD: 9.

Geraedts, R. P., Remøy, H. T., Hermans, M. H., & Van Rijn, E. (2014). Adaptive capacity of buildings: A determination method to promote flexible and sustainable construction. In UIA2014: 25th International Union of Architects World Congress" Architecture otherwhere", Durban, South Africa, 3-7 August 2014.

Geraedts, R. (2015). *Afwegingsmodel adaptief vermogen: De match tussen vraag en aanbod*. Delft.

Geraedts, R. (2016). FLEX 4.0, a practical instrument to assess the adaptive capacity of buildings. Energy Procedia, 96, 568-579.

Gitman, L. J., & Vandenberg, P. A. (2000). Cost of capital techniques used by major US firms: 1997 vs. 1980. *Financial Practice and Education, 10*, 53-68.

Groak, S. (1992). The idea of building. E & FN Spon, London.
Habraken, N. J. (1972). Supports: an alternative to mass housing. *LONDON: ARCHITECTURAL PRESS(1972), 97 PP.(General)*.
Hermans, M. H., Geraedts, R. P., Van Rijn, E., & Remøy, H. T. (2014). *Gebouwen met toekomstwaarde! Het bepalen van de toekomstwaarde van gebouwen vanuit het perspectief van adaptief vermogen, financieel rendement en duurzaamheid: Eindrapport*. Retrieved from https://blackboard.tudelft.nl/webapps/blackboard/execute/content/file?cmd=view&content_id=_2760075_1&course_id=_56447_1
Hull, J.C., and White, A., Pricing interest-rate-derivative securities. The Review of Financial Studies, 3:573{592, 1990.
Hulsmann, M., Grapp, J. and Wycick, C., (2007). *Real-Options-Approach – A Basis for the Economic Evaluation of Autonomous Cooperating Logistics Processes in International Supply Networks?* In: 12th International Symposium on Logistics 2007, Loughborough
University, UK, 8th – 10th July 2007, pp. 1 – 7.
Huuhka, S., & Lahdensivu, J. (2016). Statistical and geographical study on demolished buildings. *Building Research & Information, 44*(1), 73-96.
Keeris, W. (2008). De halve waarheid is funester dan de onjuistheid. Real Estate nr. 58. pp. 42-47.
Kendall, S., Teicher, J. (2000). Open Building Implementation. Washington.
Kumar, S., & Phrommathed, P. (2005). *Research methodology*: Springer.
Leung, K. C.-K. (2014). *Beyond DCF analysis in real estate financial modeling : probabilistic evaluation of real estate ventures.* Massachusetts Institute of Technology, Massachusetts Institute of Technology.
Lugard, J. (2009). De Nederlandse kantoren-cv's: een inventariserend onderzoek naar kantoren-cv's waarbij exitwaarde centraal staat. Amsterdam: Amsterdam School of Real Estate.
Lusht, K. M. (2001). *Real estate valuation: principles and applications*: KML publishing.
Manewa, R. M. A. S. (2012). Economic considerations for adaptability in buildings (Doctoral dissertation, © RMAS Manewa).
Mathews, S. (2009). Valuing risky projects with real options. Research-Technology Management, 52(5), 32-41.
Miller, L. T., & Park, C. S. (2002). Decision making under uncertainty—real options to the rescue? *The engineering economist, 47*(2), 105-150.
Mun, J. (2002). *Real options analysis: Tools and techniques for valuing strategic investments and decisions* (Vol. 137): John Wiley & Sons.
NFCindex (2017). *NFC index kantoren 2016.* Retrieved on 10-10-2017 from https://www.nfcindex.nl/
Option-price (2017), *Strategy Option calculator.* Retrieved on 21-11-2017 from http://www.option-price.com/option-strategies.php?stype=lco
Park, C. S., & Herath, H. S. (2000). Exploiting uncertainty—investment opportunities as real options: a new way of thinking in engineering economics. *The Engineering Economist*, *45*(1), 1-36.
Prins, M., Heintz, J. L., & Vercouteren, I. J. (2001). Ontwerpen en management. Proc. Vormgeven aan verandering, De toekomst van bouw-en vastgoedmanagement, TU Delft.
Rabobank. (2017, 13-6-2017). Rabobank Cijfers & Trends. Retrieved from https://www.rabobankcijfersentrends.nl/index.cfm?action=sector&sector=bouw
Rabobank. (2017a, 13-10-2017). Rabobank Cijfers & Trends. Retrieved from https://www.rabobank.nl/bedrijven/cijfers-en-trends/vastgoed/vastgoedbericht-2017/deelmarkten/kantoren
Remøy, H., de Jong, P., & Schenk, W. (2011). Adaptable office buildings. *Property Management, 29*(5), 443-453.
Remøy, H., & van der Voordt, T. (2014). Adaptive reuse of office buildings into housing: opportunities and risks. *Building Research & Information, 42*(3), 381-390.
Remøy, H. T. (2010). *Out of office: a study on the cause of office vacancy and transformation as a means to cope and prevent*: IOS Press.

Richard, R. B.(2010).FourStrategiesto Generate Individualised Buildings with Mass Customisation New Perspective in Industrialisation in Construction; A state of the art report. S. F. Girmscheid Gerhard. Zürich, IBB Institut für Bauplanung und Baubetrieb: 10.

Rodermond, W. (2011). *Het taxeren van leegstaande kantoorruimte, Analyse van een actueel waarderingsvraagstuk, inclusief ontwikkeling van een best practise*. Retrieved from Amsterdam:

Scarrett, D. (2008). *Property valuation: The five methods*: Routledge.

Schenk, W. (2009). *Investeren in mogelijkheden: De haalbaarheid van een aanpasbaar kantoor.* (Master thesis), TU Delft, Delft.

Schneider, T., Hill, J. (2007). *Flexible Housing*. Oxford, Architectural Press Elsevier.

Schuetze, T. (2009). *Designing Extended Lifecycle*s. 3rd CIB International Conference on Smart and Sustainable Built Environment. A. v. d. Dobbelsteen. Delft, The netherlands, Delft University of Technology.

SEV (2007). *Leren door demonstreren; de oogst van zeven jaar Industrieel, Flexibel en Demontabel bouwen.* Rotterdam, SEV Realisatie.

Stoop, J. (2015). *Office up to date.* (MsC), TU Delft, Delft.

Van Gool, P., Brounen, D., P. Jager en R.M. Weisz (2007) Onroerend goed als belegging. Groningen/Houten: Wolters-Noordhoff [4th edition].

Van Gool, P. en Rodermond, W. (2011), Waarde lege kantoren verschilt nauwelijks van de verkoopprijs, Vastgoedmarkt, jaargang 38, september 2011

Vastgoedmarkt. (2009). Crisis zorgt voor afname indirect vastgoed van professionele beleggers. *Vastgoedmarkt*.

Veenstra, J. (2006). De eindwaarde van kantoren. Tilburg: Tias Business School.

Vimpari, J., & Junnila, S. (2016). Theory of valuing building life-cycle investments. *Building Research & Information, 44*(4), 345-357.

Vlek, P. J., van Oosterhout, T., Rust, W., van den Berg, S., & Chaulet, T. (2015). Investeren in vastgoed, grond en gebieden. Vlaardingen, Nederland: Management Producties.

Vrederust (2017). Location Hoofdlaan Halsteren. Retrieved on 20-12-2017 from https://www.ggzwnb.nl/locaties-ggzwnb.html

Wang, L., Toppinen, A., & Juslin, H. (2014). Use of wood in green building: a study of expert perspectives from the UK. *Journal of cleaner production, 65*, 350-361.

Wilkinson, S. J., & Remoy, H. T. (2011). Sustainability and within use office building adaptations: A comparison of Dutch and Australian practices. In PRRES 2011: Proceedings of the 17th Pacific Rim Real Estate Society Annual Conference. Pacific Rim Real Estate Society.

Interviews:

Amlal, M. (2018). Long term investor perspective about (investing in) adaptivity. NSI, HetNieuweKantoor, Den Haag: 24 January 2018

Heuvel-Gotink, I. H. van den (2018). Owner-user perspective about (investing in) adaptivity. Nationale Politie, Den Haag: 17 January 2018

Marchand, F. (2018). Short term investor perspective about (investing in) adaptivity. Cairn Real Estate, Amsterdam: 3 January 2018

Wassenaar, K. (2018): Owner-user perspective about (investing in) adaptivity. Rijksvastgoedbedrijf, Den Haag: 22 January 2018

Appendices

Appendix 1	1-a	Qualitative subscription of the adaptive indicators of FLEX 2.0 light
	1-b	Quantitative subscription of the adaptive indicators of FLEX 2.0 light
Appendix 2	2-a	Financial model – Input data
	2-b	Financial model – Historical data and assumptions
	2-c	Financial model – Optimization adaptivity
	2-d	Financial model – Cash flow original case
	2-e	Financial model – Cash flow new model
Appendix 3	3-a	Floor plans original case
Appendix 4	4-a	Decision Tree Analysis stochastic approach Bergen op Zoom
	4-b	Decision Tree Analysis stochastic approach Amsterdam

Appendix 1-a Qualitative subscription of the adaptive indicators of FLEX 2.0 light

2	**Overmaat aan locatieruimte** Is de locatieruimte (opp.) overgedimensioneerd en is het gebouw daarop centraal gelegen?	**Meetwaarden overmaat locatie** 1. Nee, de locatie is niet overgedimensioneerd 2. 10-20% 3. 20-50% 4. De locatie is meer dan 50% overgedimensioneerd	**Opmerking** Naarmate een gebouw meer gecentreerd gelegen is op een grotere locatie, neemt de uitbreidbaarheid van het gebouw toe.
5	**Overmaat aan gebouwruimte / oppervlak** Is het gebouw of zijn de gebruikersunits overgedimensioneerd m.b.t. vereiste ruimte c.q. beschikbaar vloeroppervlak?	**Meetwaarden overmaat gebouwruimte** 1. Nee 2. 10-30% overgedimensioneerd 3. 30-50% overgedimensioneerd 4. > 50% overgedimensioneerd	**Opmerking** Naarmate de ruimte/het vloeroppervlak van een gebouw of de units overgedimensioneerd is (b.v. d.m.v. een zoneringssysteem met margeruimtes), neemt de herverkavelbaarheid, herindeelbaarheid en herbestemmingsmogelijkheid t.b.v. toekomstige functiewijzigingen toe, is de korrelgrootte van een gebouw makkelijker te wijzigen, kan beter tegemoet gekomen worden aan veranderende eisen m.b.t. faciliteiten, voorzieningen, de inrichting en kwaliteit van het gebouw of de units, des te makkelijker zijn delen van een gebouw afstootbaar, hoe meer mogelijkheden aanwezig zijn om het oppervlak van de units in het gebouw uit te breiden, en hoe groter de afstootbaarheid van (een deel van) de unit.
11	**Vrije verdiepingshoogte** Hoe groot bedraagt de netto vrije verdiepingshoogte?	**Meetwaarden vrije verdiepingshoogte** 1. < 2.60 m 2. 2.60 - 3.00 m 3. 3.00 - 3.40 m 4. > 3.40 m	**Opmerking** Hoe groter de vrije verdiepingshoogte, hoe beter de verkavelbaarheid, herindeelbaarheid c.q. transformeerbaarheid en herbestemmingsmogelijkheid van het gebouw, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. faciliteiten en voorzieningen, hoe beter tegemoet gekomen kan worden aan veranderende kwalitatieve gebruikerseisen.
17	**Gebouwontsluiting, plaatsing liften/kernen/trappen** In hoeverre is er sprake van een centrale en/of decentrale gebouwontsluiting (positie van entree(s) en kern/trap/lift)?	**Meetwaarden gebouwontsluiting** 1. Decentrale gescheiden entree en kern 2. Decentrale gecombineerde entree en kern 3. Gebouw verdeeld in vleugels voorzien van een centrale gecombineerde entree en kern 4. Gebouw met één centrale hoofdentree, verdeeld in vleugels, elk voorzien van een centrale gecombineerde entree en kern.	**Opmerking** Naarmate de gekozen gebouwontsluiting zich meer leent voor een onafhankelijk gebruik door de verschillende gebruikersgroepen, is het gebouw beter verkavelbaar en herindeelbaar, is het gebouw beter (horizontaal) uitbreidbaar, en zijn delen van het gebouw beter afstootbaar.
21	**Draagvermogen van de vloeren** Hoe groot is het nuttig draagvermogen van de vloeren in kN/m2?	**Meetwaarden draagvermogen vloeren** 1. < 3 kN/m2 2. 3 - 3,5 kN/m2 3. 3,5 - 4 kN/m2 4. > 4 kN/m2 en meerdere gebieden van 8 kN/m2 of meer.	**Opmerking** Hoe hoger het draagvermogen van de vloeren, hoe beter de verkavelbaarheid c.q. transformeerbaarheid en herbestemmingsmogelijkheid van het gebouw, hoe beter tegemoet gekomen worden aan eisen m.b.t. het wijzigen van de kwaliteit van het gebouw, hoe beter de verticale uitbreidbaarheid van het gebouw, hoe groter de herindeelbaarheid van de unit, en hoe meer mogelijkheden aanwezig zijn om de locatie van de units in het gebouw te wijzigen.
29	**Uitbreidbaar gebouw/unit, horizontaal** Kan het gebouw/unit horizontaal uitgebreid worden, b.v. voor nieuwe aanbouwen?	**Meetwaarden horizontale uitbreiding gebouw/unit** 1. Horizontale uitbreiding van het gebouw/unit is niet mogelijk. 2. Horizontale uitbreiding van het gebouw/unit is zeer beperkt mogelijk (b.v. maar aan één zijde). 3. Horizontale uitbreiding van het gebouw/unit is beperkt mogelijk (b.v. aan meer zijden) 4. Horizontale uitbreiding van het gebouw/unit is eenvoudig te realiseren (aan alle zijden, b.v. door toepassing zone-margesystemen).	**Opmerking** Naarmate een gebouw/unit uitgebreid kan worden voor nieuwe of grotere bestaande functies, neemt de herbestemmingsmogelijkheid en uitbreidbaarheid van het gebouw toe, neemt de mogelijkheid om te voldoen aan de individuele kwalitatieve gebruikerswensen op unitniveau toe, en hoe meer mogelijkheden aanwezig zijn om het oppervlak van de units in het gebouw uit te breiden.
30	**Uitbreidbaar gebouw/unit, verticaal** Kan het gebouw/unit verticaal uitgebreid worden, b.v. voor nieuwe verdiepingen (optoppen) of een kelder?	**Meetwaarden verticaal uitbreidbaar gebouw/unit** 1. Individuele verticale uitbreiding van een gebouw/unit is (constructief) niet mogelijk. 2. Verticale uitbreiding van het gebouw d.m.v. een kelder óf topverdieping is mogelijk, en slechts zeer zeer beperkt voor enkele units in het gebouw. 3. Verticale uitbreiding van het gebouw d.m.v. een kelder én topverdieping is mogelijk, en van de meerdere units bij een algemene herverkaveling (toepassing van een beperkt aantal fontanelconstructies/zones in dragende vloeren). 4. Verticale uitbreiding van het gebouw met kelder en meerdere verdiepingen is mogelijk, en individuele verticale unit-uitbreiding is eenvoudig te realiseren, zonder dat andere units daar hinder van ondervinden (toepassing zone-margesystemen en fontanelconstructies/zones in dragende vloeren).	**Opmerking** Naarmate een gebouw/unit makkelijker verticaal uitgebreid kan worden met nieuwe bouwlagen voor nieuwe of grotere bestaande functies, neemt de herbestemmingsmogelijkheid en verticale uitbreidbaarheid van het gebouw toe, neemt de mogelijkheid om te voldoen aan de individuele kwalitatieve gebruikerswensen op unitniveau toe, en hoe meer mogelijkheden aanwezig zijn om het oppervlak van de units in het gebouw uit te breiden (inclusief extra intern stijgpunt).
42	**Demontabele gevel** In hoeverre kunnen bij transformatie gevelcomponenten worden gedemonteerd?	**Meetwaarden demontabele gevel** 1. Gevelcomponenten zijn niet of nauwelijks te demonteren en dienen volledig gesloopt en verwijderd te worden (<20%). 2. Een klein deel van de gevelcomponenten is te demonteren (tussen 20 en 50%). 3. Een groot deel van de gevelcomponenten kan gedemonteerd worden (tussen 50 en 90%). 4. Alle gevelcomponenten zijn nagenoeg volledig demonteerbaar > 90%).	**Opmerking** Naarmate meer gevelcomponenten demonteerbaar zijn, hoe groter de herverkavelbaarheid, herindeelbaarheid c.q. transformeerbaarheid of hergebruiksmogelijkheden van een gebouw, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. faciliteiten en voorzieningen en de inrichting en kwaliteit van het gebouw, en neemt de uitbreidbaarheid van het gebouw toe.

52	**Meet- en regeltechniek** Vindt de meet- en regeltechniek (verbruiksmeting en bediening) van (W + E) installaties zowel op gebouwniveau (centraal) als unitniveau (lokaal) plaats?	**Meetwaarden meet/regeltechniek** 1. Alleen op centraal niveau. 2. Op centraal niveau en incidenteel op unitniveau. 3. Op centraal niveau en beperkt op unitniveau. 4. Zowel op centraal als in grote mate op unitniveau.	**Opmerking** Hoe meer mogelijkheden voor meet- en regeltechniek (b.v. een thermostaat) op unitniveau, des te groter de verkavelbaarheid en herindeelbaarheid van een gebouw, hoe makkelijker de korrelgrootte van een gebouw gewijzigd kan worden, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. faciliteiten en voorzieningen, hoe beter tegemoet gekomen worden aan eisen m.b.t. het wijzigen van de kwaliteit van het gebouw, hoe groter de (horizontale) uitbreidbaarheid van het gebouw, des te beter een deel van het gebouw afstootbaar is, hoe groter de herindeelbaarheid van de unit, hoe meer mogelijkheden aanwezig zijn om de locatie van de units in het gebouw te wijzigen, hoe meer mogelijkheden om te voldoen aan de individuele kwalitatieve gebruikerswensen op unitniveau, hoe meer mogelijkheden om te voldoen aan de individuele voorzieningswensen op unitniveau, hoe meer mogelijkheden aanwezig zijn om het oppervlak van de units in het gebouw uit te breiden, en hoe groter de afstootbaarheid van (een deel van) de unit.
56	**Overdimensionering leidingkanalen / schachten** Zijn de distributiekanalen (W, E, ICT) installaties overgedimensioneerd?	**Meetwaarden kanalen overdimensionering** 1. Niet overgedimensioneerd. 2. 10-30% overgedimensioneerd. 3. 30-50% overgedimensioneerd. 4. > 50% overgedimensioneerd.	**Opmerking** Naarmate de leidingkanalen/schachten van de (W, E, ICT) installaties meer zijn overgedimensioneerd, neemt de uitbreidbaarheid van het gebouw toe.
57	**Overdimensionering capaciteit installaties** Is de capaciteit (voedende voorzieningen) van de (E, W, ICT) installaties overgedimensioneerd?	**Meetwaarden capaciteit overdimensionering** 1. Niet overgedimensioneerd. 2. 10-30% overgedimensioneerd. 3. 30-50% overgedimensioneerd. 4. > 50% overgedimensioneerd.	**Opmerking** Naarmate de capaciteit van de installaties meer is overgedimensioneerd, neemt de uitbreidbaarheid t.b.v. toekomstige functiewijzigingen toe, en neemt de mogelijkheid om te voldoen aan de (uitbreiding van de) individuele kwalitatieve gebruikerswensen op unitniveau toe.
65	**Ontkoppelbaarheid installatiecomponenten** Hoe is de ontkoppelbaarheid van de installatie-componenten?	**Meetwaarden ontkoppelbaarheid installatiecomponenten** 1. Niet ontkoppelbaar, demonteerbaar; natte verbindingen. 2. Slecht ontkoppelbaar, demonteerbaar. 3. Deels ontkoppelbaar, demonteerbaar. 4. Goed ontkoppelbaar (volledig demonteerbaar, stekkerbaar).	**Opmerking** Naar mate de ontkoppelbaarheid van de installatiecomponenten groter is, hoe groter de herindeelbaarheid en/of transformeerbaarheid naar andere functies van het gebouw, hoe makkelijker de korrelgrootte van een gebouw gewijzigd kan worden, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. faciliteiten en voorzieningen, hoe beter tegemoet gekomen worden aan eisen m.b.t. het wijzigen van de kwaliteit van het gebouw, hoe groter de (horizontale) uitbreidbaarheid van het gebouw, des te groter de afstootbaarheid van een deel van het gebouw, hoe groter de verplaatsbaarheid van het gebouw, hoe beter een unit herindeelbaar is, hoe meer mogelijkheden aanwezig zijn om de locatie van de units in het gebouw te wijzigen, hoe meer mogelijkheden om te voldoen aan de individuele kwalitatieve gebruikerswensen en voorzieningswensen op unitniveau, hoe meer mogelijkheden aanwezig zijn om het oppervlak van de units in het gebouw uit te breiden, en hoe groter de afstootbaarheid van (een deel van) de unit.

70	**Onderscheid Drager-Inbouw** In welke mate is in het gebouwontwerp onderscheid gemaakt tussen drager (gebouwcomponenten met een lange levensduur) en inbouw (gebouwcomponenten met een korte levensduur, die eenvoudig kunnen worden vervangen zonder de drager aan te tasten)? *Als meetwaarde hiervoor is het % toegepaste projectonafhankelijke inbouwsystemen gehanteerd: hoe groot is het percentage inbouwcomponenten dat projectonafhankelijk geproduceerd is (en derhalve goed uitwissel- en/of demonteerbaar)?*	**Meetwaarden in % projectonafhankelijke inbouwsystemen** 1. < 10% 2. 10 - 50% 3. 50 - 90% 4. > 90%	**Opmerking** Hoe meer gebouw-componenten tot de inbouw behoren, des te makkelijker is een gebouw (her)verkavelbaar en herindeelbaar, des te makkelijker is de korrelgrootte van een gebouw te wijzigen, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. faciliteiten en voorzieningen, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. de inrichting en kwaliteit van het gebouw, des te makkelijker zijn delen van een gebouw afstootbaar, des te makkelijker is een gebouw makkelijker verplaatsbaar, hoe makkelijker gebruikersunits opnieuw zijn in te delen, hoe makkelijker gebruikersunits zijn te verplaatsen, hoe makkelijker de interne relaties met andere gebruikers gewijzigd kunnen worden, hoe makkelijker gebruikersunits zijn uit te breidenen hoe makkelijker delen van gebruikersunits zijn af te stoten.
73	**Horizontale routing, corridors, ontsluiting** Op welke wijze vindt de horizontale gebouw/unit-ontsluiting plaats binnen de plattegronden? (enkelcorridor, dubbelcorridor, etc., in relatie tot gebouwdiepte)	**Meetwaarden horizontale routing** 1. Ontsluiting via een enkele interne corridor 2. Ontsluiting via een dubbele interne corridor 3. Alle ontsluitingen direct via een centrale kern en een daarom heen liggende corridor. 4. Alle ontsluitingen direct via een centrale kern.	**Opmerking** Naarmate de gekozen horizontale ontsluiting zich alleen beperkt vanuit een centrale kern, is het gebouw beter verkavelbaar, herindeelbaar en derhalve herbestembaar naar andere functies, neemt de herindeelbaarheid van de unit toe, hoe meer mogelijkheden aanwezig zijn om de locatie van de units in het gebouw te wijzigen, en neemt de veranderbaarheid van de interne relatie met andere gebruikers toe.

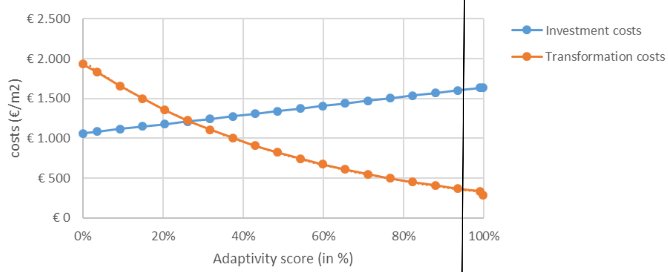
76	**Verplaatsing gebouw/unit-ontsluiting** In hoeverre is het mogelijk om de horizontale gebouwontsluiting te verplaatsen of een nieuwe toe te voegen?	**Meetwaarden verplaatsing gebouwontsluiting** 1. Het is niet mogelijk om de gebouw/unit-ontsluiting te verplaatsen en/of toe te voegen. 2. De ontsluiting kan in beperkte mate in één richting verplaatst worden. 3. De ontsluiting kan in beperkte mate in meer richtingen verplaatst worden. 4. De gebouw/unit-ontsluiting kan op eenvoudige wijze in meerdere richtingen verplaatst worden of er kunnen meerdere nieuwe toegevoegd worden.	**Opmerking** Naarmate de horizontale gebouwontsluiting makkelijker verplaatst kan worden, neemt de herverkavelbaarheid, herindeelbaarheid en/of transformeerbaarheid naar andere functies van het gebouw toe, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. faciliteiten en voorzieningen, hoe makkelijker een gebouw (horizontaal) uitbreidbaar is, des te makkelijker zijn delen van een gebouw afstootbaar, neemt de herindeelbaarheid van de unit toe, hoe meer mogelijkheden aanwezig zijn om de locatie van de units in het gebouw te wijzigen, neemt de veranderbaarheid van de interne relatie met andere gebruikers toe, hoe groter de mogelijkheid om te voldoen aan de individuele kwalitatieve gebruikerswensen en voorzieningswensen op unitniveau toe, hoe meer mogelijkheden aanwezig zijn om het oppervlak van de units in het gebouw uit te breiden, en hoe groter de afstootbaarheid van (een deel van) de unit.
78	**Verplaatsbare binnenwanden** In hoeverre zijn binnenwanden eenvoudig verplaatsbaar?	**Meetwaarden verplaatsbare binnenwanden** 1. Binnenwanden zijn niet zonder ingrijpende/kostbare bouwkundige ingrepen verplaatsbaar. 2. Binnenwanden zijn niet verplaatsbaar, wel afbreekbaar. 3. Binnenwanden zijn verplaatsbaar door ze af te breken en opnieuw op te bouwen. 4. Binnenwanden eenvoudig zonder ingrijpende/kostbare bouwkundige ingrepen verplaatsbaar (b.v. systeemwanden).	**Opmerking** Naar mate binnenwanden eenvoudiger te verplaatsen zijn, neemt de verkavelbaarheid van het gebouw toe, is de korrelgrootte van een gebouw makkelijker te wijzigen, hoe beter tegemoet gekomen worden aan eisen m.b.t. het wijzigen van de kwaliteit van het gebouw, neemt de verplaatsbaarheid van het gebouw toe, neemt de herindeelbaarheid van de unit toe, hoe meer mogelijkheden aanwezig zijn om de locatie van de units in het gebouw te wijzigen, neemt de mogelijkheid om de relatie met de andere gebruikers te wijzigen toe, neemt de mogelijkheid om te voldoen aan de individuele kwalitatieve gebruikerswensen op unitniveau toe, neemt de uitbreidbaarheid van de unit toe, en neemt de afstootbaarheid van (een deel van) de unit toe.
79	**Aansluitdetaillering binnenwanden - horizontaal/verticaal** Welke detaillering is toegepast tussen de aansluiting van binnenwanden op wanden / kolommen / gevel / vloeren / plafonds?	**Meetwaarden horizontale aansluitdetaillering** 1. Indringende verbindingen. 2. Natte verbindingen (zoals specie- en/of kitvoegen). 3. Specifiek projectgebonden koppelstukken. 4. Projectongebonden demontabele koppelstukken.	**Opmerking** Hoe makkelijker de aansluitdetaillering ontkoppelbaar is, hoe beter een gebouw herindeelbaar is, hoe makkelijker de korrelgrootte van een gebouw gewijzigd kan worden, hoe beter tegemoet gekomen kan worden aan veranderende eisen m.b.t. faciliteiten en voorzieningen, hoe beter tegemoet gekomen worden aan eisen m.b.t. het wijzigen van de kwaliteit van het gebouw, des te groter de afstootbaarheid van een deel van het gebouw, hoe beter een gebouw verplaatsbaar is, hoe beter een unit herindeelbaar is, hoe meer mogelijkheden aanwezig zijn om de locatie van de units in het gebouw te wijzigen, hoe meer mogelijkheden aanwezig zijn om het oppervlak van de units in het gebouw uit te breiden, en hoe groter de afstootbaarheid van (een deel van) de unit.

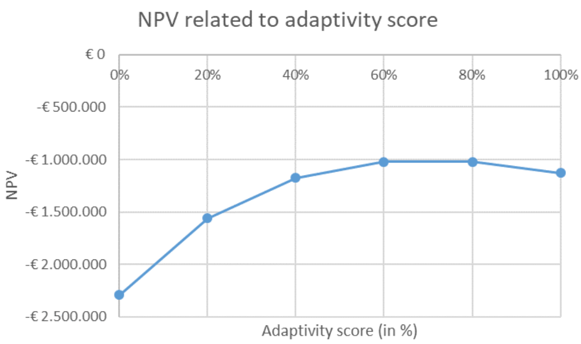
Appendix 1-b Quantitative subscription of the adaptive indicators of FLEX 2.0 light

Extra costs per level of indicator based on the experience of costs experts of Brink Groep. These extra cost per indicator can be related to the adaptivity score. The yellow boxes of the right figure are based on numbers of the original case and figures of Kengetallenkompas (De Groot, 2013). In combination on the extra costs per indicator are the transformation costs an investment costs calculated per adaptivity score.

Indicator	meetwaarden	Influence c
Surplus of site space	1	0,00%
	2	2,00%
	3	6,00%
	4	10,00%
Surplus of building space / floor space	1	0,00%
	2	2,00%
	3	4,00%
	4	6,00%
Surplus free of floor height	1	0,00%
	2	0,00%
	3	5,00%
	4	10,00%
Access to building: location of stairs, elevators, core b	1	0,00%
	2	2,00%
	3	4,00%
	4	7,00%
Surplus of load bearing capacity of floors	1	0,00%
	2	0,75%
	3	2,50%
	4	5,00%
Extendable building / Unit horizontal	1	0,00%
	2	0,75%
	3	1,50%
	4	2,50%
Extendable building / Unit vertical	1	0,00%
	2	0,75%
	3	1,50%
	4	2,50%
Dismountable facade	1	0,00%
	2	1,00%
	3	3,00%
	4	6,00%
Customisability and controllability of facilities	1	0,00%
	2	0,50%
	3	1,00%
	4	2,00%
Surplus of facilities shafts and ducts	1	0,00%
	2	0,50%
	3	1,00%
	4	1,50%
Surplus capacity of facilities	1	0,00%
	2	0,00%
	3	0,75%
	4	1,50%
Disconnection of facilities components	1	0,00%
	2	0,00%
	3	0,50%
	4	1,00%
Distinction between support - infill	1	0,00%
	2	2,00%
	3	4,00%
	4	7,00%
Acces to building: horizontal routing, routing, corridors	1	0,00%
	2	0,50%
	3	1,00%
	4	1,50%
Disconnectible, removable, relocatable units in buildin	1	0,00%
	2	0,50%
	3	1,00%
	4	1,50%
Disconnectible, removable, relocatable interior walls	1	0,00%
	2	0,50%
	3	1,00%
	4	1,50%
Disconnecting/detailed connection interior walls; hor/v	1	0,00%
	2	0,50%
	3	1,00%
	4	1,50%

inv costs	transf cost	extra costs	Flex score	NPV
1062	1933	0%	0%	1933
1083	1830	10%	4%	1796,498
1116	1656	20%	9%	1605,581
1148	1498	30%	15%	1434,953
1180	1356	40%	21%	1282,458
1213	1227	50%	26%	1146,169
1245	1110	60%	32%	1024,364
1278	1004	70%	37%	915,5026
1310	909	80%	43%	818,2105
1342	822	90%	49%	731,2578
1375	744	100%	54%	653,5457
1407	673	110%	60%	584,0923
1440	609	120%	65%	522,0198
1472	551	130%	71%	466,5438
1505	499	140%	77%	416,9633
1537	451	150%	82%	372,6519
1569	408	160%	88%	333,0495
1602	369	170%	94%	297,6558
1634	334	180%	99%	266,0234
1638	289	190%	100%	262,5114





Original case

FUNCTION		Flexible built			Traditional built					PARAMETERS	
	m2 GFA	m2 LFA	Formfactor	rent per m2 LFA	Formfactor	m2 LFA	rent per m2 LFA				
Office	2.628	2.308	0,88	€ 123	0,88	2.308	€ 123	Function 1 (year 1 t/m 15)	Office	Discount rate	5,0%
Dementia apartments	2.628	2.305	0,88	€ 140	0,88	2.305	€ 140	Function 2 (after year 15)	Service apartments	Cost-increase	2,0%
Service apartments	2.628	2.294	0,87	€ 127	0,87	2.294	€ 127			Benefit-increase	2,0%
Healthcare apartments	2.628	2.299	0,87	€ 127	0,87	2.299	€ 127			Increase exploitationcosts	2,0%
School	2.628	2.316	0,88	€ 115	0,88	2.316	€ 115			Interest	5,0%
Apartment (6x)	2.628	2.311	0,88	€ 113	0,88	2.311	€ 113			Vacancy	0,0%
Apartment (8x)	2.628	2.344	0,89	€ 111	0,89	2.344	€ 111				

New financial model

INPUT TABLE			
Function transform choice	Office	Apartment (8x)	6
Flexibility level	0%		
Market level	Bad market	Good market	1

	Good market	Moderate market	Bad market
Inflation rate	2,80%	1,20%	0,91%
Vacancy rate growth	-12%	-6,80%	0,00%

Rent prices FLEXIBLE	Good market	Moderate market	Bad market
Healthcare apartments	€ 100	€ 80	€ 60
Service apartments	€ 102	€ 87	€ 70
Dementia apartments	€ 113	€ 100	€ 85
School	€ 90	€ 80	€ 60
Apartment (6x)	€ 120	€ 100	€ 90
Apartment (8x)	€ 110	€ 100	€ 85
Office	€ 170	€ 160	€ 150

Rent prices TRADITIO	Good marke	Moderate r	Bad marke
Healthcare apartment:	€ 125	€ 108	€ 90
Service apartments	€ 130	€ 110	€ 95
Dementia apartments	€ 150	€ 125	€ 97
School	€ 110	€ 100	€ 85
Apartment (6x)	€ 135	€ 100	€ 95
Apartment (8x)	€ 130	€ 96	€ 90
Office	€ 110	€ 100	€ 85

investment costs	0%	€ 1.062
transformation costs	0%	€ 1.933

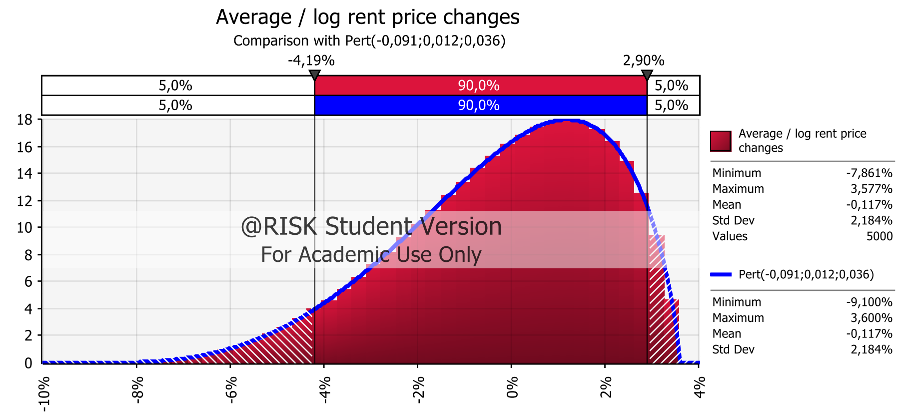
Adjustable are the different inputs on top of the figure: Function, flexibility and Market level

Appendix 2-b Financial model – Historical data and assumptions

Monte Carlo Simulation of the new variables. 5000 simulations.

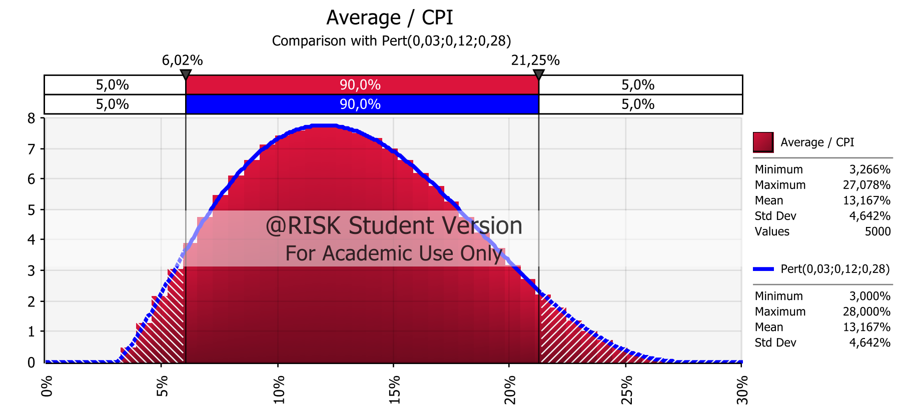
Years	G4 Randstad Rents	og rent price changes	Other NL rents	log rent price changes
2010	179		128	
2011	191	6,5%	127	-0,8%
2012	181	-5,4%	116	-9,1%
2013	178	-1,7%	107	-8,1%
2014	183	2,8%	110	2,8%
2015	187	2,2%	108	-1,8%
2016	191	2,1%	112	3,6%
2017	193	1,0%	113	0,9%
Std	5,52	3,5%	7,62	4,6%
Average	185	1,1%	115,13	2,4%
Min	178	-5,4%	107,00	-9,1%
Max	193	6,5%	128,00	3,6%

Bron: NVM business kantorenmarkt Randstad 2017



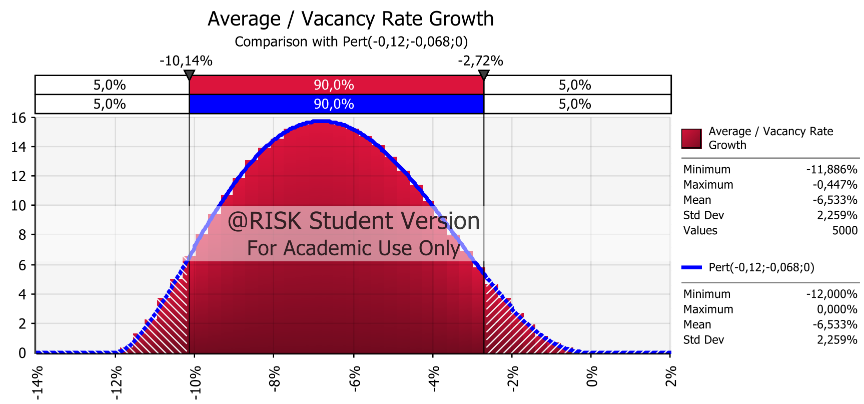
Years	CPI
2010	0,9%
2011	2,5%
2012	2,8%
2013	2,6%
2014	0,3%
2015	0,7%
2016	1,0%
2017	1,3%
Std	0,9%
Average	7,5%
Min	0,3%
Max	2,8%

Bron: Gemiddelde inflatie Nederland (CPI)



Years	Vacancy Rates	Vacancy Rate Growth
2010	17,0%	
2011	16,0%	-6,1%
2012	15,0%	-6,5%
2013	15,0%	0,0%
2014	15,0%	0,0%
2015	13,3%	-12,0%
2016	12,5%	-6,2%
2017	11,2%	-11,0%
Std	1,8%	4,4%
Average	11,6%	-7,5%
Min	11,2%	-12,0%
Max	17,0%	0,0%

Bron: Cushman & Wakefield medio 2017 leegstand nederlan



Appendix 2-c Financial model – Optimization adaptivity

TRADITIONAL

#	Indicator	Weighting		Assessment value		Score	Extra cost %
1	Surplus of site space	1	x	4	=	4	10%
2	Surplus of building space / floor space	2	x	2	=	4	4%
3	Surplus free of floor height	3	x	2	=	6	0%
4	Access to building: location of stairs, elevators, core b	2	x	1	=	2	0%
5	Surplus of load bearing capacity of floors	3	x	3	=	9	8%
6	Extendable building / Unit horizontal	3	x	2	=	6	2%
7	Extendable building / Unit vertical	1	x	3	=	3	2%
8	Dismountable facade	3	x	2	=	6	3%
9	Customisability and controllability of facilities	2	x	2	=	4	1%
10	Surplus of facilities shafts and ducts	2	x	2	=	4	1%
11	Surplus capacity of facilities	3	x	2	=	6	0%
12	Disconnection of facilities components	2	x	2	=	4	0%
13	Distinction between support - infill	3	x	2	=	6	6%
14	Acces to building: horizontal routing, routing, corridors	1	x	1	=	1	0%
15	Disconnectible, removable, relocatable units in buildin	3	x	4	=	12	5%
16	Disconnectible, removable, relocatable interior walls	3	x	1	=	3	0%
17	Disconnecting/detailed connection interior walls; hor/v	3	x	1	=	3	0%
				36		83	41%
						41%	

FLEXIBLE

#	Indicator	Weighting		Assessment value		Score	Extra cost %
1	Surplus of site space	1	x	4	=	4	10%
2	Surplus of building space / floor space	2	x	2	=	4	4%
3	Surplus free of floor height	3	x	4	=	12	30%
4	Access to building: location of stairs, elevators, core b	2	x	3	=	6	8%
5	Surplus of load bearing capacity of floors	3	x	4	=	12	15%
6	Extendable building / Unit horizontal	3	x	4	=	12	8%
7	Extendable building / Unit vertical	1	x	4	=	4	3%
8	Dismountable facade	3	x	3	=	9	9%
9	Customisability and controllability of facilities	2	x	3	=	6	2%
10	Surplus of facilities shafts and ducts	2	x	3	=	6	2%
11	Surplus capacity of facilities	3	x	3	=	9	2%
12	Disconnection of facilities components	2	x	2	=	4	0%
13	Distinction between support - infill	3	x	3	=	9	12%
14	Acces to building: horizontal routing, routing, corridors	1	x	4	=	4	2%
15	Disconnectible, removable, relocatable units in buildin	3	x	4	=	12	5%
16	Disconnectible, removable, relocatable interior walls	3	x	4	=	12	5%
17	Disconnecting/detailed connection interior walls; hor/v	3	x	2	=	6	2%
				56		131	116%
						64%	

Optimal

#	Indicator	Weighting		Assessment value		Score	Extra cost
1	Surplus of site space	1	x	4	=	4	10%
2	Surplus of building space / floor space	2	x	2	=	4	4%
3	Surplus free of floor height	3	x	2	=	6	0%
4	Access to building: location of stairs, elevators, core b	2	x	4	=	8	14%
5	Surplus of load bearing capacity of floors	3	x	4	=	12	15%
6	Extendable building / Unit horizontal	3	x	4	=	12	8%
7	Extendable building / Unit vertical	1	x	4	=	4	3%
8	Dismountable facade	3	x	3	=	9	9%
9	Customisability and controllability of facilities	2	x	4	=	8	4%
10	Surplus of facilities shafts and ducts	2	x	4	=	8	3%
11	Surplus capacity of facilities	3	x	4	=	12	5%
12	Disconnection of facilities components	2	x	4	=	8	2%
13	Distinction between support - infill	3	x	4	=	12	21%
14	Acces to building: horizontal routing, routing, corridors	1	x	4	=	4	2%
15	Disconnectible, removable, relocatable units in buildin	3	x	4	=	12	5%
16	Disconnectible, removable, relocatable interior walls	3	x	4	=	12	5%
17	Disconnecting/detailed connection interior walls; hor/v	3	x	4	=	12	5%
				56		147	116%
						72%	

Appendix 2-d Financial model – Cash flow original case

FLEXIBEL BUILT - COSTS AND BENEFITS

		per m2 land	m2 land		total
Purchase costs land	€	200	2.000	€	400.000
Investmentcosts		per m2 GFA	m2 GFA		total
basic	€	1.069	2.628	€	2.809.918
function	€	419	2.628	€	1.102.448
	€	1.488		€	3.912.365
Transformationcosts		per m2 GFA	m2 GFA		total
demolition	€	25	2.628	€	65.863
new layout	€	751	2.628	€	1.974.187
	€	776		€	2.040.050
Exploitationcosts		per m2 GFA	m2 GFA		total
function 1	€	21,23	2.628	€	55.789
function 2	€	21,84	2.628	€	57.416

		per m2 LFA	m2 LFA		total
Rent					
function 1	€	123	2.308	€	283.838
function 2	€	127	2.294	€	291.358
		per m2 land	m2 land		total
Residual value	€	200	2.000	€	400.000

CASHFLOW FLEXIBEL BUILT

Year	Costs					Benefits		start balance	Cashflow	Interest	end balance
	IC land	IC building	Demolition	Re-investing	Exploitationcosts	Rent	Residual value				0
0	400.000	3.912.365	0	0	0	0	0	0	-4.312.365	0	-4.312.365
1	0	0	0	0	56.905	289.515	0	-4.312.365	232.610	-215.618	-4.295.373
2	0	0	0	0	58.043	295.306	0	-4.295.373	237.262	-214.769	-4.272.880
3	0	0	0	0	59.204	301.212	0	-4.272.880	242.007	-213.644	-4.244.516
4	0	0	0	0	60.388	307.236	0	-4.244.516	246.848	-212.226	-4.209.895
5	0	0	0	0	61.596	313.381	0	-4.209.895	251.785	-210.495	-4.168.605
6	0	0	0	0	62.828	319.648	0	-4.168.605	256.820	-208.430	-4.120.215
7	0	0	0	0	64.085	326.041	0	-4.120.215	261.957	-206.011	-4.064.269
8	0	0	0	0	65.366	332.562	0	-4.064.269	267.196	-203.213	-4.000.287
9	0	0	0	0	66.674	339.213	0	-4.000.287	272.540	-200.014	-3.927.761
10	0	0	0	0	68.007	345.998	0	-3.927.761	277.990	-196.388	-3.846.159
11	0	0	0	0	69.367	352.917	0	-3.846.159	283.550	-192.308	-3.754.917
12	0	0	0	0	70.755	359.976	0	-3.754.917	289.221	-187.746	-3.653.441
13	0	0	0	0	72.170	367.175	0	-3.653.441	295.006	-182.672	-3.541.108
14	0	0	0	0	73.613	374.519	0	-3.541.108	300.906	-177.055	-3.417.257
15	0	0	88.643	2.656.996	75.085	382.009	0	-3.417.257	-2.438.715	-170.863	-6.026.835
16	0	0	0	0	78.820	399.973	0	-6.026.835	321.153	-301.342	-6.007.023
17	0	0	0	0	80.396	407.972	0	-6.007.023	327.576	-300.351	-5.979.799
18	0	0	0	0	82.004	416.131	0	-5.979.799	334.127	-298.990	-5.944.661
19	0	0	0	0	83.644	424.454	0	-5.944.661	340.810	-297.233	-5.901.084
20	0	0	0	0	85.317	432.943	0	-5.901.084	347.626	-295.054	-5.848.512
21	0	0	0	0	87.023	441.602	0	-5.848.512	354.579	-292.426	-5.786.359
22	0	0	0	0	88.764	450.434	0	-5.786.359	361.670	-289.318	-5.714.007
23	0	0	0	0	90.539	459.443	0	-5.714.007	368.904	-285.700	-5.630.804
24	0	0	0	0	92.350	468.632	0	-5.630.804	376.282	-281.540	-5.536.062
25	0	0	0	0	94.197	478.004	0	-5.536.062	383.807	-276.803	-5.429.058
26	0	0	0	0	96.081	487.564	0	-5.429.058	391.484	-271.453	-5.309.027
27	0	0	0	0	98.002	497.316	0	-5.309.027	399.313	-265.451	-5.175.165
28	0	0	0	0	99.962	507.262	0	-5.175.165	407.299	-258.758	-5.026.624
29	0	0	0	0	101.962	517.407	0	-5.026.624	415.445	-251.331	-4.862.510
30	0	0	0	0	104.001	527.755	724.545	-4.862.510	1.148.299	-243.125	-3.957.336
NPV	400.000	3.912.365	42.639	1.278.060	1.114.483	5.664.266	167.643		**-915.638**		**-915.638**

TRADITIONAL BUILT - COSTS AND BENEFITS

		per m2 land	m2 land		total
Purchase costs land	€	200	2.000	€	400.000
Investingscosts		per m2 bvo	m2 bvo		totaal
basic	€	1.415	2.628	€	3.719.299
function					
Transformationcosts		per m2 bvo	m2 bvo		totaal
demolition	€	45	2.628	€	118.282
new layout	€	1.456	2.628	€	3.827.724
	€	1.501		€	3.946.006
Exploitationcosts		per m2 bvo	m2 bvo		totaal
function 1	€	21,23	2.628	€	55.789
function 2	€	21,84	2.628	€	57.416

		per m2 LFA	m2 LFA		total
Rent					
functie 1	€	123	2.308	€	283.838
functie 2	€	127	2.294	€	291.358
		per m2 grond	m2 grond		totaal
Restwaarde	€	200	2.000	€	400.000

CASHFLOW TRADITIONAL BUILT

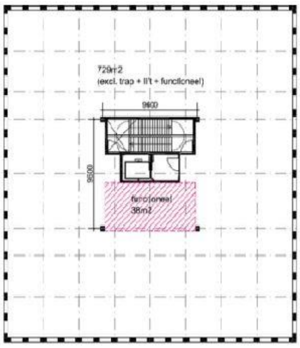
Year	Costs					Benefits		start balance	Cashflow	Interest	end balance
	IC land	IC building	Demolition	Re-investing	Exploitationcosts	Rent	Residual value				0
0	400.000	3.719.299	0	0	0	0	0	0	-4.119.299	0	-4.119.299
1	0	0	0	0	56.905	289.515	0	-4.119.299	232.610	-205.965	-4.092.654
2	0	0	0	0	58.043	295.306	0	-4.092.654	237.262	-204.633	-4.060.025
3	0	0	0	0	59.204	301.212	0	-4.060.025	242.007	-203.001	-4.021.019
4	0	0	0	0	60.388	307.236	0	-4.021.019	246.848	-201.051	-3.975.222
5	0	0	0	0	61.596	313.381	0	-3.975.222	251.785	-198.761	-3.922.198
6	0	0	0	0	62.828	319.648	0	-3.922.198	256.820	-196.110	-3.861.488
7	0	0	0	0	64.085	326.041	0	-3.861.488	261.957	-193.074	-3.792.606
8	0	0	0	0	65.366	332.562	0	-3.792.606	267.196	-189.630	-3.715.040
9	0	0	0	0	66.674	339.213	0	-3.715.040	272.540	-185.752	-3.628.253
10	0	0	0	0	68.007	345.998	0	-3.628.253	277.990	-181.413	-3.531.675
11	0	0	0	0	69.367	352.917	0	-3.531.675	283.550	-176.584	-3.424.708
12	0	0	0	0	70.755	359.976	0	-3.424.708	289.221	-171.235	-3.306.723
13	0	0	0	0	72.170	367.175	0	-3.306.723	295.006	-165.336	-3.177.053
14	0	0	0	0	73.613	374.519	0	-3.177.053	300.906	-158.853	-3.035.000
15	0	0	159.191	5.151.613	75.085	382.009	0	-3.035.000	-5.003.880	-151.750	-8.190.630
16	0	0	0	0	78.820	399.973	0	-8.190.630	321.153	-409.531	-8.279.009
17	0	0	0	0	80.396	407.972	0	-8.279.009	327.576	-413.950	-8.365.383
18	0	0	0	0	82.004	416.131	0	-8.365.383	334.127	-418.269	-8.449.525
19	0	0	0	0	83.644	424.454	0	-8.449.525	340.810	-422.476	-8.531.191
20	0	0	0	0	85.317	432.943	0	-8.531.191	347.626	-426.560	-8.610.124
21	0	0	0	0	87.023	441.602	0	-8.610.124	354.579	-430.506	-8.686.052
22	0	0	0	0	88.764	450.434	0	-8.686.052	361.670	-434.303	-8.758.684
23	0	0	0	0	90.539	459.443	0	-8.758.684	368.904	-437.934	-8.827.715
24	0	0	0	0	92.350	468.632	0	-8.827.715	376.282	-441.386	-8.892.819
25	0	0	0	0	94.197	478.004	0	-8.892.819	383.807	-444.641	-8.953.652
26	0	0	0	0	96.081	487.564	0	-8.953.652	391.484	-447.683	-9.009.851
27	0	0	0	0	98.002	497.316	0	-9.009.851	399.313	-450.493	-9.061.031
28	0	0	0	0	99.962	507.262	0	-9.061.031	407.299	-453.052	-9.106.783
29	0	0	0	0	101.962	517.407	0	-9.106.783	415.445	-455.339	-9.146.676
30	0	0	0	0	104.001	527.755	724.545	-9.146.676	1.148.299	-457.334	-8.455.711
NPV	400.000	3.719.299	76.574	2.478.014	1.114.483	5.664.266	167.643		**-1.956.461**		**-1.956.461**

Appendix 2-e Financial model – Cash flow new model

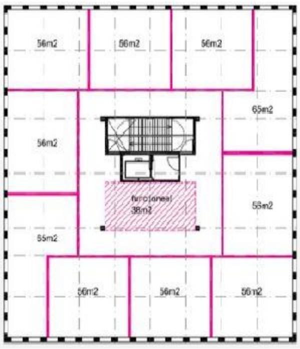
(in 000's)	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Potential Gross Office Income		349294	352473	355680	358917	362183	365479	368805	372161	375548	378965	382414	385894	389406	392949	396525
Vacancy		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Efective Gross Income		349294	352473	355680	358917	362183	365479	368805	372161	375548	378965	382414	385894	389406	392949	396525
Operating Expenses		-56297	-56809	-57326	-57848	-58375	-58906	-59442	-59983	-60529	-61079	-61635	-62196	-62762	-63333	-63910
Net Operating Income		**292997**	**295664**	**298354**	**301069**	**303809**	**306573**	**309363**	**312178**	**315019**	**317886**	**320779**	**323698**	**326643**	**329616**	**332615**
Capital Expenditures		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Casf Flow from Operations		292997	295664	298354	301069	303809	306573	309363	312178	315019	317886	320779	323698	326643	329616	332615
Reversion (Purchase & Sell)	-3.191.446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transformation		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before Tax Cash Flow	**-3191446**	**292997**	**295664**	**298354**	**301069**	**303809**	**306573**	**309363**	**312178**	**315019**	**317886**	**320779**	**323698**	**326643**	**329616**	**332615**
PV of Costs	€ -4.149.968															
PV of Benefits	€ 6.068.581															
NPV	€ 1.918.613															
ENPV	€ 1.918.613															

(in 000's)	YEAR	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Potential Gross Office Income		400133	403775	407449	411157	414898	418674	422484	426328	430208	434123	438073	442060	446083	450142	454238
Vacancy		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Efective Gross Income		400133	403775	407449	411157	414898	418674	422484	426328	430208	434123	438073	442060	446083	450142	454238
Operating Expenses		-64491	-65078	-65670	-66268	-66871	-67479	-68093	-68713	-69338	-69969	-70606	-71249	-71897	-72551	-73211
Net Operating Income		**335642**	**338697**	**341779**	**344889**	**348027**	**351194**	**354390**	**357615**	**360870**	**364153**	**367467**	**370811**	**374186**	**377591**	**381027**
Capital Expenditures		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Casf Flow from Operations		335642	338697	341779	344889	348027	351194	354390	357615	360870	364153	367467	370811	374186	377591	381027
Reversion (Purchase & Sell)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	524912
Transformation		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before Tax Cash Flow		**335642**	**338697**	**341779**	**344889**	**348027**	**351194**	**354390**	**357615**	**360870**	**364153**	**367467**	**370811**	**374186**	**377591**	**905938**

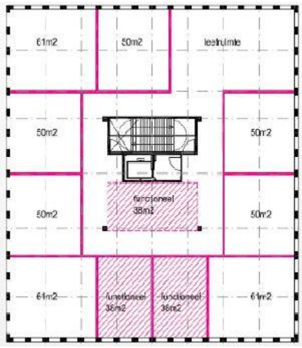
Appendix 3-a Floor plans original case



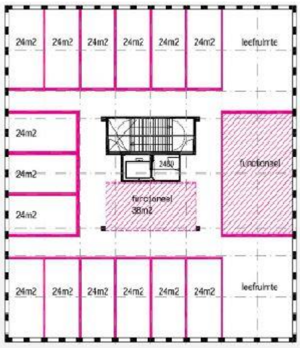
Office floor plan



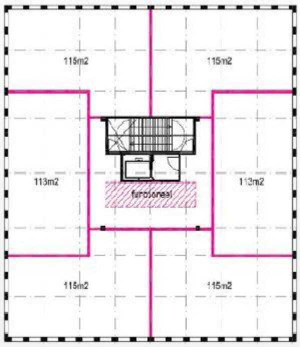
Service apartments



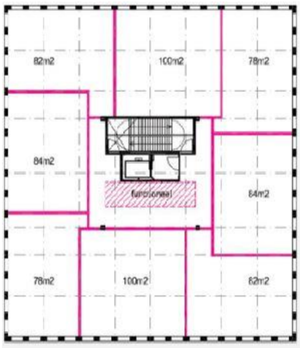
Health apartments



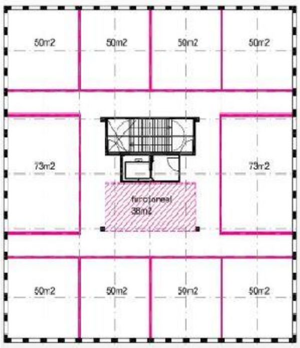
Dementia apartments



6x apartments floor plan



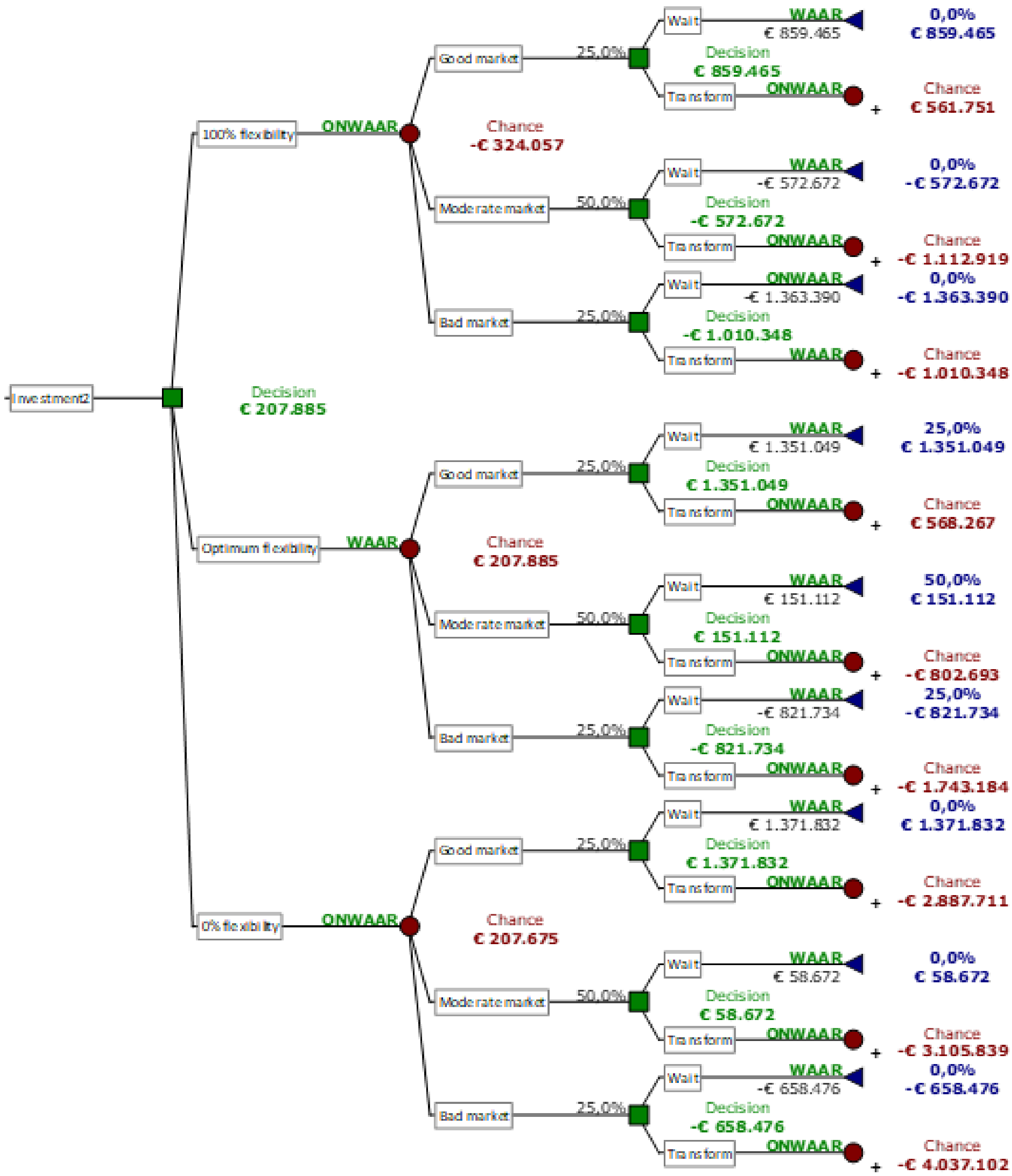
8x apartments floor plan



School floor plan

Appendix 4-a Decision Tree Analysis stochastic approach Bergen op Zoom

eNPV calculation based on the case information.



Appendix 4-b Decision Tree Analysis stochastic approach Amsterdam

eNPV calculation based on the case information, but located at the Amsterdam South-axis.